Cyfoeth Naturiol Cymru
Natural Resources Wales

State of Natural Resources Report 2025

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Noddir gan **Lywodraeth Cymru**
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State of Natural Resources Report 2025.

An assessment of Wales' Sustainable management of natural resources

About Natural Resources Wales

Natural Resources Wales' purpose is to pursue sustainable management of natural resources. This means looking after air, land, water, wildlife, plants and soil to improve Wales' well-being, and provide a better future for everyone.

Recommended citation:

Natural Resources Wales, State of Natural Resources Report (SoNaRR 2025), December

2025, 792pp, NRW, Cardiff

Review process: All content has been reviewed internally and by subject matter experts. Further independent peer review was arranged, with help from the Environment Platform Wales. We would like to thank all academic and other external experts for critically reading the individual sections and evidence and for suggesting substantial improvements. We are very grateful for their help and advice.

We would also like to thank other experts who have provided evidence and advice

Rhagair

Nid dim ond rhan o'n treftadaeth yw amgylchedd naturiol Cymru - dyma sylfaen ein dyfodol hefyd. Ein dewisiadau heddiw fydd yn pennu a fydd cenedlaethau'r dyfodol yn etifeddu ecosystemau sy’n ffynnu a chymunedau cadarn neu, yn hytrach, yn wynebu argyfyngau sy’n fwyfwy difrifol - argyfyngau y gallem fod wedi'u hatal.

Mae ein trydydd Adroddiad ar Gyflwr Adnoddau Naturiol (SoNaRR 2025) yn darparu'r dystiolaeth sydd ei hangen arnom i weithredu. Mae'n dangos lle mae cynnydd wedi'i wneud a lle mae heriau brys yn parhau i fodoli. Nid adroddiad yn unig yw hwn - mae'n alwad i ymgorffori tystiolaeth amgylcheddol wrth wraidd pob penderfyniad, pob polisi, a phob buddsoddiad y mae Cymru'n ei wneud, wrth i ni baratoi ar gyfer etholiad nesaf y Senedd.

Caiff SoNaRR 2025 ei gyhoeddi wyth mis ar ôl i Gomisiynydd Cenedlaethau'r Dyfodol nodi blaenoriaethau a meysydd ffocws sy'n sail i genhadaeth. Yn yr adroddiad hwn, rydym yn dangos yr hyn sydd wedi’i gyflawni dros y pum mlynedd ddiwethaf ac yn darparu tystiolaeth glir i ddangos beth mae hynny'n ei olygu i gyflwr adnoddau naturiol Cymru a chydnerthedd a chadernid ein hecosystemau. Er bod rhywfaint o gynnydd wedi'i wneud, mae llawer i'w wneud o hyd. Nid yw Cymru eto’n cyflawni’r pedwar nod hirdymor o reoli adnoddau naturiol yn gynaliadwy - ac mae’n hanfodol bod penderfyniadau polisi yn y dyfodol yn seiliedig ar y dystiolaeth hon.

Nid bygythiadau neu beryglon pell i ffwrdd yw newid hinsawdd, colli bioamrywiaeth a llygredd - maent yma nawr, yn siapio bywydau a bywoliaethau. Mae SoNaRR 2025 yn nodi beth mae hyn yn ei olygu i Gymru - ar draws ecosystemau, economïau a chymunedau - ac yn tynnu sylw at gyfleoedd i weithredu. Fod bynnag, nid rhywbeth dewisol yw’r cyfleoedd hyn. Mae manteisio arnynt yn hanfodol os ydym am gyflawni uchelgeisiau Deddf yr Amgylchedd a Deddf Llesiant Cenedlaethau'r Dyfodol, a chreu Cymru sy’n deg, yn gynaliadwy ac yn llewyrchus.

Rydym ar drobwynt i natur a hinsawdd. Mae ein hamgylchedd dan straen digynsail, ac nid bygythiadau neu beryglon y dyfodol yw effeithiau newid hinsawdd mwyach - maen nhw yma nawr. Mae tywydd eithafol yn 2025 wedi dangos pa mor fregus yw ein hecosystemau, tra bod llygredd yn parhau i erydu iechyd ein dyfroedd a'n tirweddau.

Eto i gyd, mae cyfleoedd i newid. Er enghraifft, mae Cynllun Ffermio Cynaliadwy Llywodraeth Cymru, a gaiff ei lansio ym mis Ionawr 2026, yn newid sylweddol yn y ffordd y caiff tir amaethyddol ei reoli - gan gefnogi cynhyrchu bwyd ochr yn ochr â gofalu am yr amgylchedd, mynd i'r afael â newid hinsawdd, a meithrin cydnerthedd a chadernid. Dyma'r math o ddull beiddgar, integredig, sydd ei angen arnom ar draws pob sector.

Gall targedau a pholisïau sy'n seiliedig ar y dystiolaeth hon greu momentwm, ysgogi atebolrwydd, a sicrhau bod pob sector yn chwarae ei ran. Hebddyn nhw, rydym mewn perygl o ohirio gweithredu gan beryglu ein dyfodol. Bydd y penderfyniadau a wneir yn y misoedd nesaf yn atseinio am ddegawdau. Y penderfyniadau hyn fydd yn siapio’r Gymru a fydd yn gartref i’n plant a'n hwyrion.

Dyma, felly, foment foment fawr, moment hollbwysig. Mae gennym y wybodaeth, y dulliau, a'r fframwaith deddfwriaethol i arwain y ffordd. Yr hyn sydd ei angen arnom nawr yw'r ewyllys i weithredu, ac i wneud hynny'n feiddgar ac yn bendant. Mae SoNaRR 2025 yma i lywio'r camau gweithredu hynny. Gadewch i ni ddefnyddio’r adroddiad i greu Cymru lle mae adnoddau naturiol yn cael eu rheoli'n gynaliadwy, lle mae cymunedau'n ffynnu, a lle mae cenedlaethau'r dyfodol yn edrych yn ôl gan wybod ein bod wedi gwneud y dewisiadau cywir.

Ceri Davies, Prif Weithredwr Interim

Foreword

Wales' natural environment is not just part of our heritage - it is the foundation of our future. The choices we make today will determine whether future generations inherit thriving ecosystems and resilient communities or face escalating crises that we could have prevented.

Our third State of Natural Resources Report (SoNaRR 2025) provides the evidence we need to act. It shows where progress has been made and where urgent challenges remain. This is not just a report - it is a call to embed environmental evidence at the heart of every decision, every policy, and every investment Wales makes, as we prepare for the next Senedd election.

The publication of SoNaRR 2025 comes eight months after the Future Generations Commissioner set out mission-based priorities and areas of focus. In this report, we show what has been achieved over the last five years and provide clear evidence of what that means for the state of Wales' natural resources and the resilience of our ecosystems. While some progress has been made, there is still much to do. Wales is not yet meeting the four long-term aims of sustainable management of natural resources, and it is vital that future policy decisions are rooted in this evidence.

Climate change, biodiversity loss, and pollution are not distant threats; they are here, shaping lives and livelihoods now. SoNaRR 2025 sets out what this means for Wales - across ecosystems, economies, and communities - and highlights opportunities for action. These opportunities are not optional. They are essential if we are to meet the ambitions of the Environment Act and the Well-being of Future Generations Act, and deliver a fair, sustainable, and prosperous Wales.

We are at a turning point for nature and climate. Our environment is under unprecedented strain, and the impacts of climate change are no longer future threats—they are here today. Extreme weather in 2025 has shown how vulnerable our ecosystems have become, while pollution continues to erode the health of our waters and landscapes.

Yet there are opportunities for change. The Welsh Government's Sustainable Farming Scheme, launching in January 2026, for example marks a step change in how agricultural land is managed - supporting food production alongside caring for the environment, tackling climate change, and building resilience. This is the kind of bold, integrated approach we need across all sectors.

Targets and policies grounded in this evidence can create momentum, drive accountability, and ensure that every sector plays its part. Without them, we risk deferring action and leaving our future to chance. The decisions made in the coming months will echo for decades. They will shape the Wales our children and grandchildren call home.

This is a pivotal moment. We have the tools, the knowledge, and the legislative framework to lead the way. What we need now is the will to act, and to do so boldly and decisively. SoNaRR 2025 is here to inform that action. Let's use it to build a Wales where natural resources are managed sustainably, communities thrive, and future generations look back knowing we made the right choices.

Ceri Davies, Interim Chief Executive

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Executive summary

Wales stands at a critical moment as our economy continues to degrade the natural resources that underpin our health, security, and prosperity. Wales is one of the most nature depleted countries in the world, with almost 1 out of 5 species at risk of extinction. Climate change is already impacting on all ecosystems within Wales, reducing ecosystem resilience and intensifying risks from other pressures. Pollution from wastewater, towns and cities, transport, agriculture and abandoned mines is compromising freshwater ecosystems. Only 40% of water bodies achieve good overall status. These pressures cascade from rivers, lakes and groundwaters into estuarine and marine environments, threatening biodiversity and coastal resilience.

There is an urgent need for climate action, both mitigation and adaptation, to create a Wales that is resilient to future climate impacts. This consists of both adaptation measures including coastal realignment and the creation of diverse ecosystems, to emissions reductions such as through peatland restoration.

Air pollution has improved, yet nitrogen emissions, such as ammonia, from agriculture remain high, impacting sensitive habitats and public health. Legacy contamination from industry and landfilling adds further complexity, with emerging pollutants such as microplastics and persistent chemicals posing long-term risks to soil and water security.

Land use decisions are intensifying these pressures. The construction sector must expand to meet the needs of our growing population; however, development often displaces farmland, coastal margins, and urban green spaces, frequently in areas vulnerable to flooding. Meanwhile, Wales' consumption levels far exceed sustainable limits. If replicated globally, our resource use would require more than two Earths, demonstrating the amount of natural resources we import, all accompanied by impacts on other countries, hampering the national Globally responsible Wales Wellbeing Goal.

Agricultural land dominates the landscape, yet the extent to which it is managed to sustain nature to deliver a consistent flow of ecosystem benefits remains low despite its provision of critical food supply. Given that the agricultural sector makes use of over 90% of Wales' land area, some of our greatest opportunities to improve the sustainable management of natural resources lies in the ecosystems and activities across Welsh farms. Welsh Government's Sustainable Farming Scheme (SFS), which commences on 1 January 2026, will support the delivery of sustainable land management outcomes linked to food provision alongside caring for the environment, tackling and adapting to climate and change and building resilience. It will mark a step change of approach in the management of agricultural land.

Introduction to SoNaRR

This is Wales' third State of Natural Resources Report (SoNaRR), required under the Welsh Environment Act 2016.

In 2016 we published the first SoNaRR as our understanding of the implications of the Environment Act were being developed. The second SoNaRR was published during the Covid-19 pandemic in 2020 and was the first time we used the four aims of sustainable management of natural resources to focus our assessment.

Since then, the evidence has grown to describe the extent of the nature and climate emergencies. The effects of these crises have been seen across the globe and here in Wales with most recently the storms and drought of 2025.

SoNaRR 2025 is the latest in a series of Welsh, UK and global assessments of the status and trends of natural resources. It looks at the risks those trends pose to our ecosystems and to the long-term social, cultural and economic well-being of Wales, in terms defined by the Well-Being of Future Generations (Wales) Act 2015.

SoNaRR's content and purpose is defined in the Environment Act

NRW must prepare and publish a report containing:

- An assessment of the state of natural resources in Wales.
- An assessment of the extent to which the sustainable management of natural resources is being achieved.
- An assessment of biodiversity to support the biodiversity duty on public bodies under section 6 of the Environment Act. Biodiversity is defined as:
  'the diversity of living organisms, whether at the genetic, species or ecosystem level'.
- What NRW considers to be the main trends and factors that are affecting and are likely to affect the state of natural resources.
- Any aspects about the state of natural resources on which NRW considers it does not have sufficient information to make an assessment.

SoNaRR is an evidence base for Welsh Ministers to use when preparing or revising the Natural Resources Policy, for NRW when preparing Area Statements, and for local planning authorities when refreshing local development plans. SoNaRR must also be considered in the publishing, adopting or reviewing of national park and area of outstanding natural beauty management plans by relevant authorities.

Our use of broad ecosystems and cross-cutting themes

Natural resources are defined in the Environment Act as:

- Animals, plants and other organisms.
- Air, water and soil.
- Minerals.
- Geological features and processes.
- Physiographical features.
- Climatic features and processes.

These components combine and work together in many ways and at many scales, forming ecosystems from which humans use and obtain benefits. SoNaRR continues to group ecosystems following the system used in the UK National Ecosystem Assessment of 2011.

Using these broad ecosystems allows us to:

- Distinguish and group together the different habitats generally found there.
- Describe the services we get from them and map the benefits to well-being.
- Look at pressures and impacts on the resilience of those ecosystems.
- Identify opportunities for action and design management interventions around the land, water and sea uses that occur there.

In SoNaRR 2016 and SoNaRR2 020 we used these ecosystems as the thread throughout the report. We continue to use the available robust evidence to describe the broad ecosystems in SoNaRR 2025, along with the three main natural resources air, soils and water. This evidence, along with updated Drivers of change, pressures, ecosystem services and evidence related to indirect drivers of change, energy, waste and landscape, is used to assess the sustainable management of natural resources

Broad ecosystems

- Urban
- Mountain, moorland and heath
- Semi-natural grassland
- Freshwater
- Enclosed farmland
- Woodland
- Coastal margins
- Marine

Natural Resources

- **Air**
- Water
- Soil

Evidence relating to Minerals; Geological features and processes; Physiographical features; Climatic features and processes is provided across the relevant ecosystem evidence

Drivers of change

- Climate Change
- Direct exploitation
- Invasive non-native species, pests and diseases
- Land and sea use and management change
- Pollution

Supporting evidence

- Waste
- Energy
- Landscapes

SMNR and the well-being goals

The Environment Act defines the sustainable management of natural resources as:

"…using natural resources in a way and at a rate that maintains and enhances the resilience of ecosystems and the benefits they provide. In doing so, meeting the needs of current generations without compromising the ability of future generations to meet their needs, and contributing to the achievement of the well-being goals set out in the Well-being of Future Generations Act."

The objective of SMNR is to build resilient ecosystems which supply ecosystem services and help Wales meet its well-being goals for a sustainable future. To do that we need to transform our socio-economic systems so that they are working more like natural regenerative systems, responding to feedback about environmental capacity and social needs.

The Welsh well-being goal of securing 'A resilient Wales' is about building healthy functioning ecosystems which support social, economic and ecological resilience. To secure this resilience, we need to focus on building healthy, regenerating systems.

The four aims of SMNR

The four long-term aims of SMNR, introduced in SoNaRR 2020 continue to guide the assessments that underpin SoNaRR 2025.

Achieving SMNR means having healthy, well-functioning and resilient social, economic and eco- systems, using feedback information to stay in balance with each other as they adapt to change.

SoNaRR 2025 updates our assessment of Wales' progress towards SMNR individually against the four aims, but it is important to note that they are inseparable and should not be seen in isolation.

Wales cannot work towards healthy places for people without resilient ecosystems and cannot make our ecosystems resilient without safeguarding stocks of natural resources.

The regenerative economy safeguards and restores those stocks and is the route to the transformational change needed to achieve SMNR.

Aim 1. Stocks of natural resources are safeguarded and enhanced

Natural resources underpin our well-being and quality of life and are the basis of healthy, resilient ecosystems. They provide our food, clean air and water, fuel our industries, and create jobs.

This assessment evaluates Wales' progress towards Aim 1 of the sustainable management of natural resources (SMNR): to safeguard and enhance stocks of natural resources. It takes a broad view of natural resources, including wild species, air, water and soil, and is not confined to economically valued stocks (which are mostly considered in the Aim 4 assessment).

Vision for Aim 1

Success would see Wales using natural resources in a way that enables their quantity and quality to improve over time, not be degraded. In this vision, our ecosystems are resilient and able to regulate, maintain and provide natural resources which benefit the people of Wales. Our economy and culture not only protect natural resources and ecosystems from pressures that would degrade them but also work to improve the quantity and quality of natural resources in Wales and those that we use from around the world. Use of non-renewable resources would be managed to reduce impacts on ecosystems and to move towards renewable alternatives.

Aim 2. Ecosystems are resilient to expected and unforeseen change

Understanding and assessing ecosystem resilience is central to Wales' ability to respond to environmental pressures and deliver the Sustainable Management of Natural Resources (SMNR). Building ecosystem resilience relies upon safeguarding and enhancing natural resources and ensures the continued provision of ecosystem services which Wales relies upon for its economy and health. Resilience means ecosystems are adaptable and can resist the impacts of habitat change, climate change, pollution, invasive non-native species and other pressures.

This Aim 2 assessment explores the ecological importance of semi-natural habitats, those most critical for resilient ecosystems. It also presents the Diversity, Extent, Condition and Connectivity (DECCA) framework used to assess resilience across ecosystems. Together, these elements provide the foundation for understanding how resilient Wales' ecosystems are to expected and unforeseen change.

Vision for Aim 2

Along with governments across the world, the Welsh Government has committed to halting and reversing the loss of nature.

Wales will achieve this through a comprehensive network of healthy, and resilient ecosystems. Through sustainable land management and a regenerative economy, harmful pollution is eliminated, we will halt and reverse biodiversity loss, ensuring our landscapes provide enhanced wellbeing benefits and consistently deliver vital ecosystem services for the health and prosperity of future generations.

Aim 3. Wales has healthy places for people, protected from environmental risks

The environment provides regulating services which protects people from risks including air, water or noise pollution and flooding. Managing those services increases well-being resulting in the provision of a healthy environment for all. Meeting this aim is dependent on having resilient ecosystems and the health and well-being of the nation contributes to our ability to take advantage of the economic opportunities of a regenerative economy.

Vision for Aim 3

That every person in Wales lives in an environment that nurtures their health, every community is resilient to environmental risk, and natural resources are managed so future generations inherit ecosystems that are healthier, more biodiverse and more valued than today. This can be achieved through:

- Health protection: Reduce air, water and soil-borne hazards, and impacts of climate change. Prioritising communities where risk and deprivation coincide.
- Health improvement: Promote daily access to green and blue space, mainstream green social-prescribing, access to nature and active-travel for health benefits.
- Cultural benefits & equity: co-design, interpret and fund nature projects as part of ‘place-making’ so every community feels welcome and represented

Aim 4. Contributing to a regenerative economy, achieving sustainable levels of production and consumption

Reducing the environmental impact of production and consumption and Wales’ global environmental footprint. The aim is for Wales to use no more than its fair share of global resources and for the economy to operate within the regenerative capacity of the Earth’s ecosystems.

Vision for Aim 4

Achieving Aim 4 would result in Wales moving from an economy that degenerates its natural resources and ecosystems, through a sustainable, circular economy, which does no net harm and uses its fair share of natural resources, to a regenerative one which works with our natural systems to restore nature.(Food and Agriculture Organization of the United Nations, 2025)

Method

The SoNaRR interim report, in December 2024, set out the method we have used to assess Wales' achievement of SMNR. SoNaRR 2025 applies the method through the twin lenses of ecosystems and the main natural resources water, air and soil

We started by updating the evidence that was in the technical chapters in SoNaRR 2020.

This time around we have set out the evidence for each broad ecosystem and natural resource within an online space for you to explore. This includes the pressures, state, and impacts on wellbeing which are barriers to the achievement of SMNR. In addition to this evidence, the report includes updates to the evidence behind the 5 Drivers of change at a Wales scale. We have used this evidence to assess progress against each of the four aims of SMNR at the ecosystem, resource and all Wales, national scale. Wider available evidence, such as international reports and publications, have been used within these assessments where relevant. Each SMNR assessment recommends opportunities for action to manage the issues described.

As in previous reports, the evidence in SoNaRR 2025 follows the internationally recognised DPSIR approach – a framework for using suitable evidence to describe drivers of change, pressures, state, impact and responses in relation to aspects of the environment.

SoNaRR builds on DPSIR and uses that structure to assess progress towards SMNR and the Welsh well-being goals.

We have followed a more prescriptive method this time around to ensure all aspects of SMNR are addressed in a consistent way. The approach taken within SoNaRR is set out below.

- Review the SoNaRR2020 drivers of change [D] and pressures [P], their magnitude, current trends and effects on each ecosystem. We have included a confidence assessment associated with the evidence.
- Update the state (current state, trends and outlook) [S]. For ecosystems this uses key metrics for Diversity, Extent, Condition and Connectivity. This informs the assessment of Aims 1 and 2. We have included a confidence assessment associated with the evidence.
- Review and update the evidence describing ecosystem services and the level of importance of the benefits to people and economy that is contributed by the

ecosystem. Also update the impacts [I] on these benefits identified through the pressures and state assessment. We have organised the ecosystem services using the SEEA EA Ecosystem Service Reference List, updating the previously used UK NEA. This informs the assessment of Aims 3 and 4.
- Review and update the status of current responses [R]: What has happened since SoNaRR2020? Identify new opportunities for action, taking into account synergies and trade-offs.
- Update the assessment of SMNR using the evidence from steps 1 to 4. An assessment against the 4 aims for each ecosystem and natural resource.
- Update the 4 National Aims assessments, using the assessments of SMNR across ecosystems and natural resources, the Drivers of change evidence, and relevant additional Wales, UK and Global evidence.
- Bring the opportunities for action together, acknowledging synergies and trade-offs.

We have used evidence that describes the direct and indirect use of ecosystem services, specifically in relation to Regulating, Provisioning and Cultural services.

The SEEA EA identified flows not related to direct or indirect use of ecosystem services - Ecosystem and species appreciation. The benefits to people are described as Existence and preservation of ecosystems and species for current and future generations, irrespective of any direct or indirect use, provides benefit to people’s well-being based on the intrinsic value of ecosystems and species. In relation to businesses and government, there are as yet unknown benefits from ecosystems and species that could contribute directly to well-being or the future resilience of ecosystems and ecosystem services supply. There is no available evidence on intrinsic value by ecosystem. We discuss valuing nature in our National Aim 1 and 4 assessments.

Collaborative working

SoNaRR is about Wales, not Natural Resources Wales, and we needed to ensure that a broad view of the subject is represented. There was direct communication with stakeholders in the updating of the evidence.

We have followed our evidence review process throughout. All the DPSIR evidence has been through an academic peer review process.

The SMNR assessments at ecosystem and natural resource scale have been reviewed by stakeholders along with the National assessments against the four aims

Direct drivers of change in Wales

Drivers of change are natural or human-induced factors that cause changes to natural resources and ecosystems. They can either be direct, causing physical change that can be measured, or indirect which are less measurable in terms of causality. The sustainable management of natural resources (SMNR) requires a better understanding of these drivers to fully appreciate the root causes of unsustainable management.

The evidence gathered and analysed within SoNaRR 2025 regarding the key drivers of environmental change and their associated pressures helps us to focus on the main pressures that affect the stocks of natural resources, the resilience of the ecosystems across Wales and the benefits, or services, that the ecosystems provide.

In SoNaRR 2025 we continue to use the five widely accepted direct drivers of change: Climate change; Direct exploitation; Invasive non-native species, pests and diseases; Land and sea use management and change; and Pollution.

Climate change

Climate change is the long-term shifts in temperatures and weather patterns. Such shifts can be natural, due to changes in the sun's activity or large volcanic eruptions. But since the 1800s, human activities have been the main driver of climate change, primarily due to the emission of greenhouse gases from the burning of fossil fuels like coal, oil and gas.

Climate change alters habitat conditions, species distributions, and resource availability, leading to reduced resilience and ecological degradation. Management and mitigation efforts are essential to address these growing impacts across Wales.

Key messages for climate change

- Increased and sustained action across all levels of government, business and civil society is required to effectively combat the climate emergency, deliver a just transition to a low carbon future and meet Wales' carbon budgets and net zero by 2050.
- Climate change is and will continue to impact all ecosystems in Wales, with warmer, wetter winters, hotter, drier summers, and a higher number of more extreme events predicted to occur.
- There is an urgent need for joined up climate adaptation and mitigation to support a climate resilient Wales that enhances biodiversity, reduces flood risk and improves public health.
- Climate change interacts with the other drivers of change - land use change, pollution and INNS - to compound the threats to our ecosystems. Integrated responses to multiple pressures presents novel opportunities for co-benefits to nature, communities and health.
- There are major opportunities for encouraging individual action and behavioural change, and for enabling ecosystems to play key roles in both reducing emissions and building a climate resilient Wales.

Summary for Climate Change

Global greenhouse gas emissions have continued to rise since SoNaRR2020, increasing the risk to the planet from human-induced climate change. Wales met the first carbon budget target to reduce greenhouse gas emissions in 2020 and is on track to meet the second budget in 2025, although this will be a greater challenge. Carbon Budget 3 (2026-2030) requires a 58% reduction in emissions in Wales against a 1990 baseline. Globally and nationally, there is a need for continued and increased action across all levels of society to meet stick to these carbon budgets and the pathway to net zero by 2050 in a way that is fair and that reaps the benefits of transition in Wales.

Climate change is and will continue to impact all ecosystems in Wales, with warmer, wetter winters, hotter, drier summers, and a higher number of more intense extreme events predicted to occur. The biggest threats from climate change in the natural environment are to vulnerable habitats which include, mountains, moorlands and heaths, and coastal margins.

There is an urgent need for climate action, both mitigation and adaptation, to create a Wales that is resilient to future climate impacts. This consists of both adaptation measures including coastal realignment and the creation of diverse ecosystems, to emissions reductions such as through peatland restoration.

Compounding impacts between multiple pressures to Wales' natural resources such as climate change, INNS, and land use change, increase the threats of these drivers of change to all ecosystems and resources.

There is an increased need for more individual action, behavioural change and for ecosystems to take a role in climate resilience to combat the climate emergency. Action Wales-wide is needed from the household, to government, to ecosystem level for both mitigation (such as support for, and implementation of, green household energy systems, peatland restoration and woodland creation) and adaptation (through the development of adaptive policies and proactive planning for incidents such as wildfire and flooding).

Key changes since SoNaRR2020

Since SoNaRR2020, Welsh carbon emissions have reduced slightly, although overall global carbon emissions continue to increase, thus also increasing the impacts from climate change to Wales. Average air and water temperatures continue to increase, with an increase in extreme events seen over the past five years.

The third Climate Change Risk Assessment for Wales was published in 2021, detailing 61 risks and opportunities to Wales from climate change (Netherwood, 2021). This has informed the second national adaptation plan, the Climate Adaptation Strategy for Wales, published in 2024 (Welsh Government, 2024).

Wales met the first carbon budget target to reduce greenhouse gas emissions in 2020 and is on track to meet the second budget in 2025, although this will be a greater challenge.

Full evidence and references in Annex 1: Climate Change evidence

Direct exploitation

Direct exploitation is the use of natural resources, including living organisms, for food and materials. The pressures caused relate to the manner in which they are removed for our use as well as the direct removal and reduction of a renewable or non-renewable natural resource

Key messages for direct exploitation

- Current regulation strives to prevent pressures from licensed water abstraction. Efficient use of water will become ever more necessary as climate change scenarios predict an increasing frequency of prolonged dry periods. Conservation and re-use of water across all sectors is vital to increase climate change resilience and water and energy security.
- The evidence to determine whether marine fisheries in Welsh waters are sustainable or not is limited. Bycatch is a significant threat to several species of marine mammal in UK waters and is of particular concern for certain fisheries operating in the wider Celtic and Irish seas and beyond. However, there is limited information on bycatch in net fisheries in Wales and further work is required to provide robust estimates in Wales.
- We have a better understanding of Freshwater fisheries in Welsh rivers and lakes, particularly migratory salmonids and eels. Eel stocks internationally are currently below sustainable limits and NRW has effectively closed the fishery since 2021. Stocks of Atlantic Salmon are also below sustainable limits, with all 22 Principal stocks classed as At Risk. We are also increasing concerned about sea trout fisheries with 32 of 33 stocks being classed as At Risk. Byelaws introduced in 2020 currently require all net and rod salmon to be released unharmed, and also provide size, method and season restrictions to protect sea trout.
- Soils can be directly exploited in the production of food, fibre and other outputs, which can place pressure on soils when unsustainably managed. Built development permanently removes or seals soils, including sending them to landfill and resulting in the irreversible loss of this finite resource.
- The historic practice of draining naturally wet soils has degraded peatlands and wetlands, released carbon, and lowered productivity. The National Peatland Action Plan has restored 3,000 hectares of peat soils between 2000 and 2025.

Underlying evidence

The SoNaRR 2025 assessment of Direct Exploitation is informed by evidence set out in the Pressures for each Natural Resource and Ecosystem. You will find it in the drivers of change and pressures detailed evidence within our interactive Power BI report. The Ecosystems with relevant evidence are freshwater, marine and mountain, moorland and heath. The Natural resources with relevant evidence are soils and water.

Full evidence and references in Annex 3: Land use and management change evidence

Invasive non native species, pests and diseases

Invasive non-native species (INNS), pests and diseases are organisms that can cause damage to human health and well-being, non-human species and ecosystems. These may be native or non-native organisms.

Invasive non-native species (INNS) are any non-native animal or plant that can spread and subsequently cause damage to the environment, the economy, our health, and the way we live.

A pest is any organism that can cause damage to other organisms or human-built infrastructure, resulting in negative impacts on human health and well-being, ecosystem health or economic activity. In SoNaRR, pests usually refers to insect pests although rabbits are included here (grey squirrels are covered within INNS).

Diseases, in this context, are illnesses of any organism caused by infection by microorganisms.

Key messages for INNS

- Over time new invasive non-native species have been establishing at continually increasing rates in Great Britain, the main global drivers are the movement of goods and people, and climate change.
- INNS are identified as one of the top five drivers affecting biodiversity worldwide; they impact all the different ecosystems of Wales, terrestrial, freshwater and marine.
- INNS are estimated to cost the economy of Wales £343 million annually (including fungi). The forestry and agriculture sectors are most significantly affected.
- Pests and diseases pose a significant threat in several ecosystems across Wales, impacting ecosystem resilience and economically important sectors such as forestry and agriculture.
- Tackling INNS, pests and diseases requires collaboration between stakeholders to improve biosecurity, target pathways of introduction, monitor the introduction and spread, ensure early intervention, and effectively plan, prioritise and implement strategic actions. It will also be important to implement INNS legislation and policy drivers and to include consideration of INNS in land management schemes.

Summary for INNS

Invasive non-native species (INNS) have a significant impact on the environment, economy, and public well-being in Wales. These species are recognized as one of the leading threats to global biodiversity, with an estimated economic impact of £343 million annually (including fungi) in Wales alone. Over the past 50 years, the rate of new INNS establishment in Great Britain (GB) has surged, reflecting a worldwide trend driven by factors such as climate change and the increased movement of goods and people.

In response to the rising threat of INNS, various legislative and policy measures have been implemented in Wales since 2020 that prioritise prevention and early intervention. Key initiatives include the embedding of the Invasive Alien Species Order 2019, which restricts activities that could introduce or spread INNS, and the implementation and refresh of the GB INNS Strategy (2023-2030) including the development of the GB Pathway Action Plans. Additionally, the establishment of the Great Britain Non-native Species inspectorate (NNSI) has focused efforts on sectors most at risk for introducing these invasive species to GB.

A strategic framework for addressing INNS in Wales is essential for long-term efficacy. This framework should expand its membership and enhance collaboration among stakeholders to create a cohesive strategy. Increasing communication and supporting the establishment of strategic projects targeting specific species or geographical areas. It is also essential to continue the implementation of marine biosecurity plans that have been developed collaboratively to address INNS in marine environments.

The agriculture sector in Wales faces a substantial financial burden from INNS, estimated at £124 million annually, while the forestry sector incurs losses of approximately £167 million annually. INNS threaten productivity, damage crops and timber, and contribute to soil health deterioration and erosion. Future land management initiatives present an opportunity to promote coordinated efforts against INNS, ensuring that actions are taken at suitable spatial and temporal scales.

Particular emphasis should be placed on preventing the introduction of marine and freshwater INNS, as they are difficult to eradicate once established. Promoting biosecurity measures, early intervention measures, planning and collaboration will be vital for addressing new arrivals and curbing the spread of existing species.

Improvements in data flows, reporting and surveillance will contribute to INNS policy and legislative drivers, including Target 6 of the Global Biodiversity Framework.

Another crucial aspect of managing INNS in Wales is addressing existing evidence gaps related to their distribution, monitoring, impact, and management. Filling these gaps is essential for informing effective policy initiatives, including the State of Natural Resources Report (SoNaRR). Improved knowledge and data on INNS will enable policymakers and stakeholders to make informed decisions and allocate resources effectively, ultimately enhancing the response to the invasive species challenge in Wales.

Reducing the impact of INNS in Wales will address localised water resource and quality issues, will support the recovery of nature and will improve the resilience of ecosystems to respond to climate change.

Key changes to INNS since SoNaRR2020

In Wales, policy and legislative implementation has advanced through the embedding of the Invasive Alien Species Regulation and Order, development of enforcement mechanisms, and strategic contributions to the renewed GB INNS Strategy (2023–2030).

Targeted projects and guidance that support prevention, control, and restoration efforts across terrestrial, freshwater, and marine ecosystems have also been delivered.

Key changes have also included the growing recognition of INNS management as a public good within future land management schemes and strengthened biosecurity promotion across sectors and ecosystems and the establishment of a collaborative INNS framework through the Wales Resilient Ecological Network (WaREN) project.

These developments reflect a maturing policy context that increasingly prioritises strategic, collaborative, and preventative approaches to INNS management.

Evidence needs for INNS

Globally and nationally, new trend data confirm that INNS introductions continue to be driven by increased movement of people and goods, and climate change. However, comprehensive trend data to describe INNS impacts across Welsh ecosystems remains limited, highlighting a continued evidence gap.

Full evidence and references in Annex 2: INNS evidence

Summary for pests and diseases

Pests and diseases pose a significant threat in several ecosystems across Wales, impacting ecosystem resilience and economically important sectors such as forestry and agriculture.

Over the last 15 years, pests and diseases have had a significant negative effect on tree health in Welsh woodlands, and farmland and urban trees. Pests and diseases cause a decline in tree health, which is a key determinant of the growth, composition and productivity of woodlands. The most significant diseases affecting Welsh woodlands are Phytophthora ramorum, primarily affecting larch species, and Ash Dieback in broadleaf woodlands, with the significance of oak processionary moth also increasing.

Within the marine ecosystem, the Highly Pathogenic Avian Influenza (HPAI) is a new and major threat to internationally important seabird populations in the UK. In enclosed farmland, livestock are at risk of vector-borne diseases such as Bluetongue, which is projected to have extended transmission seasons in future due to climate change. The abundance and distribution of pests and diseases are expected to increase in future due to climate change and global trade.

Key changes to pests and diseases since SoNaRR2020

Over the last 5 years, Phytophthora ramorum and Chalara Ash Dieback have continued to cause a deterioration in tree health, but more significantly other species have emerged or have gained more of a hold since SoNaRR2020, including Phytophthora pluvialis and Oak Processionary Moth.

The first cases of bluetongue virus were detected in south-east England in November 2023. The virus has since been found in Powys and Monmouthshire.

Highly Pathogenic Avian Influenza (HPAI) caused mass mortality of seabirds in the UK and Wales for the first time in 2022 and 2023.

The SoNaRR 2025 assessment of pests and diseases is informed by evidence set out in the pressures for each Natural Resource and Ecosystem. You will find it in the drivers of change and pressures detailed evidence within our interactive Power BI report.

Land and sea use management and change

Land use change refers to a change in the use or management of land by humans. In Wales this can include management practices which cause changes in land use and land cover. Examples include intensification of agriculture, converting land from semi-natural grassland to enclosed farmland; or building of human settlements converting land from one ecosystem to urban ecosystem; or afforestation converting land to forestry use and woodland ecosystem land cover.

Sea use change refers to a change in the use or management of the sea by humans. In Wales this can include building infrastructure in the marine environment which can lead to loss or degradation of habitat; construction of coastal defences which could lead to coastal squeeze; and unmanaged recreational activities which can cause disturbance and physical impacts.

Key messages for land and sea use management and change

- Land is a finite and valuable asset that underpins the delivery of ecosystem goods and services essential for well-being. There are increasing demands on the limited supply of land to provide multiple services, including food, timber, renewable energy, housing, carbon storage, climate change mitigation, habitat restoration, and resilience to extreme weather.
- Wales has a rich and diverse marine ecosystem which can provide many important services for people and the economy, including food, energy, blue carbon, and recreation. If appropriately managed, this could generate revenue to invest in local ecosystem resilience, markets, and communities.

- There is a risk of unsustainable land use and management changes (increased intensity or reduced management intensity) without appropriate policies and alignment of economic drivers. Farmers and land managers are vulnerable to global economic shocks, pandemics, and extreme weather events.
- Land, sea and terrestrial ecosystems play a crucial role in climate mitigation and supporting nature, especially in the uplands and around the coast.
- Expansion of offshore renewable energy to meet net zero targets needs careful management to meet the requirements of both the climate and nature emergencies
- Future land use and management decisions should consider land use suitability and capability, alongside resource stocks and services to deliver for climate, nature, and people.
- Alignment between various types of interventions can address some of the challenges of the climate and nature emergencies, decarbonization targets, and well-being benefits.
- Priorities for interventions include, protecting special places for nature, implementing peatland restoration programmes, increasing tree and woodland cover, tackling multiple sources of pollution, integrating sustainable management systems and practices, and influencing behaviour change through engaging people with the land and sea.

Summary for land and sea use management and change

Land is a finite and valuable asset; it underpins the delivery of ecosystem goods and services on which the built and natural environment depends for well-being. The most changes seen within Wales occurred within urban land use, followed by woodland, and improved productive land. There are growing demands on the limited supply of land to provide a greater range of multiple services. There is a risk that land has already been overpromised.

Demand for food and fibre sits alongside increasing policy ambitions for more renewable energy for the decarbonisation agenda, more organic materials for recovery to land, to supply housing for a growing population, to store and sequester carbon, to mitigate and adapt to climate change, maintain and restore habitats for biodiversity and improve resilience to extreme weather. These are all likely to influence future land use and management change in Wales. There is a risk of unsustainable land use and management changes (increased intensity or reduced management intensity) without appropriate policies and alignment of economic drivers. Farmers and land managers have been vulnerable to global economic shocks caused by pandemics, war, and extreme weather events.

The sea plays a vital role in supporting biodiversity, regulating climate, and sustaining human activities such as fisheries, recreation, and transport. However, it faces growing pressures from built development and human use. Infrastructure placed in the sea can directly remove or degrade habitats and alter physical processes like currents and sediment movement, with impacts often extending beyond the immediate site.

Coastal development, including defences and transport infrastructure, contributes to coastal squeeze, preventing habitats from migrating inland in response to sea-level rise. According to the NRW Evidence Report ‘Understanding the likely scale of deterioration of Marine Protected Area (MPA) features due to coastal squeeze’ 29% of the Welsh coast (719km) has some form of linear or shore-parallel structure (this could include a coastal defence, railway infrastructure, or port infrastructure) which could prevent habitats from migrating landwards in response to sea-level rise, and therefore cause coastal squeeze. Marine species are affected through collisions, disturbance, and loss of critical habitats. Activities such as aggregate extraction and dredging disrupt sediment budgets, can physically damage sensitive habitats, and disturb wildlife. These pressures also contribute to pollution and the spread of invasive species, threatening protected sites and valuable ‘blue carbon’ habitats like saltmarsh and seagrass. Effective management and mitigation are essential to safeguard the health and resilience of the marine environment. Many pressures on the marine environment relate to unmanaged access and recreation. Recreational sea angling, recreational boating, bait digging and collection of living resources and foot access are potentially having the most impact on sites and should be tackled. Several other recreational activities and unmanaged access can also cause disturbance of birds and marine mammals; the severity of their effects will be dependent on the location at which they take place.

Land, sea and marine and terrestrial ecosystems have an important role in climate mitigation and supporting nature but over the long term the net sink of emission has been declining. Decisions on future land and sea use and management change must give greater consideration to land and sea use suitability and capability alongside a land and sea use change decision making frameworks.

Key changes since SoNaRR2020

Since SoNaRR2020, land use and management in Wales has undergone notable policy developments influenced by a combination of drivers and pressures. For example, the Agriculture (Wales) Act 2023 introduced Sustainable Land Management as an overarching framework. Demand for food and fibre sits alongside increasing policy ambitions for more renewable energy, more organic materials for recovery to land, more housing for a growing population and more habitat creation and restoration for nature recovery and climate resilience. Nutrient neutrality in SAC river catchments for phosphorus discharges are now key planning and permitting considerations. These changes reflect growing global and national ambitions for climate mitigation and adaptation, biodiversity recovery, and sustainable food production, underscoring the need for integrated land use and management decision-making.

Since SoNaRR 2020, new evidence has provided a better understanding of the key pressures in the marine environment which can be used to support the development of more targeted actions to enhance the resilience of marine and coastal ecosystems. The effects of climate change are becoming more evident and increasing, with new evidence which predicts significant effects due to coastal squeeze. The planned expansion of offshore renewable energy has accelerated since the introduction of net zero targets, and this presents both opportunities and challenges in responding to the climate and nature emergencies. The publication of an Ocean Literacy Strategy for Wales in 2025 represents an opportunity to increase capacity and engagement, promote behaviour for sustainable use of marine resources and increase access to well-being benefits.

Full evidence and references in Annex 3: Land use and management change evidence

Pollution

Pollution is contaminants and other nuisances in the environment which can harm human health, living organisms or the natural or built environment. These contaminants may be in the form of substances (e.g. chemicals) or energy (e.g. light, noise, radioactivity, heat). These contaminants can directly or indirectly change the biological, thermal, chemical, physical, or radioactive properties of the medium they are in (e.g. water, air, land) in a way that can create a hazard. These may be produced by natural processes and human activity.

Key messages for pollution

- While air quality in Wales has improved, pollution still impacts health and ecosystems, making coordinated action under new legislation essential to achieving environmental goals.
- Land and soil pollution incudes atmospheric deposition (e.g. nitrogen, sulphur), land spreading and application or waste disposal (e.g. heavy metals, pesticides, microplastics, nutrients above crop need, fly tipping), and from polluted waters (e.g. runoff, flooding). Contaminants like PFAS, veterinary medicines and other pharmaceuticals are concerning, but evidence on their long-term effects is limited. While some pollutants have declined, others persist or increase locally.
- 0% of Wales' freshwater and marine bodies achieve good status under the Water Framework Directive regulations, which has not changed since the last SoNaRR report. Significant pressures include wastewater, towns and cities, transport, agriculture and abandoned mines. Growing public concern around impacts of poor water quality highlights how important our freshwater and marine environments are to the people of Wales.
- Noise pollution in Wales is a public health concern, with 25% of residents report being affected, especially in urban areas. New Welsh legislation on soundscapes aims to improve well-being by promoting healthier, more inclusive acoustic environments.
- 18.84% of Wales has a dark sky designation. Although awareness of the opportunities of a night sky and the effects of light pollution are becoming more apparent, light pollution remains a problem across much of Wales. Light pollution disrupts the behaviours of whole ecosystems and migratory birds, which rely on natural darkness. Light pollution where people live can impact human health and wellbeing**.**
- Strategic interventions, nature-based solutions, and collaborative land and water management are showing some success in restoring ecosystems and reducing pollution, but action must be taken at pace and at scale to manage the sources of pollution and mitigate its impacts.

The SoNaRR 2025 assessment of Pollution is informed by evidence set out in the Pressures for each Natural Resource and Ecosystem. You will find it in the drivers of change and pressures detailed evidence within our interactive Power BI report**.** All Ecosystems and Natural resources are affected by pollution and have relevant evidence.

Indirect drivers of change

Indirect drivers include demographic, economic, socio-political, cultural and behavioural, and technological changes. While a societal disconnect from nature is a factor, it is fundamentally reinforced by prevailing economic models and production systems that externalise environmental costs. This disconnect obscures our dependency on natural processes, driving unsustainable consumption patterns that accelerate biodiversity loss, climate change and pollution. The relevant evidence is included within the overall assessments of Aim 3 and Aim 4.

Assessment of the sustainable management of natural resources (SMNR) for each ecosystem

In SoNaRR 2025 we use four interlinked aims as a framework to assess Wales' progress towards SMNR. These aims focus on stocks of natural resources, ecosystem resilience, healthy places for people and a regenerative economy

The SMNR assessments use the evidence set out in the SoNaRR evidence portal. The evidence in the portal describes the pressures, state, trends of state and impacts on wellbeing, using evidence available at the ecosystem level. Where suitable evidence is not available, we have made that clear. A confidence assessment is provided for each description within the SoNaRR evidence portal.

Coastal margins ecosystem

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The coastal margins ecosystem consists of the habitats around the coastline of Wales. The three most extensive habitats are sand dunes, saltmarsh, and sea cliffs. Others are saline or coastal lagoons and shingle.

This coastal margins assessment is one of eight ecosystem and three natural resource assessments that inform the overall SoNaRR2025 report. It builds on the findings of SoNaRR2020, drawing together updated evidence from subject experts, national datasets, and collaborative projects such as *Sands of LIFE* and *Dynamic Dunescapes*. This assessment is closely linked to the marine and enclosed farmland ecosystem assessments.

The assessment is structured around four interlinked aims that guide Wales' progress toward the sustainable management of natural resources (SMNR), helping to communicate the relationship between the environment, well-being, and the economy

Key messages

1. Coastal habitats provide unique biodiversity and valuable services, including flood defence, blue carbon, recreation and health. These services could be developed as nature-based solutions for the people and economy of Wales through habitat restoration and enhancement.
2. Habitat loss and fragmentation, poor condition and loss of biodiversity are affecting coastal habitats. The main causes include non-sustainable agricultural management, invasive non-native species and air and water pollution.
3. Climate change will lead to increasing pressures including sea level rise and higher rates of erosion. Some habitats are naturally able to roll-back inland, responding to change, but in many cases the coastal habitats are hemmed in by other land use.
4. Recent work on sand dunes demonstrated successful landscape scale restoration of dune systems across Wales. We now need restoration programmes for saltmarsh and sea cliff habitats which will benefit biodiversity and increase resilience, carbon sequestration and natural flood alleviation.
5. Many pressures, including climate change and water quality, require a strategic and multi-faceted approach to improve ecosystem resilience. Key opportunities include coastal land use planning, tackling multiple sources of pollution and maximising outcomes for biodiversity from sustainable agricultural management of coastal habitats

Coastal Margins Summary SMNR Assessment

Aim 1: Stocks of natural resources are safeguarded and enhanced

Biodiversity in coastal margin ecosystems is declining, with several species now extinct in Wales, including the Oysterplant and Belted beauty moth. Many species are restricted to single localities or specific habitats, such as the Large mason bee and Foxtail stonewort. Others, like Shore dock and Fen orchid, are in unfavourable condition due to habitat degradation. Invasive Non-Native Species (INNS), pests, and diseases continue to impact native biodiversity. Despite eradication efforts under projects like Sands of LIFE, INNS remain widespread, with climate change likely to exacerbate these impacts. Meanwhile, diseases such as Myxomatosis, Rabbit Haemorrhagic Disease and Avian Influenza have caused population declines in rabbits (important for the maintenance of sand dune habitats) and seabirds.

Air, water, and soil pollution also threaten coastal margins. Nitrogen deposition exceeds safe levels in dunes, sea cliffs and saltmarsh, which can alter vegetation and reduce habitat quality. Water pollution from nutrients, contaminants, and marine litter persists, with saltmarshes and lagoons being particularly vulnerable. Historic landfill sites near the coast pose ongoing risks with rising sea levels. Soil pollution trends are deteriorating, and climate-related changes—like increased storminess and sea level rise—are expected to intensify these pressures. Projects such as Sands of LIFE, Dynamic Dunescapes, Connecting the Coast and Tir a Môr Llŷn have gone some way to restore habitats and improve species conditions, demonstrating positive steps toward safeguarding natural resources within the coastal margins ecosystem.

Aim 2: Ecosystems are resilient to expected and unforeseen change

Coastal margin ecosystems show medium resilience overall, but pressures are causing deterioration in diversity, extent, condition, and connectivity. Diversity is declining in sand dunes, saltmarshes, and sea cliffs due to over and under-grazing, stabilisation, and pollution. Coastal lagoons face species loss and community shifts. While some habitats benefit from active management, others lack sufficient intervention. Future resilience is uncertain, with climate change, tourism, and invasive species posing ongoing threats. The new Sustainable Farming Scheme may offer improvements, but confidence remains low.

Extent is generally stable but has deteriorated historically due to development, erosion, and historic afforestation. Sea level rise and coastal squeeze threaten future habitat loss, especially for saltmarshes and dunes. Condition is assessed as low across all habitats, with pollution, over grazing and under-grazing and vegetation succession contributing to poor condition. Connectivity is also low, with fragmentation from agriculture and development. Restoration projects have improved local connectivity, but future trends suggest further deterioration without sustained action. Projects like Sands of LIFE, Dynamic Dunescapes and Connecting the Coast have enhanced resilience through targeted habitat restoration and improved land management.

Aim 3: Healthy places for people, protected from environmental risk

Coastal margin ecosystems provide vital services that protect human health. Saltmarshes and dunes reduce flood risk and store carbon, helping mitigate climate change. Welsh saltmarshes sequester over 7,700 tonnes of carbon annually. These habitats also filter air pollutants, removing 850,000 kg in 2023, and purify water by absorbing nutrients and heavy metals. Pollination services from dunes and saltmarshes support crop production and biodiversity. Waste remediation and water purification further enhance environmental quality and reduce treatment costs.

These ecosystems also support health improvement through recreation and cultural services. Over 21 million visits were made to coastal margins in 2021/22, generating £70 million in health benefits. Projects like Sands of LIFE contribute £26 million annually to local economies and support hundreds of jobs. Coastal areas offer spiritual and educational value, with saltmarshes and sand dunes inspiring art and research. Despite socio-economic deprivation in some coastal towns, the physical environment remains a source of well-being. Initiatives like CoastSnap and shoreline adaptation planning are engaging communities and improving access to nature-based solutions.

Aim 4: Contributing to a Regenerative Economy, Achieving Sustainable Levels of Production and Consumption

Coastal margin ecosystems support economic resilience through natural flood protection, water purification, and high-value agricultural products. Saltmarshes protect 2,000 ha of farmland and reduce nutrient pollution. Grazing on saltmarshes and dunes produces premium meat, while rare livestock breeds and plant seeds contribute valuable genetic resources. Sustainable agriculture, when appropriately managed, enhances biodiversity and carbon sequestration. However, overgrazing and historic afforestation continue to degrade habitats, and future trends depend on effective implementation of schemes like the new Sustainable Farming Scheme.

Tourism and recreation offer economic opportunities but also pose pressures through trampling and littering. Coastal development and flood defence infrastructure contribute to habitat loss and fragmentation. Nature-based solutions, such as saltmarsh restoration, offer co-benefits for climate adaptation and ecosystem regeneration. Projects like Ffermio Bro and Pembrokeshire Heathland Beef demonstrate how collaborative farming can support biodiversity and community engagement. With 42 million recreational visits annually, sustainable tourism has the potential to fund ecosystem restoration and build resilience, if managed responsibly.

Key changes since SoNaRR2020

Since SoNaRR 2020, new evidence from vegetation mapping of shingle, selected sand dunes, and saltmarshes has improved our knowledge base supporting coastal habitat management. These new data are improving understanding of erosion and accretion dynamics and informing future management. A new report on coastal squeeze has modelled its extent around the Welsh coast, alongside additional reports examining climate change impacts on coastal habitats.

The Nature Networks Programme, launched in 2021, has delivered targeted habitat management on statutory sites, improving the condition and connectivity of protected areas and supporting more resilient ecological networks. Invasive Non-Native Species control has also been strengthened, particularly on sand dune sites, through the Sands of LIFE AfterLIFE project and Nature Networks funding. Despite these positive developments, nitrogen and ammonia deposition pressures remain critically high, posing an ongoing threat to coastal margin habitats. The Sustainable Farming Scheme, launching in 2026, offers a promising opportunity to bring more coastal habitats into positive management.

Coastal Margins Full Assessment of SMNR

Aim 1: Stocks of natural resources are safeguarded and enhanced

The natural resources, as defined in the Environment (Wales) Act 2016. Section 2, most relevant to Coastal margins are Animals, plants and other organisms; Air; Water; Soil; Climatic features and processes.

Animals, plants and other organisms

In the coastal margin ecosystems biodiversity is declining due to a reduction in species population numbers and their distribution along with extinction of some characteristic species.

Extinct species: Oysterplant (*Mertensia maritima*) is now lost from its last known location, a shingle site in north Wales (Jones *et al.*, 2011; Stroh *et al.*, 2020). Blunt bryum (*Bryum calophyllum*) and Broad-nerved hump-moss (*Meesia uliginosa*) are now lost from the last recorded location at Tywyn Aberffraw (Holyoak, 2015) and the Belted beauty moth (*Lycia zonaria*) (last seen on Morfa Conwy in 2012), the Crucifix ground beetle (*Panagaeus cruxmajor*) (Tywyn Burrows, 1998) and the Mud wasp (*Podalonia affinis*) (Gronant Dunes & Talacre Warren, 2012), are all now listed as extinct in Wales (Bosanquet *et al.*, 2025).

Restricted species: Strandline Beetle (*Eurynebria complanata*) is restricted in the UK to the Carmarthen Bay dune systems, having become extinct in Pembrokeshire in 2013 (Howe, 2016; Stewart, 2017, 2023). Declines of the lagoon specialist Spire snail (*Ecrobia ventrosa*) have been documented at Cemlyn between 2016 and 2021 (NRW, 2025b).

There are four invertebrate species in Wales which are restricted to soft cliff habitat: the Large mason bee (*Osmia xanthomelana*), known only from Porth Ceiriad and Porth Neigwl in the UK and with just 15 females recorded in 2024 (Dafis, 2023), the weevil *Sitona gemellatus*, the Crane-fly *Symplecta chosenensis* and the ground beetle *Tachys micros* (Bosanquet *et al.*, 2025). A total of 65 coastal and coastal cliff ecosystem species are restricted to a single Welsh locality including Foxtail stonewort (*Lamprothamnium papulosum*), Sea pea (*Lathyrus japonicus*), the spiders *Callilepis nocturna* and *Dipoena erythropus*, the weevil *Trachyphloeus heymesi* (at its only UK locality at South Stack) and the long-legged fly *Tachytrechus ripicola* (Bosanquet *et al.*, 2025). Dwarf Spike-rush *Eleocharis parvula* is restricted at a Wales level to Merionnydd in North-West Wales. South Stack fleawort *Tephroseris integrifolia subsp. maritima* is an endemic subspecies found only at South Stack (Anglesey). Yellow Whitlow-grass is restricted in the UK to sites in Wales on the Gower Peninsula (Bosanquet *et al.*, 2025). On the upper saltmarsh, a suite of plant species, including slender hare's-ear, *Bupleurum tenuissimum*, and sea barley, *Hordeum marinum,* rely on short swards and bare ground created by cattle poaching.

Unfavourable condition species: Shore dock (*Rumex rupestris*) populations are in unfavourable condition; the total Welsh population has decreased from 286 (2016-2017) to 158 (2024). Fen orchid (*Liparis loeselli*) populations remain in unfavourable condition across the three sand dune sites where it is found (Kenfig, Whiteford and Pendine). Petalwort (*Petalophyllum ralfsii*) is in an unfavourable condition in Wales due to a steady decline in its known localities from 17 in 1995 to 10 in 2024. These declines are combined with a reduction in individual numbers, currently there are only five sand dune sites which have stable or increasing populations (NRW, 2025n). Narrow mouthed snail (*Vertigo angustior*) is in unfavourable condition at three of its four Welsh sand dune localities including Oxwich Burrows and in Pembrey Forest (NRW, 2025m).

Historically, **Invasive Non-Native Species (INNS)** have negatively affected animals, plants and other organisms in coastal margin ecosystems. Over the short-term (2020 – 2025) there is a mixed picture, and this is expected to continue into the future. INNS outcompete or predate native species, affecting their abundance and diversity in Wales' coastal margin ecosystems (e.g. Sea buckthorn). Climate change may exacerbate pressures for INNS in coastal ecosystems (e.g. by creating more favourable habitats for species such as the Hottentot fig). Despite positive actions to eradicate INNS, there are many areas where INNS remain a significant pressure.

Historically, there is a mixed picture for **pests and diseases** affecting animals, plants and other organisms in coastal margin ecosystems. This has not changed over the short-term (2020 – 2025) and is likely to continue in the future (to 2030). Rabbits on sand dunes have historically been negatively affected by two diseases, Myxomatosis and Rabbit Haemorrhagic Disease (RHD). From 1997 onwards there has been a constant decline in the number of rabbits and these diseases are likely to remain present within rabbit populations occurring on sand dunes, meaning that sand dune management cannot rely solely on rabbit grazing to maintain habitat condition in the future. Avian influenza has severely impacted wildfowl and seabird populations across the globe over the last decade, attributed to a rise in poultry farming and thus increased disease transmission between wild birds and poultry (White et al., 2001). Wales has seen mass mortalities in seabird populations such as terns, gulls, auks and gannets. There have been significant mass mortality events in the UK outside of Wales (Griffin & Peach 2025). These have had an impact on Welsh bird populations. So far populations have been able to recover fully, however increased frequency and intensity of outbreaks, coupled with other climate stressors, may lead to long-term declines in wildfowl and sea birds, leading to potential changes in habitat.

Air

Historically, there is a mixed picture for air pollution affecting coastal margin ecosystems. This has not changed over the short-term (2020 – 2025) and is likely to continue in the future (to 2030). Air pollution from sulphur dioxide has decreased over the historic long-term, however, atmospheric nitrogen deposition (from industrial activities, agricultural practices, waste management and energy production) has posed a significant threat to coastal habitats, especially sand dune ecosystems and coastal heath, over the historic long-term and short-term. Impacts include increases in competitive grass species, accelerated succession leading to loss of pioneer, stress tolerant and open ground species (NRW, 2021a). Nitrogen deposition is currently exceeding the critical load range for coastal sand dunes in Wales (NRW, 2025i, 2025l) and over 90% of Sea cliffs exceed the critical load (NRW, 2025e) of the critical load range (NRW, 2025e) , and if this continues then air pollution will remain a pressure for coastal margins in the future. Saltmarsh and vegetated shingle communities are relatively tolerant of Nitrogen deposition compared to other coastal margins habitats.

Soil

Historically (until 2023), **soil (land) pollution** has had an unknown effect on coastal margin ecosystems. Over the historic short-term (2020 – 2025) there is a deterioration in land pollution. This is expected to continue in the future. 265 out of 1632 individual authorised and historic landfill sites across the whole of Wales are at the coast and have the potential to release waste directly into the marine environment, which will affect coastal margin ecosystems. The release of landfill waste could be further exacerbated by the effects of climate change, such as sea-level rise and increase in extreme weather events, in the future (Robbins *et al*. 2023).

Water

Historically (1980 – 2025), there is a mixed picture for **water pollution** in coastal margin ecosystems. This has not changed over the short-term (2020 to 2025) and is expected to cause a deteriorating trend in the future (2025 – 2035). Saltmarshes, coastal lagoons and sand dunes are all at risk of, and sensitive to, nutrients and chemical pollution present in marine and freshwater ecosystems.

There are excess levels of nutrients in transitional waters (particularly estuarine) as a result of point source or diffuse pollution mainly from agriculture. Of the coastal margin habitats, coastal lagoons and saltmarsh are situated within the marine environment and are therefore exposed to high levels of nutrients within some waterbodies. This is impacting on the condition of coastal lagoons. The impacts of raised nutrient levels on saltmarsh are not well understood, however there have been areas where opportunistic macroalgae has been recorded smothering the pioneer saltmarsh. Out of the 5 coastal lagoons within Special Areas of Conservation (SACs) in Wales 4 had failures for water quality due to elevated levels of dissolved inorganic nitrogen (DIN) (Cuthbertson *et al.*, 2025).

There has been a statistically significant decrease between 2015 and 2020 in the number of marine litter items found overall in the Celtic Seas Region (OSPAR, 2023). However, beach litter levels remain high in the UK, with plastic items dominating. Pollution from historic landfill sites is expected to continue to be an issue in the future, which could also cause water pollution in the marine environment and affect the coastal margin ecosystem (Robbins *et al.*, 2023).

Climatic features and processes

Historically (1990 – 2023), there has been a deteriorating trend for changes in intensity and frequency of weather events affecting coastal margins over the long-term. It is not possible to provide a short-term trend due to the long-term nature of storm modelling. A deteriorating trend is expected to continue in the future (2030 – 2050). Since the 1990s storms have increased in number in the UK, with the mean significant wave height reducing in the North of the UK and increasing in the South. Recent reductions in numbers of Fen Orchids may be attributable to long periods of winter flooding and summer droughts which are predicted to become more regular because of climate change (NRW, 2025o). All populations of narrow mouthed snails are at risk from summer droughts and rising sea levels as a result of climate change (NRW, 2025m). Dune slacks in England have experienced drying out due to changes in hydrological conditions which has reduced their extent, this may be affecting Welsh dune slacks also. Some projections suggest there will be an increase in frequency and intensity of storms over the next century, but natural variability could continue to dominate changes in the near future (Wolf, Woolf and Bricheno, 2020; Oaten et al., 2021). Changes in patterns of rainfall or temperature will affect vegetation composition of many coastal wetlands. Evapo-transpiration is likely to increase, leading to greater impact of summer droughts (Burden et al., 2020). The number of hectares of land at risk of coastal erosion is expected to increase over time in prediction to 2105.

Historically (1990 – 2020), there has been a deteriorating trend to changes in air temperature affecting coastal margins over the long-term. This has not changed over the short-term (2020 – 2025) and is expected to continue into the future (to 2100). The frequency of discrete periods of regional extreme air temperatures has increased over the last couple of decades and caused what are known as marine heatwaves (Tinker et al., 2020). The loss of Oyster plant, Mertensia maritima, which has a northern distribution, has disappeared from shingle in North Wales which has been attributed to a warming climate (Jones et al., 2011; Stroh et al., 2020). Climate models predict that the frequency of marine heatwaves and the maximum daily mean air temperatures around the coast will continue to increase. Saltmarshes in Wales have been assessed as highly vulnerable to projected changes in air temperature. Over 95% of the spatial extent of the saltmarsh was assessed as highly vulnerable to increasing air temperatures based on predicted air temperatures by 2049, under RCP8.5. (Oaten et al., 2021).

Historically (1960 – 2020), there has been a deteriorating trend to changes in water temperature affecting coastal margins over the long-term. This has not changed in the short-term (2020 – 2025) and is expected to continue into the future (to 2050). The coastal habitats affected are primarily saltmarsh, sand dune and coastal lagoons. In the case of dune slacks, they are vulnerable as increased temperatures can promote algal growth which can negatively affect their fauna (Burden et al., 2020). Data from the Irish Sea region shows a strong warming trend over the period 1960 to 2020 of 0.3°C per decade, with values since 2000 being consistently above the 1991–2020 average (Cornes et al., 2023). If decadal observations of water temperatures (Cornes et al., 2023) are consistent, sea surface temperature is likely to have increased by 0.05-0.15°C, over the five years between 2020 and 2025. In addition to this, 2022 was the warmest year for UK near-coastal sea surface temperature since 1870 (Kendon et al., 2023). This warming is expected to continue into the future, with saltmarsh and dune habitats being classed as having a medium sensitivity and vulnerability to increases in water temperature.

Historically (1900 – 2020), there has been a deteriorating trend to change in sea level rise affecting coastal margins over the long-term. This has not changed in the short-term (2019 – 2025) and is expected to continue into the future to 2080. Sea-level rise and increased erosion are the greatest risks to coastal habitats into the future. Sea-level rise results in deeper waters and bigger waves reaching coastal habitats and causing erosion at the seaward edge and can cause coastal squeeze (Burden et al., 2020). Where coastal habitats have space to roll-back this has the potential to be mitigated, however there are few places where this can naturally occur due to the presence of embankments resulting in coastal squeeze. Mean sea level around the UK has risen by about 12–16 cm since 1900 and evidence suggests that the rate of sea level rise in the UK is increasing (Kendon et al., 2021). Red hemp-nettle, Galeopsis angustifolia, has only two native populations in Wales. Baltic bryum (Bryum marratii), is one of Wales' rarest and most threatened mosses, (Callaghan and Farr, 2018). Both are under threat from sea level rise. It is predicted that by 2049 100% of saltmarsh within SACs around the Welsh coast will be highly vulnerable to sea level rise. along with 50% coastal lagoons in Pembrokeshire Marine SAC (Oaten et al., 2021). Sea level around Wales is projected to rise by around 1m by the end of the century. (Oaten et al., 2021). Saltmarsh is considered one of the most vulnerable habitats at risk from coastal squeeze however no significant changes in the extent of saltmarshes in Wales have been identified and attributed to sea level rise to date. At a national level, 21% to 25% loss is predicted by 2155 (depending on which sea level rise projection is used). Whilst the scale of absolute losses of dunes and vegetated shingle associated with coastal squeeze is predicted to be small, losses are fairly large relative to current habitat extents; up to 40% and 20% by 2155, respectively (Oaten, Finch and Frost, 2024).

Pressures from economic activity (see Aim 4 for more detail)

Pressures arising more directly from economic activity are also negatively affecting natural resources in coastal margin ecosystems (see Aim 4 for more details). These pressures are (in alphabetical order): access, sport and recreation, afforestation; agricultural intensification, built development and infrastructure, physical modifications and reduced land use or management intensity.

Access, sport or recreational activity associated with people visiting coastal margin ecosystems is affecting animals, plants and other organisms in some areas due to trampling by foot, cycling, horse riding, access by vehicles and littering (Saunders *et al.*, 2000; Provoost, Jones and Edmondson, 2011; Natural England, 2015; NRW, 2026)

Historic **afforestation**, particularly on sand dunes, has led to the reduction in diversity and abundance of animals, plants and other organisms in some areas (Muñoz-Reinoso, 2021). Most of these historically planted areas continue to be managed for timber production.

Agricultural intensification and **Reduced land use / management intensity**: Agriculture is an established practice in many coastal margin ecosystems, and is important in maintaining habitats, including cliff-tops, coastal grasslands and heathlands, saltmarsh and sand dunes. However, a careful balance on the intensity of this activity is needed. Over-grazing is negatively affecting the condition and diversity of animals, plants and other organisms in some areas.

Built development, infrastructure and physical modifications (e.g., for coastal flood protection and caravan parks) has led to loss and fragmentation of coastal margin ecosystems which will get more severe into the future as coastal squeeze increases with sea level rise and development continues. This also affects the habitat available for animals, plants and other organisms in some areas.

Progress to meeting Aim 1 (Stocks of natural resources are safeguarded and enhanced)

The key opportunities taken up since SoNaRR2020 comprise:

- The Sands of LIFE and Dynamic Dunescapes projects continued until 2024. These projects continue to provide benefit to the coastal margin ecosystems (sand dunes particularly). Habitat has been restored by creating dynamic conditions via mechanical means, removing scrub, tackling INNS, installing or enhancing grazing infrastructure, felling conifers and creating early successional habitat. The projects focus on restoring pioneer conditions benefits much of the specialist dune invertebrate fauna. These management works have yielded some positive results with sand dune slack specialist species such as dune slack beetles (Bembidion pallidipenne and Bledius subniger) responding positively. The works are also expected to increase abundance of specialist fauna such as Petalwort (Petalophyllum ralfsii) and Fen Orchid (Liparis loeselli).
- Rumney Great Wharf Polders project, funded through Nature Networks. The capital works were implemented in 2024 to restore saltmarsh along the Rumney Great Wharf by reinstating and extending the sedimentation polders.
- The ‘Tir a Môr Llŷn’ project lead by Partneriaeth Tir a Môr Llŷn’ (Partnership) trial 'Payment for Outcomes (PFO)' programme (2018-2022) with three coastal National

Trust farms on the Llŷn; prioritising restoration of coastal heathland grassland habitats. Improvements to habitat condition were recorded on all 3 farms as a result of PFO actions by the farmers.

- Connecting the Coast, a project run by Pembrokeshire Coast Park supported positive management of over 80ha of coastal slopes (Pembrokeshire Coast National Park, 2024).

Opportunities for Action Aim 1

The possible actions identified with respect to achieving Aim 1 in Coastal Margins relate to INNS and other species management, Pollution management, Species conservation and enhancement, and Sustainable agriculture, forestry and fisheries.

Action 1. Monitor and control INNS and diseases in affected areas

Action 2. Monitor and control pollution of coastal margin ecosystems with particular emphasis on water and land sources.

Action 3. Protect and boost native species populations by monitoring, protecting and restoring key habitats.

Action 4. Change land management practices so that they benefit coastal margin ecosystems.

Aim 2: Ecosystems are resilient to expected and unforeseen change

Ecosystem Resilience is assessed in SoNaRR using four ecosystem attributes as proxies. Diversity, extent, condition and connectivity are assessed for each of the five habitat types that make up the coastal margin ecosystems. The five habitat types are sand dune, saltmarsh, shingle, sea cliff and coastal lagoons. There is a large variation in data availability across each of the habitats making up the coastal margin habitats broad ecosystem. Many data gaps remain.

Diversity

The overall assessment of coastal margins diversity is ‘Medium’. There is high or moderate diversity for most ecosystem types, however there are declines in diversity due to ongoing pressures. Saltmarsh and coastal lagoons have generally low-medium natural species diversity due to the saline conditions, however both include salt tolerant species that are restricted to their specific habitat (Cuthbertson *et al.*, 2025; Sherry and Douglas, In Preparation). Sand dunes have a high natural diversity of types which has suffered declines. Sea cliff diversity remains high overall and supports the range of habitats expected, but there are declines in diversity for some areas. Shingle ecosystems have moderate diversity which are largely maintained but vulnerable to loss.

The historic trend in saltmarsh, sea cliff, shingle and sand dune diversity is deterioration. Two of the primary pressures on saltmarshes are over- and under-grazing, both impact diversity across significant areas of marsh and are ongoing issues. Losses to diversity have been documented for vegetated shingle in Wales (Jones *et al.*, 2011; Stroh *et al.*, 2020). Studies show there has been a clear trend towards increasing sand dune stabilisation that has likely resulted in the loss of diversity (Rhind *et al.*, 2001; Rhind, Stevens and Sanderson, 2006; Rhind and Jones, 2009; Rhind, Jones and Jones, 2013).Under-grazing is also a pressure on sea cliffs resulting in diversity decline as agricultural abandonment is leading to replacement of species rich coastal grassland and coastal heathland with the spread of scrub. In the historic short-term however, the trend for sea cliff diversity is a 'mixed picture' due to positive management and localised but significant improvements. Coastal Lagoons have suffered significant declines in individual species abundance and changes in community composition, for example at Cemlyn lagoon there has been a shift driven by a decline in the Spire snail (*Ecrobia ventrosa*), a lagoon specialist, and increases in more opportunistic species.

The future outlook for coastal margin diversity is a mixed picture. For sand dunes, where long-term management on sites is secured, the outlook is positive, however, for sites which have little to no management, ongoing pressures will have a more negative outlook on diversity. For shingle, nitrogen deposition is unlikely to be a limiting factor for this habitat which currently has no agreed Critical Load, however, ongoing pressures affecting diversity such as pressures from sports, tourism and leisure activities, problematic native and non-native species and the effects climate change are likely to lead to a negative future outlook. For saltmarsh, there are ongoing positive management actions being carried out within protected saltmarsh sites, these are relatively localised. The Sustainable Farming Scheme will shortly be phased in which has the potential make a positive difference to condition. Therefore, long-term future trend has the potential to improve, but this is of low confidence. For coastal lagoons, active management will be required to protect them from impacts negatively affecting diversity, such as water quality and water depth in the future.

Extent

The overall assessment of coastal margins extent is 'Medium'. The current extent has remained generally stable across the habitat types. Total sand dune extent is 7919.43 hectares in 2025, although there have been some climate related losses (NRW, 2026). Saltmarsh change maps show minor increases in the saltmarsh in some places however, confidence in overall change in extent, taking into account patterns of erosion and accretion, is low. The total area of vegetated shingle Annex 1 habitat is 52.91 hectares in 2025. The extent of shingle is generally stable despite some losses due to sediment starvation. Successful restoration projects have made significant improvements to sea cliff habitat however; in other areas there are continuing losses of cliff top vegetation (NRW, 2025g). The assessment for extent of coastal lagoons is 'Low', Wales' resources cover 84 hectares, 1.6% of the UK lagoon resource (Cuthbertson et al., 2025).

The long-term historic trend in coastal margins extent is deterioration. Large scale losses of extent have occurred in three coastal margin ecosystems. For shingle, this is due to shoreline structures constraining physical processes. For sea cliffs, this is due to both agricultural intensification and abandonment. For sand dune, approximately 30% of their original area in Wales has been lost to development and erosion since 1900 (Pye, Blott and Guthrie, 2017). In Wales, conifer plantations occupy around 1,700 hectares of dune habitat (approximately 20%), notably impacting the conservation status of these dunes. This represents a significant loss of habitat (afforestation occurring between 1929 and 1965). The long-term historic trend in saltmarsh ecosystems extent is a mixed picture.Many saltmarshes have been altered to a greater or lesser extent due to land claim, changes to hydrological flows and sedimentary processes. However, new evidence shows that over the last 150 years, marshes in northern Britain expanded due to sediment inputs, while most southern marshes have eroded (Ladd *et al.*, 2019). The long-term historic trend for coastal lagoons extent is stable, for the three coastal lagoons (Cemlyn Lagoon, Morfa Gwyllt Lagoon, Pickleridge lagoon) in Wales which are notified SAC features due to small scale change (Cuthbertson *et al.*, 2025).

The short-term historic trend (2013 – 2024) in coastal margins extent is a mixed picture. For saltmarsh, any losses due to sea level rise have been offset by gains due to expansion within infilling estuaries. However, there is a lack of evidence to confirm this. For sand dunes, losses to erosion in some locations are being balanced with increases due to accretion in others. There have been some small-scale reductions in conifer cover on sand dunes through restoration projects (e.g. Sands for life) in an effort to restore the underlying sand dune habitat. For sea cliffs, there is ongoing positive management however losses continue, due to abandonment, agricultural intensification and other pressures. For shingle, there is little to no contemporary information on short-term trends of extent. (Heathcote, Finch, Carter, *et al.*, 2022; Heathcote, Finch, Lamacraft, *et al.*, 2022) will allow future losses or gains to be mapped. For coastal lagoons, there has been some deterioration over the short terms with losses of 0.19% of Welsh coastal lagoon resource (Cuthbertson *et al.*, 2025).

The future outlook (2024 onwards) for coastal margin extent is for deterioration to continue. Mean sea-level rise, coastal squeeze and changes in sediment supply are contributing to a decline in the extent of sand dunes, saltmarshes and shingle beaches (Haigh *et al.*, 2022). For sand dunes, there is also currently no plans for any significant further restoration of historically afforested sand dune habitat. The future outlook for sea cliff extent is a mixed picture. Coastal squeeze is a known pressure and threat to Marine Protected Areas (MPAs) and is causing (or likely to cause) the deterioration or loss of coastal and intertidal features around the coast of Wales (Oaten, Finch and Frost, 2024). Projected sea level rise figures suggest an 8% loss of UK sand dune area by 2080. Saltmarsh has been highlighted as the most vulnerable habitat to sea level rise as a result of coastal squeeze (Oaten, Finch and Frost, 2024) and the likelihood is that the pressures of climate change will become more apparent in the future. The overall extent of coastal lagoons is likely to decline over the long-term due to slow retreat of barriers (Green and Lindenbaum, 2019). There is also potential for catastrophic loss due to breaches of barriers (MCCIP, 2018).

Condition

The overall assessment of coastal margins condition is 'Low'. All of the sand dune sub-types are classed as being in unfavourable condition (NRW, 2025g, 2025h, 2025i, 2025j, 2025k, 2025l). 61% of Atlantic salt meadows, a saltmarsh sub-type, within Wales are assessed as being in an unfavourable condition (NRW, 2025f). Approximately 51% of shingle ecosystems are in good condition (NRW, 2025c, 2025d). Condition of lagoons is unfavourable for all lagoons, loss of diversity or apparent recent loss of lagoon specialist species being a causal factor (NRW, 2025b). Sea cliff habitats were assessed for SoNaRR 2020 as 'Low', and there is no new condition monitoring information relating to sea cliff habitats since.

The long-term historic trend in coastal margins condition is deterioration. For sand dunes, declining condition is mostly attributable to increased vegetation cover and over-stabilisation because of agricultural abandonment, crashes in rabbit populations, air pollution, scrub encroachment, and a lack of dynamic condition (Rhind, Stevens and Sanderson, 2006; Rhind and Jones, 2009; Rhind, Jones and Jones, 2013). For shingle ecosystems, shoreline structures are disrupting coastal processes and causing sediment starvation in places. Local damage occurs from trampling and parking. Condition of sea cliffs have been negatively affected by pressures such as over- and under-grazing pressures and air pollution. Over-grazing and under-grazing are impacting saltmarshes and ongoing issues with water quality are affecting condition. Coastal lagoons have numerous pressures which have caused deterioration in condition, water quality in particular is a widespread issue causing lagoons to fail condition assessments due to issues like high levels of dissolved inorganic nitrogen.

The short-term historic trend (2013 – 2024) and future outlook (2024 onwards) for sand dune, sea cliff and saltmarsh condition is a mixed picture. For sand dunes, where long-term management on sites is secured the outlook is positive, however, for sites which have little to no management, ongoing pressures affecting condition such as under-grazing, pressures from sports, tourism and leisure activities, problematic native and non-native species and the effects of pollution will have a more negative outlook(Heathcote, 2024c, 2024c, 2024b, 2024a; Heathcote, Gillis, Wallis and Tomas, 2024; Heathcote, Gillis, Wallis and Williams, 2024). For sea cliffs, there have been several successful restoration projects and with funding these could continue to improve the condition of sea cliffs. However significant barriers are present which are preventing cliff top habitats from 'rolling back' in response to erosion due to the presence of intensive agriculture and to a lesser extent development (NRW, 2025e). Air pollution is likely to remain high into the near future which could affect the condition of both ecosystems. Abandonment of grazing on traditionally grazed saltmarsh is increasing, and a significant area of saltmarsh is suffering from overgrazing causing poor condition in the form of a uniform sward structure, low species diversity, plants being unable to flower and set seed and areas of bare ground due to livestock poaching and erosion of creek sides. Water quality issues are impacting the condition of saltmarsh (Lewis, 2025).

The future outlook (2024 onwards) for the condition of shingle and coastal lagoons is for deterioration to continue. For shingle, very little is known about the current status of these habitats in Wales, but what is known, is that the range and area of the habitat is likely to be affected by shoreline structures and sea level rise. Water quality issues continue to cause deterioration for coastal lagoons in the historic short term and Due to the vulnerability of lagoons to climate change, ongoing nutrient issues and presence of litter in lagoons without current measures to mitigate impacts, this is expected to continue into the future.

Connectivity

Much of the evidence available for coastal margin ecosystem connectivity is linked to extent.

The overall assessment of coastal margins connectivity is 'Low'. Saltmarsh and sea cliff ecosystems have both lost connectivity due to a number of pressures leading to poor connectivity in many places. Sand dune and shingle has some loss of connectivity between sites, although they are both generally a clustered resource. Coastal lagoons are a limited habitat resource and are in relative isolation from each other naturally.

The long-term historic trend in coastal margins connectivity is deterioration. The short-term historic trend (2013 – 2024) in coastal margins connectivity is a mixed picture. For saltmarsh, connectivity is poor due to historic land claim for agriculture and development means that flood defences often truncate the full zonation of saltmarsh, cutting off the natural transitional margins. 55% of the coastline habitat length in Wales is constrained, which equates to 255km (Fairley, 2025), the remainder is relatively well connected... Habitat loss of sea cliffs due to more intensive agriculture, residential and tourism developments has led to the narrowing and fragmentation of the band coastal habitats along the clifftops. In the short term the rate of change is less but still present. Restoration projects have increased connectivity of sand dune habitats in the historic short term. Restoration projects have increased connectivity of sand dune habitats in the historic short term.

The future outlook (2024 onwards) for coastal margin connectivity is for deterioration to continue. Coastal habitats, including shingle, are particularly vulnerable to sea level rise and changes to wave climate which can impact connectivity. Cliff top habitats are vulnerable to fragmentation as in many areas they are confined to a narrow strip along the coast. At many locations there is cliff erosion and loss of connectivity can occur where habitat is unable to 'roll-back'. However, there are on-going efforts to improve connectivity, which have made improvements to cliff top habitats. Erosion, sea level rise, increased storminess and atmospheric nitrogen deposition all have the potential to have a negative effect on the future connectivity of sand dune habitat. The threat of coastal squeeze to coastal margin ecosystems, particularly salt marshes, will also impact connectivity.

Progress towards meeting Aim 2 (Ecosystems are Resilient to Expected and Unforeseen Change)

The key opportunities taken up since SoNaRR2020 comprise:

- The Sands of LIFE and Dynamic Dunescapes projects continued until 2024. These projects continue to provide benefit to the coastal margin ecosystems (sand dunes particularly). Habitat has been restored by creating dynamic conditions via mechanical means, removing scrub, tackling INNS, installing or enhancing grazing infrastructure, felling conifers and creating early successional habitat. 22ha of conifers were felled and there was 35ha of conifer stump and brash removal at Whiteford, Morfa Harlech and Newborough (which included already dead and dying trees (affected by coastal exposure) totalling 5.8ha at Newborough).
- Rumney Great Wharf Polders project, funded through Nature Networks. The capital works were implemented in 2024. This project could help to restore up to 5 Ha of saltmarsh in the Severn Estuary, that has previously been eroded.
- The ‘Tir a Môr Llŷn’ project undertook and delivered a programme of land management interventions to improve the connectivity and resilience of the coastal strip on Pen Llŷn. This included changes in grazing regimes to enable plants to flower and set seed and introducing fencing and a water supply to enable cattle to graze the coastal slope.
- Pembrokeshire Coastal Park's 'Connecting the Coast' project funded by the Nature Networks was a land management scheme which offers funding for the creation and maintenance of wildlife habitats along Pembrokeshire’s coastline. The project provides payments for capital works for management of coastal grasslands and heathlands but also includes other habitats such as neutral grasslands in the vicinity of the coast.
- A project on the Gower Peninsula (funded by Nature Networks) focused on getting sea cliff and saltmarsh into good condition has included delivery of INNS removal on areas of sea cliffs and delivery of capital works to allow controlled grazing on sea cliffs and saltmarsh.
- A Nature Networks project is starting up within the Burry Inlet. It aims to improve water quality and improve saltmarsh condition.

Opportunities for Action Aim 2

The possible actions identified with respect to achieving Aim 2 in coastal margin ecosystems and opportunities to Ecosystem creation, Ecosystem protection, Ecosystem restoration, INNS and other species management, Integrated plans, strategies and delivery, Nature based Solutions, Pollution management, Species conservation and enhancement, and Sustainable agriculture forestry and fisheries.

Action 5. INNS removal to support diversity and condition.

Action 6. Changes in land management to support correct grazing levels and improve diversity and condition.

Action 7. Increase extent and/or improve condition of sand dune, saltmarsh, sea cliff habitats.

Action 8. Improve connectivity of coastal margins habitat.

Action 9. Improve and support coastal margin ecosystems species conservation.

Action 10. Improve air and water quality

Aim 3: Healthy places for people, protected from environmental risk

Health Protection

Coastal margin ecosystems contribute to human health protection through the supply of the following regulating services:

- **Global climate regulation services** contribute to reducing greenhouse gas concentrations and mitigating climate change impacts on people. Coastal margins habitats hold significant stocks of carbon relative to their extent. Saltmarshes are of importance and saltmarsh carbon sequestration should be recognised alongside woodlands for the carbon sequestration service provided.
    - Welsh saltmarshes hold up to 50 tonnes of Carbon per hectare in the top 10 cm of soil (Ford *et al.*, 2019). Saltmarshes in Wales accumulate 7,726 ± 977 t of organic carbon each year (Smeaton *et al.*, 2024).
    - The total contribution of Welsh SAC coastal margin habitats to carbon storage was estimated to account for almost 10% of the total carbon storage across all habitats in the Welsh National Marine Plan area.
    - The carbon stocks of features such as saltmarsh are vulnerable to climate change, mainly due to projected rises in sea level (Oaten, Finch and Frost, 2024).
- **Coastal protection and storm mitigation services** reduce the risk of flooding and damage to households in coastal areas, including during storm events. Saltmarshes, shingle beach systems and sand dunes protect against waves, storm surges, and coastal erosion.
    - Saltmarshes and beach systems attenuate waves. As Sand dunes can act as a physical barrier to prevent flooding (Mehrtens *et al.*, 2023), Narayan *et al.* (2016) found that saltmarshes were one of the most effective habitats in terms of wave reduction, on average reducing wave heights by 72% (95% CI 62-79%).
    - New models show the importance of saltmarshes in Wales on estuary hydrodynamics and flood mitigation (Bennett *et al.*, 2023).
    - A recent study by Rendón et al., (2022) found that there is a willingness amongst residents in Wales to pay for coastal flood protection, especially through nature-based solutions, including expanding saltmarsh area and increasing saltmarsh with high vegetation, compared to traditional defence structures.
- Air filtration services contribute to reducing concentrations of air pollutants and lessening the damage to people’s health. Around 850,000 kilograms of air pollutants were removed by Wales’ Coastal Margins vegetation in 2023 compared with 880,000 in 2007. In 2023, the benefit realised prevented 16 life years lost from long-term exposure

to particulates (PM2.5 and PM10) and 2 life years lost from long-term exposure to NO2. In 2023 the avoided burden on mortality is estimated at 1 fewer death from short-term exposure to Ozone (Office for National Statistics, 2024).

- Waste remediation services provide reduced costs of waste disposal to people by providing an alternative method. Saltmarshes can significantly reduce faecal organism concentrations and absorb heavy metals such as mercury, cadmium and uranium from the water, thereby improving water quality (Hudson, Kenworthy and Best, 2021). Waste remediation services are facilitated by enhanced sediment accumulation by saltmarsh plants (Lloret et al., 2021).
- Water purification services contribute to decreasing pollutants in water which leads to cleaner water for consumption and for recreational use. Sand dune and shingle habitats play a role in purifying groundwater through filtration, saltmarsh habitats purify surface flow and can help to reduce high nutrient levels (Hudson, Kenworthy and Best, 2021)..
- Pollination services increase the fertilisation and production of household crops and flowers. Coastal margin ecosystems provide habitats for pollinator species, particularly sand dunes and saltmarshes. Sand dunes are hot-spots for pollinator species, particularly Hymenoptera which utilise the sandy substrate for nesting locations (Fantinato, 2019). A study of south Wales saltmarshes showed that ungrazed and lightly grazed saltmarshes can support high abundance of honey bees and bumblebees via two key food plants: sea aster Tripolium pannonicum and sea lavender Limonium spp. (Davidson et al., 2020).

Health Improvement

Coastal margin ecosystems contribute to human health improvement through the supply of the following cultural services:

- **Recreation-related services** provide opportunities for people to enjoy in-situ interactions with nature and associated physical and mental health benefits.
    - In 2021/2022, the People and Nature Survey for Wales indicated that people in Wales made 21,922,081 visits to coastal margin ecosystems for recreation. Overall 41,849,672 visits are estimated to have been made to coastal margin and marine ecosystems by people in Wales in the 2021/2022 financial year(Owen, Rhydderch and Williams, 2025) .
    - In 2022, 200,000 people in Wales gained health benefits from recreation in coastal and marine ecosystems, these health benefits were valued at £70 million(Office for National Statistics, 2023, 2024). The value of outdoor activities across Wales, including in coastal ecosystems, to mental health has been estimated at £26.5 million per annum (Pembrokeshire Coastal Forum, 2024).
    - 1.16 million people visit the sand dune sites within the Sands of LIFE project per annum with perceived benefits to wellbeing arising from a visit to a Sands of LIFE site being £5.3 million (Seville et al., 2021).

Cultural Well-being

Coastal margin ecosystems contribute to people's cultural well-being through the supply of the following cultural services:

- **Spiritual, artistic and symbolic services** are provided by coastal ecosystems as a source of inspiration for expression (e.g. though art) leading to well-being benefits and enjoyment. Some recent studies have explored people's perceptions, values and attachments to the coast:
    - According to the Ocean Literacy in Wales report (2022) 63% of respondents felt saltmarshes were an underappreciated habitat.
    - Thomas *et al.*(2022) explored the perceptions of people to saltmarshes in two case studies in Wales. They note how change is inherent not only in the physical nature of saltmarshes but also in peoples' relationship with them and the ways in which they are valued, as values may gain or lose prominence as the saltmarshes themselves change under different pressures.
- **Education scientific and research services** provide intellectual development, advancement of knowledge and understanding for people from interactions with coastal ecosystems. Several UK universities and schools use Welsh coastal habitats either in teaching and / or research. 64 peer reviewed papers were published between 2020 and 2024 in the UK for sand dunes and saltmarshes (Data derived from Web of Science searches). Educational activities on the coast are common for members of the public, schools, and universities. However, there remains more potential 'for coastal place-based learning and fun based sea programmes for both well-being and positive environmental behaviour' (Kelly, 2018).

Equitable access

Acott et al., (2023) highlight the strong relational values and personal connections held by people towards their local coastal environments through case studies along the UK coast (not in Wales). Using a Community Voice Method, they found that despite levels of relative deprivation in the case study locations, interviewees expressed strong relational values and connections to the coast despite material changes and transformations in people's lives and the places they live, which they argued should be reflected more in coastal management.

For instance, the WIMD (Welsh Index of Multiple Deprivation) 2019, reveals the North Wales coastal town of Rhyl as containing the two most overall deprived small areas in Wales (Rhyl West 2 (the area around Rhyl High Street) and Rhyl West 1 in Denbighshire) (Welsh Government, 2019a). However, these areas show a lower level of deprivation in the physical environment domain compared to the other factors used to determine overall deprivation. This suggests that the deprivation experienced in these coastal areas is not due to their physical environment, which aligns with Acott et al.'s 2023 study (Acott et al., 2023).

Progress towards meeting Aim 3 (Healthy Places for people, protected from environmental risk)

The key opportunities taken up since SoNaRR2020 comprise:

- Rumney Great Wharf Polders project, funded through Nature Networks. The capital works were implemented in 2024 and will restore saltmarsh as well as providing some flood risk and potentially carbon sequestration benefits.
- Improved access to information on coastal erosion and flooding risk and Shoreline Management Plan policies (NRW, 2024).
- Further development of the Memorandum of Understanding with Network Rail who have substantial coastal assets. It is hoped that closer working will aid consideration of adaptive approaches in line with Shoreline Management Plan policies.
- Engagement with communities is ongoing at specific locations through NRW's Coastal Adaptation Programme and via Local Authorities where they manage structures facing change.
- Development of a webpage to provide coastal managers with information on options for nature-based solutions at the coast (NRW, 2025a).
- Collaboration with Wales Coastal Monitoring Centre and Local Authorities to implement CoastSnap, a citizen science project to enable coastal visitors to contribute photographs to record coastal change. The project aims to engage coastal users in understanding coastal change as well as contributing data (Wales Coastal Monitoring Centre, 2024).
- Working with Local Authorities to consider the pressures on coastal access as a result of climate change, increasing erosion and flooding risks, and management policy in Shoreline Management Plans. This has increased awareness of the need to forward plan for provision of the Wales Coast Path and Public Rights of Way to maintain good access into the future.

Opportunities for Action Aim 3

The possible actions identified with respect to achieving Aim 3 in coastal margin ecosystems relate to Access to nature; Integrated plans, strategies and delivery; Nature based solutions, and Payment for ecosystem services.

Action 11. Protect and restore coastal margins habitats to increase carbon sequestration and reduce coastal flooding.

Action 12. Community engagement through consultation.

Action 13. Implementing strategies to ensure physical access to coastal margins habitats is maintained.

Action 14. Collaboration with stakeholders on coastal margins plans and programmes.

Aim 4: Contributing to a Regenerative Economy, Achieving Sustainable Levels of Production and Consumption

Coastal margin ecosystems contribute to economic well-being through the supply of the following regulating services:

- **Coastal protection services:** Coastal habitats and ecosystems can provide natural flood management services to reduce the impact of flooding on various economic activities (e.g., transport, agricultural and other productive land and wider infrastructure). The ONS Saltmarsh flood mitigation in England and Wales, natural capital: 2022 estimate that around 2,000ha of agricultural land (arable, horticultural and grasslands) in Wales benefits from coastal protection services supplied by saltmarshes alone (Office for National Statistics, 2022). The estimated value of flood mitigation by saltmarsh in 2019 was £9 million in Wales (Office for National Statistics, 2022). Sand dunes also provide a vital function for coastal protection where the foredunes provide an initial buffer against storm surges and reduce the height of waves, whilst the taller shifting dunes provide a coastal defence barrier sheltering the hinterland from storm surges (Mehrtens *et al.*, 2023).

- **Water purification / waste remediation services** (water quality regulation) - Reduced water treatment costs for water utility and industries to responsibly discharge waste waters and run-off. The supply of these services is dependent on context. For instance, when occupying areas within sheltered water bodies, such as within estuaries, coastal embayment's or back barrier settings, saltmarshes can play a particularly important role in regulating water quality. For example, they can reduce high nutrient levels as the ecosystem takes up inorganic nutrients such as phosphates and nitrates (Hudson, Kenworthy and Best, 2021). Saltmarshes can also significantly reduce faecal organism concentrations and absorb heavy metals such as mercury, cadmium and uranium from the water, thereby improving water quality (Hudson, Kenworthy and Best, 2021).

Coastal margin ecosystems contribute to economic well-being through the supply of the following provisioning services:

- **Grazed biomass provisioning:** Livestock grazing is carried out, primarily on saltmarsh, cliff top habitat and sand dune. Saltmarsh can provide productive, valuable grazing including the production of ‘saltmarsh lamb’, a premium product for Wales (SoNaRR 2020). Livestock grazing has long been one of the most common uses of coastal saltmarshes globally (Gedan, Silliman and Bertness, 2009; Barr and Bell, 2017; Davidson *et al.*, 2017; Muenzel and Martino, 2018; McKinley *et al.*, 2022), with saltmarsh reared livestock regularly achieving higher than average market price for their meat (Gedan, Silliman and Bertness, 2009; Jones *et al.*, 2013).

- **Genetic material services:** Rare and traditional livestock breeds are sometimes used on coastal agricultural grazing land as they are well suited to the conditions (e.g. Hebridean sheep and Welsh Black cattle, Belted Galloway cattle at Newborough). Maintenance of such flocks / herds helps to preserve the genetic resource of these breeds and may also provide valuable genetic material for future commercial livestock breeding programmes (Hewitt, 2024). Genetic material, in the form of seeds, is also periodically harvested from coastal margin habitats for the purposes of reintroducing or boosting populations of rare species or plant communities at other locations on the same or different sites (Hewitt, 2024). These important genetic resources may also support commercial opportunities in the future.

Coastal margin ecosystems contribute to economic well-being through the supply of the following cultural services:

- **Recreation-related services** - The People and nature survey for Wales indicated that people in Wales made 21,922,081 visits to coastal margin ecosystems for recreation (overall 41,849,672 visits are estimated to have been made to coastal margin and marine ecosystems combined by people in Wales in the 2021/2022 financial year). ONS natural capital accounts (2024) contain figures for the numbers values for recreation and tourism expenditure derived from recreation in Wales at coastal margins (£120 million in 2022).1.16 million people visit the sand dune sites within the Sands of LIFE project per annum with perceived benefits to wellbeing arising from a visit to a Sands of LIFE site being £5,323,009 (Seville *et al.*, 2021).

  Events such as sporting events, local group meetings, training and educational events, hosted at Newborough generate approximately £30,000 of revenue for the local economy annually, while those at Kenfig contribute around £23,000. For these two sites alone the combined, value is £66,000. This revenue is in addition to the income from recreational visitor spending, which refers to the money spent by visitors on recreational day visits to the sites, as opposed to organized events (Seville *et al.*, 2021) . In total the Sands of LIFE project sites generate £26.06 million of local income per annum (Seville et al., 2021). A total of 559.95 person-years of employment was generated per annum across all sites in the Sands of LIFE project (Seville *et al.*, 2021).

Economic drivers and their pressures on coastal margins

The key direct economic drivers within Wales directly related to the degradation of coastal margin ecosystems relate to ‘Land and sea use change’. It is highlighted that intensive use of coastal margin ecosystems for recreation and agriculture are treated as pressures related to the ‘Land and sea use change driver.’ Climate change pressures are considered to be driven by global economic activity, and the specific economic drivers of pollution pressures are assessed via the relevant natural resource assessments.

Land and sea use and management change

Agricultural intensification can lead to habitat loss, fragmentation and declines in biodiversity. At the same time, appropriate levels of gazing are often needed to maintain ecosystem condition (NRW, 2021b). The long-term (2000 to 2024) and short-term (2020 to 2025) trends indicate grazing levels have intensified on cliff top grasslands and heathlands in some locations. Application of fertilizer directly applied or through run off will lead to loss and change in habitat type from unimproved grasslands to semi-improved and improved grasslands (NRW, 2025e). High levels of grazing on saltmarshes is also affecting the condition and diversity of these coastal margin habitats (Sherry and Douglas, In Preparation). The future outlook (2025 to 2035) for this pressure is mixed; there is potential that the sustainable farming scheme will help address these pressures (and their trends) on coastal ecosystems.

Built development and infrastructure, including those associated with leisure and tourism have historically led to loss and fragmentation of coastal margin ecosystems and also created barriers for habitats to roll-back in to as coastlines erode. It is estimated that approximately 30% of sand dunes in Wales have been lost to development and erosion since 1900 (Pye, Blott and Guthrie, 2017). There is limited evidence and quantitative data on the long and short-term trends in this pressure. However, aerial imagery identifies substantial urban areas, caravans / holiday parks along Wales coastline. The future outlook (from 2025) is mixed, with planned increase for offshore renewable energy infrastructure such as cabling where it makes landfall, the requirement for upgraded flood defences due to sea level rise and for tourism are likely to increase.

The long-term trend (1929 to 2025) for **afforestation** pressures on coastal ecosystems is mixed. Dunes with conifer plantations have a reduction in biodiversity (Muñoz-Reinoso, 2021), reduced mobility and are less likely to keep pace with climate change (increased storminess, erosion and sea-level rise) (Choi, Kim and Jung, 2013; Kim, Kong and Choi, 2021; Reeves *et al.*, 2022). Historically planted sand dunes in Newborough and Pembrey continue to be managed and replanted for commercial timber crops, although some areas have been restored here and elsewhere via projects such as Sands for LIFE. The future outlook for this pressure (from 2030 to 2050) is mixed, with no substantial changes in current forest management plans anticipated.

Many coastal vegetation communities are dependent on appropriate grazing levels to maintain good condition. **Reduced grazing or abandonment**, of historically grazed coastal habitats can lead to dense, coarse vegetation building up or the development of scrub which out competes other plant species and affects ecosystem condition. The long-term trend is of increasing abandonment of grazing on cliff tops, leading to increased cover of scrub, bracken and bramble (NRW, 2021). Reduced grazing on sand dunes is also leading to accelerated succession, affecting several specialist species (Howe, Knight and Clee, 2010; Provoost, Jones and Edmondson, 2011; Pye, Blott and Howe, 2014; Pye and Blott, 2017; Van der Biest *et al.*, 2017). The short-term trend (2020 to 2025) is more positive, via management agreements to get the right grazing regimes delivering localised improvements in the condition of coastal margin ecosystems (NRW, 2021b). The future outlook for this pressure (from 2025 to 2035) is mixed, again the sustainable farming scheme could play a part in addressing this pressure.

Physical modifications for coastal protection, such as groynes, offshore breakwaters, sea walls and other coastal defence structures effect coastal processes through changes to sediment transport and supply (NRW, 2025g). The short-term trend (2020-2025) reveals this pressure is increasing, as coastal defences continue to be built and upgraded. Several schemes have been brought forward in response to damage from winter storms (e.g., Prestatyn, Rhyl, Kinmel Bay, Llandudno, Hirael Bangor, Barmouth, Aberaeron, Mumbles and Cardiff and ongoing works at Aberaeron and Mumbles) (Welsh Government, 2023)). Whilst important for protecting people and property, they result in coastal squeeze and loss of habitats such as saltmarsh (Oaten, Finch and Frost, 2024). Given projected climate change impacts, the future outlook (to 2100) is for this pressure on coastal margin ecosystems to increase (Oaten, Finch and Frost, 2024).

Access, sport or recreational activity, important to the tourism and leisure sector, are a substantial pressure on coastal ecosystems due to trampling by foot, cycling, horse riding, access by vehicles and littering (Gómez-Pina *et al.*, 2002; Natural England, 2015; NRW, 2026). The short-term trend (2014 to 2023) has been an increase in this pressure, reflecting a significant growth and change in profile in the outdoor activity tourism in Wales since 2014 (Miller *et al.*, 2023). In 2021/2022, the People and nature survey for Wales indicated that people in Wales made 21,922,081 visits to coastal margin ecosystems for recreation (Owen, Rhydderch and Williams, 2025). The number of outdoor recreation visits to coastal and marine ecosystems has risen from 56 million in 2019 to 39 million in 2022 (Office for National Statistics, 2024). The future outlook (2025 to 2050) for this pressure is mixed, whilst increasing levels of recreational activity are expected in coastal margin ecosystems, it is important that these are mitigated by management and public communication interventions.

Contributions of coastal margins to sustainable economic production and consumption

The Welsh National Marine Plan highlights the role that the tourism and recreation sector can play in contributing to sustainable development by protecting and promoting access to the coast and improving the quality of the visitor experience (Welsh Government, 2019b). The high-level panel for a sustainable ocean economy, also highlights that coastal and marine tourism is highly dependent on the quality of coastal and marine ecosystems (Northop, 2022, p. 5). In their report, the High-Level Panel recognise the need to manage pressures, such as access, sport or recreational activity and the negative environmental effects. At the same time, the report highlights the important role sustainable tourism can play in generating revenue to reinvest in and regenerate ecosystems, local markets and communities and build resilience to future threats and future shocks and crises. Given there are approximately 42 million recreational visits per year to coastal margins and marine ecosystems by people in Wales, there is clearly a big potential for this sector to contribute to a regenerative economy if appropriately managed.

Physical modifications, including those associated with flood defences are identified as a pressure on coastal margin ecosystems. At the same time, coastal margin ecosystems can supply important coastal protection services (e.g., sand dunes, shingle and saltmarsh). Saltmarsh areas can also deliver effective solutions to tackling nutrient pollution, faecal and heavy metal pollution (Hudson, Kenworthy and Best, 2021), noting that there will be trade-offs in relation to poorer condition to support biodiversity. These are examples of how investment in coastal ecosystems can support transitioning away from investment in 'grey' built infrastructure solutions to NbS that deliver co-benefits for nature and people (e.g., restoration of saltmarsh increases the supply of global climate regulation services via increased carbon storage and sequestration).

Similarly, while Agricultural intensification is identified as a pressure, well managed and targeted livestock grazing in coastal margin ecosystems is also shown to deliver benefits for biodiversity (NRW, 2021b). These activities often deliver higher value outputs, with saltmarsh meat regularly achieving higher than average market price (Gedan, Silliman and Bertness, 2009; Jones et al., 2013). Therefore, sustainable agriculture (e.g., at the right level of grazing intensity), can contribute to regeneration of coastal ecosystems. Depending on the individual farm's carbon footprint, sustainable agriculture can deliver wider benefits, including increases in global climate regulation services via increased carbon storage and sequestration (Welsh Government, 2024).

Progress towards meeting Aim 4 (Contributing to a Regenerative Economy, Achieving Sustainable Levels of Production and Consumption)

The key opportunities taken up since SoNaRR 2020 comprise:

- The Sustainable Farming Scheme could potentially deliver multiple benefits (e.g., nature conservation, food, flood protection, climate change mitigation)
- A Payments for Ecosystems Services (PES) trial was established on the Llŷn Peninsula in 2018 funded by Welsh Governments Sustainable Management Scheme and the National Trust. The Tir a Môr scheme, offered payments for outcomes (PfO) for habitats and species, much of this was within habitats on the coastal slopes. The 3 farms in the scheme all showed nature positive improvements and informing numerous stakeholders on the scope and potential of PfO projects.
- NRW has published information for coastal managers on options for nature-based solutions at the coast, which has been widely shared with coastal practitioners, and officers can easily refer to this when providing advice (NRW, 2025a)

Opportunities for Action Aim 4

The possible actions identified with respect to achieving Aim 4 relate to Nature based Solutions, Payments for ecosystem services, Pollution management, Renewable energy, Sustainable agriculture, forestry and fisheries, Sustainable construction, and Sustainable transport.

Action 15. Mitigate pressures from built development and infrastructure (including for renewable energy and coastal defence)

Action 16. Sustainable agriculture with appropriate grazing intensity to improve coastal margin ecosystem condition, biodiversity, produce high value produce and climate change mitigation co-benefits

Action 17. Harnessing sustainable tourism to fund regeneration of coastal ecosystems and communities

Action 18. Encourage investment in coastal margin ecosystems for Nature based Solutions for coastal protection and climate change adaption and for water / waste purification.

Evidence needs

A wide range of evidence needs has been identified to support the sustainable management of Wales' coastal margins. These include updated data on the extent and condition of key habitats such as sand dunes, saltmarshes, sea cliffs, shingle, and lagoons, along with improved understanding of habitat change and resilience. Climate change impacts are a major concern, with evidence needed on habitat rollback, sediment budgets, and the effects of changing temperature and rainfall patterns on coastal systems.

Further research is required to understand the ecosystem services provided by coastal margins, including the role of saltmarshes in supporting fish populations, flood protection, and nature-based solutions. The impact of human pressures such as agriculture and recreation also requires further investigation. Restoration and connectivity opportunities should be identified to reverse habitat fragmentation. Finally, long-term impacts of chemical and nutrient pollution on coastal ecosystems remain a critical evidence gap, particularly in relation to saltmarsh.

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Enclosed farmland ecosystem

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Enclosed Farmland comprises the agricultural land in lowland Wales that is surrounded by field boundaries. It includes arable crops, horticulture, orchards and temporary grasslands as well as agriculturally improved permanent grasslands, but excludes areas of enclosed semi-natural grassland, scrub, farm woodland and habitats in the upland fringes (ffridd).

This Enclosed Farmland assessment is one of eight ecosystem and three natural resource assessments that inform the overall SoNaRR2025 report. It builds on the findings of SoNaRR2020, drawing together updated evidence from subject experts and national datasets such as the ERAMMP Report-105: Wales National Trends and Glastir Evaluation, ONS Natural Capital Accounts and Welsh Government Agricultural Surveys. This assessment is closely linked to the Woodland ecosystem assessment, Soils assessment and the evidence we have set out in the Land and sea use and management change evidence pack.

The assessment is structured around four interlinked aims that guide Wales' progress toward the sustainable management of natural resources (SMNR), helping to communicate the relationship between the environment, well-being, and the economy

Key messages

1. Enclosed farmland remains vital for food production and cultural identity in Wales, but its resilience is under increasing pressure from climate change and land use intensification.
2. The condition of enclosed farmland is deteriorating due to multiple pressures including extreme weather, pests and diseases, pollution, and invasive species, with significant implications for biodiversity and ecosystem services.
3. Future risks to enclosed farmland are expected to intensify, particularly from climate-driven changes such as seasonal drought, flooding, and heat stress, which will impact productivity and land capability.
4. Practical actions such as integrated pest management, soil health improvement, and targeted tree planting can help mitigate pressures and enhance resilience on the ground.
5. Strategic responses including the Sustainable Farming Scheme, climate adaptation planning, and better land use regulation are essential to safeguard ecosystem services and support a regenerative economy.

Enclosed Farmland Summary SMNR Assessment

Aim 1: Stocks of natural resources are safeguarded and enhanced

Enclosed farmland in Wales is under pressure from biodiversity loss, pollution, and climate change. Traditional habitats have declined, with farmland birds and pollinators showing long-term deterioration. However, hedgerows and wood pasture retain higher species diversity, and some indicators—like hedgerow woody species richness—show marginal improvement. Pests, diseases, and invasive non-native species (INNS) continue to threaten farmland ecosystems, with diseases like Ash Dieback and Dutch Elm causing widespread tree loss. Air pollution, particularly ammonia emissions from agriculture, is rising and affects sensitive plant communities. Soil health is compromised by compaction, phosphorus leaching, and microplastics, while water pollution trends remain unclear.

Climate change is intensifying pressures, with more frequent droughts, floods, and heat stress affecting productivity and land capability. Sea level rise and coastal erosion pose future risks to farmland and aquifers. Strategic responses include the Sustainable Farming Scheme (SFS), launching in 2026, which promotes integrated pest management, soil health, and pollution control. Actions such as tree planting, rotational grazing, and reduced fertiliser use can enhance resilience and safeguard natural resources.

Aim 2: Ecosystems are resilient to expected and unforeseen change

The resilience of enclosed farmland ecosystems varies across habitat types. Arable land and improved grassland have low diversity and condition, while hedgerows and trees outside woodlands show higher diversity and connectivity. Long-term trends indicate deterioration in diversity and condition, especially for farmland species and soil health. Hedgerows have seen recent improvements in extent and species richness, but tree losses continue due to disease and storm damage. Connectivity is high for hedgerows and grasslands but low for arable land and isolated trees.

Future resilience depends on land management choices. Sustainable practices—such as varied swards, reduced inputs, and habitat connectivity—can improve ecosystem health. Financial incentives and nature-based solutions are needed to support low-input systems and climate adaptation. The SFS aims to enhance resilience through improved soil health, habitat coverage, and connectivity. Projects like DeeLIFE and 4 Rivers for LIFE contribute by advising on land management and planting riparian buffers. However, more evidence is needed on the impacts of climate change and INNS to guide future actions.

Aim 3: Healthy Places for people, protected from environmental risk

Enclosed Farmland contributes to health protection through climate regulation, air filtration, and water supply. Grassland soils sequester carbon, while vegetation removes air pollutants, reducing premature deaths. However, agriculture is a major source of ammonia emissions, which can harm ecosystems and human health. Water abstraction for farming is increasing, highlighting the need for sustainable water use.

Health improvement is supported through recreation, education, and cultural services. In 2022, over 42 million visits were made to Enclosed Farmland, generating £80 million in value. The landscape supports equestrian activities, farm education, and research. It also holds cultural significance, with strong ties to Welsh identity and language. The SFS promotes public access and cultural conservation. Integrated strategies and community engagement are essential to maintain access, manage pollution, and adapt to climate pressures.

Aim 4: Contributing to a Regenerative Economy, Achieving Sustainable Levels of Production and Consumption

Enclosed Farmland underpins Wales’ agri-food sector, supporting 49,500 jobs and producing crops, livestock, and biomass. However, intensification has led to biodiversity loss, soil degradation, and pollution. Maize cultivation and heavy machinery increase erosion risks. Organic farming supports biodiversity and soil health but has declined in area. The SFS and Agricultural Soil Policy aim to promote sustainable practices, including reduced tillage, crop rotation, and integrated pest management.

Economic pressures and land use changes—such as urban expansion and renewable energy infrastructure—threaten productive land. Enclosed Farmland also provides regulating services like flood mitigation and pollination, though evidence is limited. Cultural services contribute to economic well-being through tourism and traditional farming. Future opportunities include investing in nature-based solutions, managing organic waste sustainably, and promoting regenerative and nature friendly practices to balance production with environmental protection.

Key changes since SoNaRR2020

Since SoNaRR2020, pressures on enclosed farmland ecosystem have intensified with emerging challenges. Climate change impacts have continued to increase, with more frequent extreme weather and increasing pressures from pests and diseases affecting livestock and crops, while new evidence showed soil compaction and nutrient imbalances have worsened. Biodiversity trends remain concerning: farmland bird declines continue, though pollinator indicators are stable, but longer term trends remain a concern.

Hedgerows show modest improvement, but ongoing deterioration in tree health from ash-dieback remains a concern. Pollution pressures persist, with ammonia emissions rising contributing to nitrogen deposition and soil phosphorus leaching risks increasing. Land use change adds to the complexity of pressures. Overall, ecosystem condition and biodiversity remain low, emphasising the need for accelerated action to meet SMNR aims. Policy developments, notably the Agriculture (Wales) Act 2023, the Soil Policy Statement and the Sustainable Farming Scheme, signal opportunities for more resilient ecosystems and soil resources. Overall, future outlook depends on uptake of nature-friendly practices and adaptation to climate and market drivers.

Enclosed Farmland Full Assessment of SMNR

Aim 1: Stocks of natural resources are safeguarded and enhanced

Animals, plants and other organisms

The modified habitats that make up Enclosed Farmland are dominated by a few species. The high biodiversity in traditional arable systems has largely been lost, and remnants are localised and very vulnerable. For example, remaining ancient and enclosure hedgerows are more species diverse. There are signs of improvement of Hedgerow woody species richness (Emmett, Anthony, *et al.*, 2025). Wood Pasture and Traditional orchards are also more species diverse.

Historically, both the plants and pollinators of the farmed environment have deteriorated (1970 to 2020) (Burns *et al.*, 2023). Farmland birds have also deteriorated over the long term (1994 – 2021) (Burns *et al.*, 2023). Populations of the greater horseshoe bat have increased both over the long-term (1999 – 2022) and short-term (2018 – 2022) (Boughey *et al.*, 2024).

Pests and diseases have negatively affected animals, plants and other organisms in Enclosed Farmland ecosystems over the historic long-term (1970 – 2024). This has not changed over the short term (2020 – 2025) and is likely to continue in the future (to 2030). Pests and diseases such as Ash Dieback, Dutch Elm disease and *Phytophthora ramorum* have caused largescale tree loss across Wales and negatively affect farmland trees, including those in hedgerows. (See Woodlands assessment)

Vector-borne diseases, such as bluetongue, can affect livestock health and welfare (cattle, sheep, goats and deer) and require monitoring and vigilance (DEFRA and APHA, 2025). First found in south-east England in 2023, it is forecast that by 2100 the bluetongue risk will extend further north, and the transmission season will extend by up to three months, with larger outbreaks (Jones *et al.*, 2019). Climate change is also expected to increase the abundance and distribution of **pests and diseases** affecting tree health, which has the potential to affect farmland trees.

There is not enough evidence to describe the long-term or short-term trends of **Invasive Non Native Species (INNS)** in Wales' Enclosed Farmland. At a GB level the numbers of established non-native species has risen at increasing rates for several centuries, recently reaching the highest total number of established non-native species and the highest annual rate of new records (Roy *et al.*, 2020). Regular GB Horizon scanning exercises (Roy et al., 2025) identify INNS that have not arrived but pose the greatest threat to GB, including those that will affect land management or livestock (e.g. plants like black swallow-wort (*Vincetoxicum nigrum)* and Box elder (*Acer negundo)* which are toxic to livestock and invertebrates (*Hishimonus hamatus* and *Eobania vermiculata) that* can affect crops were identified during the recent exercise).

The estimated cost of INNS to the agriculture sector in Wales has increased from £71 million per annum in 2010 to approximately £124 million per annum in 2023 (Williams *et al.*, 2010; Eschen *et al.*, 2023). Should they be introduced in the future, the New Zealand flatworm (*Arthurdendyus triangulates*) and Australian flatworm (*Australoplana sanguinea*) would predate native earthworms which may affect soil processes (GB Non-native Species Secretariat, 2016; European Commission. Directorate General for the Environment., 2018). Yellow legged (Asian) hornet (*Vespa velutina*) is likely to directly affect honey production and affect populations of pollinators in the future (Marris, Brown and Jones, 2011).

Air

The component of the enclosed farmland ecosystem impacted the most by **air pollution** are Trees outside Woodlands. Bryophyte-and lichen-rich woodland communities associated with ancient semi-natural woodlands, small blocks of which will be located within enclosed farmland. If the ammonia Critical Level for vascular plants is exceeded, typical ground flora may be lost and replaced with more vigorously growing nutrient-demanding species.

Historically, there is a mixed picture for **air pollution** affecting Enclosed Farmland ecosystems over the long-term (1990 – 2023). Over the short term (2020 – 2023) air pollution is deteriorating. There are signs that this will revert to a mixed picture in the future (to 2030 and 2050). Air pollution from ammonia emissions have been increasing since 2011 (Mitchell *et al.*, 2024). It is expected to continue to increase in the future if measures to control agricultural emissions are not implemented. Nitrogen oxides emissions have generally decreased over the last 20 years (Mitchell *et al.*, 2024) and should continue to fall as the plans for net zero are implemented.

Atmospheric nitrogen deposition (from industrial activities, agricultural practices, waste management and energy production) can lead to nutrient enrichment of soils. These changes impair plant health, alter vegetation structure and community composition, and can modify carbon in soils affecting the role of soil in climate regulation. (See Air assessment)

Soil

When managed and utilised appropriately organic manures have a valuable role in improving soil health. Where organic manures are not managed properly, for example over applied to soil, this activity has the potential to cause harm to the environment. ((SoNaRR 2025 Land use and management change chapter). Land pollution disrupts soil condition and introduces harmful substances, leading to soil degradation and impacts on the animals and plants.

Historically (until 2023), **soil (land) pollution** trends are a mixed picture on the enclosed farmland ecosystems. Legacy phosphorus levels have declined over time. Across the UK, they often exceed agronomic needs, posing risks to water quality—especially in sensitive river catchments. Limited sub-national data makes it challenging to fully assess the scale and impact of this issue in Wales (Cordell *et al.*, 2022). Agricultural fertilisers have contributed to microplastic concentrations in agricultural soils over time (Cusworth *et al.*, 2024).

Over the historic short term (2020 – 2025), soil (land) pollution has increased. 17% of Improved Grassland sites and 8% of arable sites surveyed by ERAMMP now exceed leaching thresholds for Phosphorous. (Emmett, Anthony, *et al.*, 2025). The future outlook is mixed, linked to the management of pests and diseases and intensification of land management. The Welsh Sustainable Farming Scheme (SFS) which will launch in 2026, includes actions aimed at minimising the use of pesticides through Integrated Pest Management and to improve Soil Health.

Across the UK atmospheric N deposition on soils decreased from 172 to 124 thousand tonnes of N between 1990 and 2023 and has reduced on average in its proportion of total inputs over this period from 7.0% to 5.6%. Conversely, atmospheric P deposition has increased very slightly from 4.9 to 5.2 thousand tonnes over the same period, representing 1.2 to 2.1% of P inputs respectively (DEFRA, 2024b).

Soil pH remained stable between the 2013-16 and 2021-23 survey periods across the Enclosed Farmland (Semi-improved grassland, Improved Grassland and arable & Horticulture). 72% of Improved Grassland had a pH below 6 in 2021-23, which has been identified as a trigger point for reduced grassland productivity on mineral soils. This was 75% in 2013-16. (Emmett, Anthony, *et al.*, 2025)

Water

Good quality and a reliable supply of water is crucial for agriculture, horticulture and livestock management in enclosed farmland, especially for horticultural businesses as most will use some form of irrigation from water mains or abstracted from springs, water bodies (rivers, lakes etc) and boreholes . Water consumptive use in the agricultural sector was 3% of all licensed abstractions and showed a small increase in use between 2019 and 2024. Over the last 24 years, those reliant on private water supply for agricultural use have risen (Farr et al., 2022).

There is no evidence to describe short or long trends of water pollution pressures impacting on the Enclosed Farmland Ecosystem. A Defra Rapid Evidence Assessment (REA) of Flooding and Coastal Erosion on Agricultural Land and Businesses in England and Wales has no specific evidence for Wales. There is limited evidence on saline flooding affecting crops, plants and soil conditions, with the potential to affect production or cropping options for several years after the event and contaminants associated with floodwaters posing a risk to animal health as well as the broader ecosystem (Hess et al., 2024).

Further evidence about water stocks is contained in the Water SMNR Assessment.

Climatic features and processes

Historically, there has been a deteriorating trend for **changes in intensity and frequency of weather events** affecting Enclosed Farmland over the long term (2010 – 2025). This trend is expected to continue in the future (to 2100). Trees within Enclosed Farmland may be particularly affected by wind. Arable land may be more at risk of soil erosion and flooding than grassland due to less soil cover. Wales has experienced a number of significant weather events in the last five years. Storm Eunice in February 2022 was the most severe storm to affect Wales since February 2014 (Kendon *et al.*, 2023), as well as periods of prolonged dry weather in 2022 and 2023.

Historically, there has been a deteriorating trend to **changes in air temperature and seasonal rainfall** affecting Enclosed Farmland over the long term (2010 – 2025). This is expected to continue into the future (to 2100). The frequency of discrete periods of regional extreme air temperatures has increased over the last couple of decades. The effects include altered hydrology, season aridity and wetness on soils, changes in soil organic matter, productivity and heat stress of grazing animals.

Other changes include changes in phenology (Reeves *et al.*, 2025), the regulation of seed dormancy and germination, the timing of plant and insect life cycles (Iler *et al.*, 2021), which may result in increased risks of frost damage and the loss of synchrony between different trophic levels. Changes in air temperature are likely to result in increased pressures from other Drivers of change such as pests and diseases (DEFRA, 2024c).

There is no long term trend data in relation to coastal flooding, coastal erosion or saline intrusion in relation to impact on enclosed farmland. These risks are all affected by **sea level rise**. Historically (1900 – 2020), there has been a deteriorating trend in **sea level rise** over the long term. This is expected to continue into the future. Sea-level rise, coastal erosion and seawater saline intrusion are a future risk to enclosed farmland habitats, agricultural land and aquifers. The effects may be more pronounced during drought periods depending on any adjustment to water abstraction rates. The current risk at the UK national scale is assessed as low and is likely to remain low in the future. The scale of saline intrusion risk would significantly increase with a more extreme rate of sea level rise.

The amount of agricultural land at risk of flooding from the sea is predicted to rise from 40,000Ha in 2020 to 46,500Ha by 2120 (NRW, 2024b).

The amount of agricultural land at risk of coastal erosion is projected to increase from 152ha in 2020 to 432ha in 2055 and to 1150 ha by 2105 (NRW, 2024a).

The Climate Change Adaptation Report (AHDB, 2025) identified the following areas as currently most at threat :

- Farm assets - for example increased flooding leading to waterlogging and soil erosion, and damage to farm buildings and equipment.
- Productivity - extreme weather events such as heatwaves, extended periods of prolonged dry weather and drought, high rainfall, and flooding impacting livestock and crops.

Pressures from economic activity (see Aim 4 for more detail)

Pressures arising more directly from economic activity in enclosed farmland ecosystems are also negatively affecting the stocks of natural resources (see Aim 4 for more detail). These pressures are (in alphabetical order): Agricultural intensification and built development and infrastructure.

Agricultural intensification: Since the end of the Second World War, levels of agricultural production have increased greatly. Semi-natural habitats have been cultivated, drained, limed and fertilised to create more productive land (Blackstock *et al.*, 2010). Extensively managed arable land is the only Critically Endangered habitat in the UK on the European Red List. Intense management of agricultural land has been identified as the most significant factor driving species population change in the UK (NRW, 2021a). Intensive management can cause root damage, compaction, eutrophication and affects the soil, resulting in changes to hedgerows, farmland and trees. Agricultural production to produce food is maintained and increased by the use of fertilisers (organic and inorganic), plant protection products, seeds, energy, animal feed and land. Their use contributes to emissions of greenhouse gases (SoNaRR 2025 Climate Change and Land Use and management Change Chapter) and if used in excess contributes to pollution of air, land and water (SoNaRR 2025 Air, Water and Soils assessments).

Much of Wales' **Built development and infrastructure** has developed on what was high-grade agricultural land. The co-location of urban areas and high-grade soils has resulted in urban expansion being at the expense of the most productive land and therefore enclosed farmland. Energy-related infrastructure (wind and ground mounted solar) on enclosed farmland affects the functioning of the ecosystem, causing habitat fragmentation, loss of biodiversity, soil and drainage impacts, loss of productive land, and potentially loss of tree cover.

Progress towards meeting Aim 1 Stocks of natural resources are safeguarded and enhanced

The key opportunities taken up since SoNaRR2020 comprise:

- Welsh Government's Sustainable Farming Scheme (SFS), which starts in 2026, aims to support farmers in the sustainable production of food whilst addressing both the climate and nature emergencies. It addresses the Sustainable Land Management objective in the Agriculture (Wales) Act 2023 to mitigate and adapt to climate change. The scheme integrates relevant measures such as actions aimed at minimising the use of pesticides through Integrated Pest Management and to improve Soil Health.
- Research has found that farmers who are engaged with nature restoration, nature-friendly or more diverse farming practices are more resilient to extreme weather events. For example: less scorched land than that of their neighbours during periods of extreme heat and water stress and less prone to flooding. Greater tree cover, shelter belts and hedges mean animals are less exposed to heat stress and given greater protection in cold weather. Lower stocking rates mean fodder management is easier and there is more resilience in the system. Rotational grazing can help maintain production while improving soil structure. Reducing synthetic fertiliser use, increasing crop rotations, water management (e.g. rainwater harvesting) and reducing tillage help to enhance soil health and fertility while increasing biodiversity (Farmlytics, 2024).
- The UK National Action plan 2025, working for a sustainable future, promotes the sustainable use of pesticides (DEFRA, 2025b). It is difficult to predict whether the new actions are likely to be sufficient to reduce the incidence and spread of new, existing and emerging pest and diseases in the face of climate change, growing resistance to conventional controls, new virulent strains and globalisation of trade (DEFRA, 2022).
- Welsh Government published A Low Carbon Wales (2019b) which aims to reduce ammonia emissions through improving efficiency of livestock production, improving crop and nutrient management, and improving on farm fuel and energy efficiency
- Innovative projects have been implemented, for example involving the installation of ammonia sensors to monitor emission levels and by producing Site Nitrogen Action Plans (NRW, 2023)
- DeeLIFE and 4 Rivers for LIFE alongside other catchment initiatives have been working to improve land management practices. Between 2020 and the end of 2024, these projects have delivered:

  More than 40,000 trees planted on riparian buffers
  Over 500m of fencing installed to exclude livestock from river corridors
  171 water troughs to reduce livestock need to enter watercourses
  120 farms visited with land management advice.
- Alongside this, 4 Rivers for LIFE have delivered · 68 farm reports, advising on land management practices over 7,300 hectares.

- The GB horticultural PAP (GBNNSS 2025) was developed in partnership with the horticultural industry and includes a suite of actions that will address horticultural escapes and hitchhikers, following public consultation it will be adopted and published and the actions identified will then be delivered. It is hoped that it will reduce the impact of INNS from Horticulture in future.
- The Wales plant health sentinel site network was established to monitor for plant pests and diseases (including some INNS) (Welsh Government, 2022b).

Opportunities for Action Aim 1

The possible actions identified with respect to achieving Aim 1 in Enclosed Farmland relate to Community engagement (place-based approaches), Increase resource use efficiency, INNS and other species management, Integrated plans, strategies and delivery, Pollution management, Resource protection, Species conservation and enhancement, Sustainable agriculture, forestry and fisheries and Waste prevention.

Action 1. Monitor and control INNS and diseases in affected areas.

Action 2. Monitor and control pollution of Enclosed Farmland ecosystems with particular emphasis on soil, particularly from pesticides and fertilizers.

Action 3. Monitor and control pollution from Enclosed Farmland ecosystems affecting Air and water, particularly ammonia emissions.

Action 4. Protect and boost native species populations by monitoring, protecting and restoring key habitats.

Action 5. Adapt agricultural practices to reduce the pressure on watercourses and mains water supply when source supplies are low.

Action 6. Adapt agricultural practices to take account of pressures from the changing climate, particularly to protect soils on arable land.

Action 7. Plan for the future risk to enclosed farmland habitats, agricultural land and aquifers from Sea-level rise, coastal erosion and seawater saline intrusion.

Aim 2: Ecosystems are Resilient to Expected and Unforeseen Change

Ecosystem Resilience is assessed in SoNaRR using four ecosystem attributes as proxies. Diversity, extent, condition and connectivity for each of the five habitat types that make up the Enclosed Farmland ecosystem. The five habitat types are arable land, hedgerows, improved grassland, trees outside woodlands (parkland, wood pasture, orchards) and semi-improved grassland. There is very little assessment available for semi-improved grassland.

Diversity

The current diversity of Enclosed Farmland extent varies by habitat type. The diversity of arable land and improved grassland is ‘Low.’ Arable land has a generally low diversity in intensively managed systems, similarly, improved grassland is a modified habitat dominated by a few species. The diversity of hedgerows and trees outside woodlands is ‘High’. Ancient hedgerows have a higher diversity than enclosure hedgerows, overall, there have been marginal signs of improvement of hedgerow woody species richness (Emmett, Anthony, *et al.*, 2025).

The long-term (1946-2019) historic trend for Enclosed Farmland diversity is deterioration. For improved grassland, specialist farmland species are in serious decline. Invertebrates, plants and farmland birds illustrate this particularly. Extensively managed arable land is the only European Critically Endangered habitat in Wales. Lowland Farmland Birds and pollinators are in decline from arable land (Emmett, Anthony, *et al.*, 2025). Farmland species reliant on hedgerows such as brown hair streak butterfly and spreading bellflower Campanula *patula* populations have been declining.

The short-term (2019-2024) historic trend for Enclosed Farmland diversity is a mixed picture. For improved grassland, there has been an increase in the plant indicator richness, however it is not classed as significant (Emmett, Anthony, *et al.*, 2025) . There has been a decline in several soil health indicators and a decline in the abundance of grassland birds between 2013-16 to 2021-23. (Emmett, Anthony, *et al.*, 2025). For Arable Land there has been no improvement in indictors such as total plant species richness and arable forbes, no change in pollinators and continued declines in arable birds (Emmett, Anthony, *et al.*, 2025). A recent report on wood pasture in Wales found that it has high diversity as it supports a variety of habitats including acid grassland, acid flush and dry heaths together with a range of structural tree types (Sherry and Douglas, 2023).

The future outlook (to 2024) for Enclosed farmland diversity is a mixed picture. For improved grassland, the future outlook is dependent on future management. A move towards more sustainable varied swards managed with less artificial inputs would be beneficial. Economic pressures leading to further intensification and more inputs to the system would be detrimental. For Arable land, prospects are poor without financial incentives in place to support farmers in maintaining low input arable systems, and to provide increased habitat provision and connectivity across the farmed landscape for mobile species. For Hedgerows and Trees outside Woodlands, the Sustainable Farming Scheme will support positive management options. but there is a lack of documented evidence on the health and loss of farmland trees although they are likely to continue to be affected by the increasing frequency and intensity of storms. National Trust parklands in Wales have lost around 30% more veteran trees each year compared to 10 years ago (National Trust, 2024).

Extent

The current assessment of Enclosed Farmland extent varies per habitat type. **The extent of improved grassland is 'High', the extent of arable land and hedgerows is 'Medium', the extent of trees outside woodlands is 'Low'.**

The long-term historic trend for Enclosed Farmland extent varies per habitat type. For the extent of arable and horticulture land used for crops, the trend is improvement. The area of arable and horticulture land in Wales increased between 2000 and 2024 from 70,000 ha to 107,800 ha. (Welsh Government, 2024c) There has been a large historical decline in the area of low-intensity arable land supporting arable plant communities. For the extent of improved grassland and hedgerows, the trend is a mixed picture. Post second world war, there was a large increase in extent of improved grassland to increase productivity, which included hedgerow removal. The extent of improved grassland had begun to decrease by the 21st century, and the extent of hedgerows had stabilised (NRW, 2021a; UK Centre for Ecology & Hydrology, 2021; Emmett, Anthony, *et al.*, 2025). For trees outside woodlands, the trend is deterioration. There has been a deterioration in the extent and condition of parkland and orchards over many decades. There have been large tree losses of trees outside woodlands due to Dutch Elm disease and Ash dieback and lack of new tree recruitment (NRW, 2021a).

The short-term (2019-2024) historic trend for Enclosed Farmland extent varies per habitat type. For the extent of improved grassland and arable land, the trend is a mixed picture. The extent of arable land increased from 5% to 6% of all land between 2020 and 2024 (Welsh Government, 2024c). Other accounts report 4% extent in 2021 and a reduction in extent by 24% since 2010 (Emmett, Anthony, *et al.*, 2025). For the extent of hedgerows, the trend is improvement. There was a 2,200km increase in new and restored hedgerows to a total length of 52,700km in 2021-23, only 0.1% of new hedgerow was supported by Glastir management payments (Emmett, Anthony, *et al.*, 2025). For trees outside woodlands, the trend is deterioration. Two out of 57 sites surveyed in South Wales have been converted from historic Wood Pasture sites to woodland (Sherry and Douglas, 2023).

The future outlook (to 2040) for Enclosed Farmland extent is a mixed picture. The extent of improved grasslands will fluctuate with arable land due to economic and market pressures. The area of productive land could be reduced, for example due to urban expansion and the use of land for renewable energy production (SoNaRR 2025 Land use and management change chapter). Hedgerow extent is predicted to be stable or increasing if there is uptake of hedgerow options in SFS and farmers recognise the importance of hedgerows in making their farming systems more resilient (Emmett, Anthony, *et al.*, 2025). Hedgerow tree losses are likely to accelerate due to Ash Dieback (Chalara). Over the next 5 to 10 years, the main loss of hedgerow extent will likely be due to Chalara (NRW, 2021c).

Condition

The current assessment of Enclosed Farmland condition is ‘Low’ for all habitat types. Improved grassland habitat is dominated by high input/output systems which reduce land condition. Similarly, arable land is experiencing a declining soil condition, compaction and high phosphorus concentrations – all of which reduce condition (Emmett, Anthony, *et al.*, 2025).

The long-term (1946 - 2019) historic trends for Enclosed Farmland condition vary per habitat type. For the condition of improved/semi-improved grassland, the trend is a mixed picture. Over time, more areas of improved grassland are being managed in a sustainable way, minimising input and building soil condition (NRW, 2021a). **For all other habitat types, the trend is deterioration.**

The short-term historic trends (2019 – 2024) for Enclosed Farmland condition vary per habitat type. For the condition improved grassland and hedgerows, the trend is a mixed picture. There has been an increase in plant indicator richness for improved grassland but a decline in soil health indicators and the abundance of grassland birds (Emmett, Anthony, *et al.*, 2025) . For hedgerows, there has been some evidence of an increase in woody species richness however ground flora species richness has declined (Emmett, Anthony, *et al.*, 2025) **For the condition of arable land and trees outside woodland, the trend is deterioration.** Storms and mismanagement have affected the condition of trees outside woodland (Sherry and Douglas, 2023). The declining soil condition of arable land has resulted in deteriorating short term historic trend (Emmett, Anthony, *et al.*, 2025) .

The future outlook (to 2040) for Enclosed Farmland condition is a mixed picture. For all habitat types there has been some increases in uptake of improved management technique which will improve condition, however more support and uptake will be required in the future to see a large-scale improvement in condition across enclosed farmland habitat types.

Connectivity

The current assessment of Enclosed Farmland connectivity varies per habitat type. The connectivity of improved grassland and hedgerows is ‘High’. For improved grassland, although connectivity is superficially high, the low condition and diversity means that habitat is fragmented for many species. Hedgerows have a high natural connectivity; however, this is often affected by gaps. The connectivity of trees outside woodlands is ‘Medium’. In some areas, such as in the fridd, connectivity is often good but, in most cases, individual trees are isolated, and parkland is also fragmented. The spatial and temporal connectivity of Arable land has largely been lost and is assessed as ‘Low’.

The long-term (1946 - 2019) historic trend, short-term (2019-2024) historic trend and future outlook (to 2020) for Enclosed Farmland connectivity is not available.

Progress towards meeting Aim 2 Ecosystems are Resilient to Expected and Unforeseen Change

The key opportunities taken up since SoNaRR2020 comprise:

- Welsh Government’s Sustainable Farming Scheme (SFS), which starts in 2026, aims to support farmers in the sustainable production of food whilst addressing both the climate and nature emergencies. It addresses the Sustainable Land Management objective in the Agriculture (Wales) Act 2023 to maintain and enhance ecosystem resilience. The scheme will support climate resilience and should support Nature Based Solutions.
- DeeLIFE and 4 Rivers for LIFE have been working to improve land management practices across catchments. Between 2020 and the end of 2024, 4 Rivers for LIFE have delivered · 68 farm reports, advising on land management practices over 7,300 hectares.

  · 2,500 trees planted on riparian buffers. - do we know how much in EF?
  · On farm works carried out on 26 farms – what kind of work?

Opportunities for Action Aim 2

The possible actions identified with respect to achieving Resilient Enclosed Farmland ecosystems relate to Ecosystem restoration, Ecosystem protection, Nature based Solutions, Ecosystem creation, INNS and other species management, and Sustainable agriculture forestry and fisheries.

Action 8. More sustainable varied swards managed with less artificial inputs

Action 9. Manage diseased trees and hedgerows

Action 10. Financial incentives to support farmers in maintaining low input arable systems

Action 11. Improve habitat provision and connectivity across the farmed landscape to support species movement

Action 12. Improving climate resilience within the farmer environment

Aim 3: Healthy Places for people, protected from environmental risk

Health Protection

Enclosed farmland ecosystems can contribute to human health protection through the supply of the following regulating services:

- Global climate regulation services: The UK natural capital accounts (Office for National Statistics, 2024a) estimate that mineral soils under croplands emitted 657,500 tCO_2e in 2022. Grassland mineral soils sequester approximately 640,000 to 650,000 tonnes CO_2 equivalent per year (general trend from 2000 to 2024). It is unclear whether Enclosed Farmland leads to net emissions or not (Gregg *et al.*, 2021).
- **Air filtration services**: Between 54 and 56 million kilograms of air pollutants have been removed by Wales Enclosed Farmland vegetation each year between 2007 and 2023. The benefit realised prevented 176 life years lost from exposure to particulates ($PM_{2.5}$ and PM_{10}) and 51 life years lost from exposure to NO_2 in 2023. The avoided burden on mortality is estimated at 44 fewer deaths from short term exposure to Ozone (Office for National Statistics, 2024a). However, the agricultural sector is a significant emitter of air pollutants (Mitchell et al., 2024). Agricultural sources dominate the 23 million kilograms of ammonia emitted to the atmosphere in Wales in 2022 (see ammonia case study).
- **Water Supply**: Land used for agricultural purposes accounts for 90% of the total land area of Wales (Welsh Government, 2024c). Whilst not all land used for agriculture is enclosed farmland, it does have considerable potential to impact water supply and affect the provisioning of this ecosystem service, including with respect to water quality. No estimates on the water supply provisioning of enclosed farmland is available.

Health Improvement

Enclosed Farmland contributes to human health improvement through the supply of the following cultural services:

- **Recreation-related services** provide opportunities for people to enjoy in-situ interactions with nature and associated physical and mental health benefits.
    - In 2021/2022, the People and Nature Survey for Wales (PaNSW) indicated that people in Wales made 25,257,483 visits to Enclosed Farmlands for recreation (Owen, Rhydderch and Williams, 2025). Note that The ONS estimate that 42 million visits were made to Enclosed farmland in 2022. The main reason for the difference is that the ONS consider visits to Fields, farmland and countryside are all to Eclosed Farmland. We have split the PaNSW results splits this number with the Semi Natural Grassland Ecosystem.
    - In 2022, 100,000 people in Wales gained health benefits from recreation in Enclosed Farmland. These health benefits were valued at £50 million (Office for National Statistics, 2024b).
    - 39,400 horses were reported in the 2024 agriculture survey, many of which will be kept on Enclosed Farmland (Welsh Government, 2024c).

Cultural Well-being

Enclosed Farmland ecosystem contributes to people's cultural well-being through the supply of the following cultural services:

- **Spiritual, artistic and symbolic services** are provided by enclosed farmland ecosystems through the close relationship between Welsh culture, farmland landscapes and their use for agriculture. The Agriculture, forestry and fishing sector had the highest share of Welsh speakers across all sectors (43% of the total working population) (Welsh Government, 2019a, para. 58)
- **Education scientific and research services** provide intellectual development, advancement of knowledge and understanding for people from interactions with Enclosed Farmland ecosystems. Across Wales, college farms, educational farm visits and Forest Schools provide training, an understanding of where our food comes from and natural environment settings to enhance children's self-confidence and understanding of their relationship with the world around them. The actively managed landscapes provide opportunities to research food production, mitigate environmental impacts, support rural economies, and address the unique challenges faced by Wales' rural communities.
- **Amenity (visual and sensory) services** and landscapes that many people cherish. Just under half the landscapes, 933,100 ha, that are associated with scattered rural and farm settlements are valued as high or outstanding (White Consultants, 2018). A fifth of Wales is characterised by landcover that contains a mixture of agriculturally improved land and habitat features, resulting in highly valued mosaic landscapes (Cottrell and Medcalf, 2019). These tranquil, pastoral landscapes have a sense of place, time-depth and cultural identity, contributing to the mental and physical well-being for those that live and work there, and delivering benefits to those who visit for recreation and tourism.

Progress towards meeting Aim 3 (Healthy Places for people, protected from environmental risk)

The key opportunities taken up since SoNaRR2020 comprise:

- Welsh Government's Sustainable Farming Scheme (SFS), which starts in 2026, aims to support farmers in the sustainable production of food whilst addressing both the climate and nature emergencies. It addresses the Sustainable Land Management objective in the Agriculture (Wales) Act 2023 to conserve and enhance the countryside and cultural resources while promoting public access and the Welsh language.
- Welsh Government have published a Climate Adaptation Strategy which considers the interrelated actions needed for addressing climate adaptation and resilience in Wales (Welsh Government, 2024a). It advocates a One Health integrated approach to addressing the health of people, animals and ecosystems with relevant ongoing and new actions.

- British Equestrian commissioned a literature review to assess the social value of equestrian activities in the UK. The findings are helping to measure the equestrian industry's impact on people's lives across the UK, including public health and wellbeing.(British Equestrian, 2025)

Opportunities for Action Aim 3

The possible actions identified with respect to achieving Aim 3 relate to Access to nature, , Community Engagement, Integrated plans, strategies and delivery, Nature based solutions, and Pollution management:

Action 13. Adapt agricultural practices to take account of pressures from the changing climate, particularly to protect soils on arable land to increase carbon sequestration.

Action 14. Implement strategies to ensure physical access to Enclosed Farmland habitats is maintained.

Action 15. Collaborate with stakeholders on Enclosed Farmland plans and programmes.

Action 16. Monitor and control pollution from Enclosed Farmland ecosystems affecting Air and water, particularly ammonia emissions

Action 17. Adapt agricultural practices to reduce the pressure on watercourses and mains water supply when source supplies are low

Aim 4: Contributing to a Regenerative Economy, Achieving Sustainable Levels of Production and Consumption

Contributions of Enclosed Farmland to sustainable economic production and consumption

Food production is the foremost ecosystem service provided by Enclosed Farmland; it underpins the Welsh agri-food sector. Increases in agricultural production seen over the last few decades have often been at the expense of external environmental costs and of other ecosystem services (NRW, 2021a). 49,500 people were working on farms in 2024 (Welsh Government, 2024c). Enclosed Farmland faces a difficult balancing act. To meet different human needs, it must simultaneously produce more food for a rising population; provide economic opportunities for rural communities; and reduce environmental impacts, including ecosystem degradation and high greenhouse gas emissions.

Welsh Government's Sustainable Farming Scheme (SFS), which starts in 2026, aims to support farmers in the sustainable production of food whilst addressing both the climate and nature emergencies. It addresses the 4 Sustainable Land Management objectives in the Agriculture (Wales) Act 2023 which are to produce food and other goods sustainably;

mitigate and adapt to climate change; maintain and enhance ecosystem resilience; and conserve and enhance the countryside and cultural resources while promoting public access and the Welsh language.

The recent WWF report concludes that climate adaptation and mitigation support for farmers is currently insufficient. Finance and lack of knowledge are key barriers to transitioning to more nature-friendly systems. Long term investment and support is required as it takes time for farmland to build resilience (Farmlytics, 2024)

Enclosed Farmland ecosystems contribute to economic well-being through the supply of the following provisioning services:

- **Crop provisioning**: 330,000 tonnes of agricultural primary biomass (Barley, Oats, Oilseed rape and Wheat) was produced in Wales in 2023, up from 275,000 tonnes in 2020. The value of these crops is not provided. Total value of agricultural biomass production estimated for 2020 was £450 million (2023 prices) (Office for National Statistics, 2024a).

  In 2022, Agricultural Biomass accounted for 16% of the total annual value of the provisioning services from the natural environment, for the whole of the UK. There has been an increase in the physical flow of Agricultural Biomass in the UK since 2020, from 93 units to 97 units (Office for National Statistics, 2024a).
  There were 107,800 hectares of arable crops in June 2024. (Welsh Government, 2024c). Maize cultivation has steadily increased in Wales, particularly for stockfeed and bioenergy as reported for the UK (DEFRA, 2025a). In 2024, the area of maize produced was estimated at 24,500 ha in Wales compared to 6,300 ha in 2000 (Welsh Government, 2024c)
  Bioenergy cropping for anaerobic digestion could increase in England and Wales in the future. Official statistics on the amount and type of crops grown used for anaerobic digestion are currently limited to maize (DEFRA, 2021)
  Recent statistics on the extent of land used for horticulture and orchards suggest this is in the region of 1,600 ha in Wales (Welsh Government, 2024c). Horticulture may be more significant in Wales in the future (Food & Drink Wales, 2025).
- **Grazed biomass provisioning:** Permanent grassland is the main component of agricultural land in Wales, and comprises of improved, semi-improved or unimproved (semi-natural) depending on the management practices (Welsh Government, 2023). These grasslands will include Enclosed Farmland, but also Semi-Natural Grasslands and Coastal Margins. For convenience, total livestock production is assigned to Enclosed Farmland here, as it is not possible to apportion across these three broad ecosystem types.

  The agricultural sector now makes use of over 90% of land area in Wales (including farm woodlands & other uses). Farmed ecosystems supply biomass for livestock. In 2024, the total number of sheep and lambs in Wales was 8.75 million and the total number of cattle and calves is 1.01million. in 2020, the number of sheep and lambs was 9 million and cattle and calves 1.1 million . (Welsh Government, 2024c) High priority climate change risks identified by AHDB (2025) identified impacts to soils, include reduced grazing productivity and quality.

- **Fibre provisioning**: fibre from woodlands on farms (blocs >0.5ha) is discussed in the Woodlands assessment. A recent summary was published by Forest Research on behalf of Welsh Government (Giannelli, 2025). There is no data on fibre provision specifically from the Enclosed Farmland ecosystem.
- **Water Supply**: Land used for agricultural purposes accounts for 90% of the total land area of Wales (Welsh Government, 2024c). Whilst not all land used for agriculture is enclosed farmland, it does have considerable potential to impact water supply and affect the provisioning of this ecosystem service, including with respect to water quality. No estimates on the water supply provisioning of enclosed farmland is available.

  The agriculture sector uses water from both surface and groundwater sources. In 2024 67040 Ml, 3% of all licensed abstractions, were licensed to the agriculture sector for consumptive use. This is a small increase from 2019 (63116 Ml). This water is from the freshwater ecosystem. Over the last 24 years, those reliant on private water supply for agricultural use have risen, (SoNaRR 2025 Water assessment).
- **Genetic material services:** Rare and traditional livestock breeds are sometimes raised in Enclosed Farmlands. Maintenance of such flocks or herds helps to preserve the genetic resource of these breeds

Enclosed Farmland ecosystems contribute to economic well-being through the supply of the following regulating services:

- **Soil quality regulation and Soil and sediment retention services:** Low intensity agricultural production benefits soil quality. Intensive grassland management reduces soil animal biodiversity, including earthworms, and threatens soil functioning in agricultural systems (NRW, 2021b). Grasslands which are not ploughed (including pastures) can contribute to soil erosion prevention, in contrast to cultivated grasslands or arable land (NRW, 2021b). See SoNaRR 2025 Soil assessment
- **Waste remediation services** : Enclosed Farmland can provide breakdown services for biological material . The use of this service may exceed the capacity of enclosed farmland to sustainably supply it due to the pressures of waste materials being put to land (Rollett and Williams, 2022).
- **Water flow regulation services**: Enclosed Farmland habitats can provide natural flood management services to reduce the impact of flooding on economic activities such as productive land, transport and wider infrastructure. In England, Environmental Land Management schemes are being designed to support farmers and land managers to provide natural flood management to protect themselves and other farm businesses in the catchment. In Wales, many of the temporary habitats in the universal actions of the Sustainable Farming Scheme will support the reduction of overland flow and will help reduce flooding.

  Crops may be able to store more flood water than grass per hectare in Wales (Fitch et al., 2022)
  Features, such as ponds, leaky dams, swales and buffer strips are identified as potential ways to ‘Work With Natural processes (WWNP) to reduce flooding in

farmland landscapes (DEFRA *et al.*, 2025). Targeted tree planting can significantly increase soil infiltration rates and help reduce peak flood flows (Woodland Trust, 2012). The [FRS21232 Main report] provides an evidence directory of the likely effectiveness of natural processes, including in farmland, in mitigating flood risks (DEFRA *et al.*, 2025)

- **Biological control services**: There is very little evidence to describe this service in Wales. Across the broad habitats, arable land contains the highest density of aphid eating hoverflies (Alison et al., 2020).
- **Pollination services**: SoNaRR 2020 highlighted rapidly declining invertebrate populations in Enclosed Farmland, indicating a substantial long-term decline pollinators from Enclosed Farmlands. Over the short-term (between 2013-16 and 2021-23l pollinator indicators were stable in Enclosed Farmland ecosystems) (Emmett, Bentley, *et al.*, 2025)

Enclosed Farmland ecosystems contribute to economic well-being through the supply of the following **cultural** services:

- **Spiritual, artistic and symbolic services:** The UK NEA (2011) highlighted public motivation to protect traditional family farm structures and the associated approaches to traditional livestock husbandry in Wales (pp.1032). It is estimated that 49,500 people were working on farms in 2024, of which 37,300 are farmers, business partners, directors and spouses. The remaining 12,200 are employees, comprised of full-time employees, managers and casual workers (Welsh Government, 2024c)
- **Recreation-related services**: The ONS estimate that 42 million visits were made to Enclosed farmland in 2022, with visitors spending a total of £80million (2023 prices) (Office for National Statistics, 2024b).

Economic drivers and their pressures on Enclosed Farmland

The key direct economic driver within Wales that relates to the degradation of Enclosed Farmland ecosystems is 'Land and sea use management and change.' Direct exploitation as a driver of change on Enclosed Farmland is not considered to be a key issue in Wales. Note that there is some overlap between how pressures on Enclosed Farmland manifest via the land use / management and direct exploitation drivers. Climate change pressures are considered to be driven by global economic activity, and the specific economic drivers of pollution pressures are assessed via the relevant natural resource assessments.

Land and sea use and management change

Historically over the long-term (1946 to 2024) **Agricultural intensification** through large-scale land modification such as drainage, fertilisation, and hedgerow removal has simplified landscapes, negatively impacting biodiversity (SoNaRR 2020). There is a **mixed picture** of this pressure over the historic long and short term.

A shift towards livestock farming resulted in a 75% decline in cultivated land (1930s–1990s) and increased the extent of improved grassland. Hedgerow removal for agricultural productivity has stabilised in recent years and there are some tentative positive trends reported by ERAMMP (Emmett, Anthony, *et al.*, 2025). Over the short-term (2020 to 2024) there has been a slight increase in the arable area from 5% to 6% (Welsh Government, 2024c) A rise in maize production has been linked to an increased risk of soil erosion (Jaafar and Walling, 2010; Vogel, Deumlich and Kaupenjohann, 2016; Smith and Boardman, 2025). Extensively managed arable land is the only Critically Endangered habitat in the UK on the European Red List. In the future, there is greater arable and horticultural cultivation potential with predictions of higher temperatures, reductions in field capacity days and an increase in growing season length (Welsh Government, 2022a). However, future risks with greater volumes and intensity of rain in the winter and spring periods and changing timing of access to land may mean this is not realised (Bell, Naumann and Medcalf, 2021)

The size and weight of field machinery has increased considerably between 1960 and 2010 (Schjønning *et al.*, 2018). (Schjønning *et al.*, 2018)The increased use of contractors may lead to more field operations being carried out under unsuitable conditions as the farmer is no longer in control of the timing of the fieldwork or the machinery (ADAS, 2019). Topsoil bulk density (i.e. compaction) has significantly increased between 2016 and 2023 in Improved Grassland, Arable Soils and 13% on Semi-Improved grasslands (Emmett, Bentley, *et al.*, 2025)

Across the UK there has been a 60% decrease in the total weight of pesticide active ingredients applied in agriculture between 1990 and 2020 (DEFRA, 2025b). More recent data shows the weight of pesticides and the number of hectares treated on arable land has fluctuated whilst the weight of pesticides and number of hectares treated on grassland and fodder crops has continued to fall (Fera, 2022).

Total application rates of purchased inorganic fertiliser (NPK) has declined overall between 2019-20 and 2022-2023 (Welsh Government, 2024b) which follows broader GB trends. Trends in organic fertilisers (livestock manures and slurries, waste, sewage sludge and end of waste materials) are not available. It is estimated that 10 million tonnes of organic manures are applied to the agricultural landbank in Wales each year. Modelling has shown in some parts of the country the landbank is already under pressure. (SoNaRR 2025 Land Use and management change chapter and SoNaRR 2025 Annex 5: Aim 4 Waste evidence).

Between 2004 and 2024, the size of the Welsh dairy herd increased by 3% and the size of the beef herd fell by 33%. Poultry numbers are higher than they were 20yrs ago (~3million) and are similar to numbers in 1999-2001 (Welsh Government, 2024c).

Organic agriculture is one form of sustainable agriculture with standards that prohibit the use of synthetic fertilisers and pesticides. The focus on utilising lower off-farm inputs with biological and mechanical pest management has multiple benefits for the environment. Organic agriculture tends to support higher levels of biodiversity, soil carbon stores and has fewer negative impacts on water quality and air quality than conventional agriculture (NRW, 2021a). The organic farming area in Wales fell from 83,100 ha in 2020 to 76,900 ha in 2023, when it was 15% of UK Organic land (DEFRA, 2024a)

Policy responses to climate change and the nature emergency, and delivery mechanisms such as the UK Pesticides National Action Plan and the Sustainable Farming Scheme, could result in more sustainable land management practices in the future (DEFRA, 2025b; Welsh Government, 2025c).

The long-term trend (1939 – 2011) for **Built development and infrastructure** on Welsh Enclosed Farmland in Wales is deterioration. Urban expansion has often been at the expense of the most productive land and therefore enclosed farmland. The Best and Most Versatile land decreased by 21,275 ha between 1939 and 2011. (Welsh Government, 2022c)

Between 1990 and 2021 the area of land classified as urban increased by 76,253ha, or 3.59% of the total area of Wales. Enclosed farmland saw the greatest conversion to urban, with 41,313ha (or 3.76%) out of a total of 1,099,191ha being converted (Office for National Statistics, 2024b). ERAMMP reports that urban cover increased by 28% (28,200ha) between 2010 and 2021. This is an area greater than the increase in woodland area and the majority has come from improved grassland (Emmett, Anthony, *et al.*, 2025). The predicted annual loss of BMV land to urbanisation (for example to increase housing provision) over the next five decades is expected to be minimal when compared to historical losses. (Lewis-Reddy and Behrendt, 2020; NRW, 2021a)

Wind and ground mounted solar on enclosed farmland affects the functioning of the ecosystem, causing habitat fragmentation, loss of biodiversity, soil and drainage impacts, loss of productive land, and potentially loss of tree cover.

Renewable energy infrastructure on enclosed farmland is a relatively new pressure. Generation of electricity from renewable sources has been steadily increasing over the past 15 years. In 2023 34% of total electricity generation in Wales came from renewable sources (Welsh Government, 2025b). Only some of this will have been on enclosed farmland. More information is provided in the SoNaRR 2025 Aim 4 assessment.

The “boom” in renewable energy capacity installations, some of which will have been sited on enclosed farmland, has apparently levelled during the last few years. The latest data shows significant growth in registrations of new domestic and small-scale solar and heat pump capacity during 2023 (MCS, 2024)).

The Department for Business, Energy and Industrial Strategy proposes that future solar power will need between 0.8 and 1.6 hectares of land to produce 1MW of power (Solar Energy UK, no date). The direct impact areas of onshore wind turbines is considerably less, and land between the turbines can still be used productively. There are many policies, strategies, plans, guidance and advice notes relevant to built development and infrastructure on enclosed farmland.

Long term trend data for **afforestation** is discussed in the Woodlands assessment. Some of this will have been within enclosed farmland but it is not possible to identify how much.

There is less trend data for Trees outside Woodlands (ToW). In 2016, the extent of ToW in Wales was 92,700ha, comprising 49,200ha of small woods (<0.5ha), 33,400ha of groups of trees and 10,00ha of lone trees (Forestry Commission, 2017).

The ERAMMP National Trends and Glastir Scheme Evaluation Report (2025) reported on woodland, hedges and veteran trees extent and condition. Content relevant to woodlands is discussed in the Woodlands assessment. In relation to hedgerows, ERAMMP (2025) reported that the length of hedgerows (as calculated by the national estimate method) has increased by 4% of 2010 values however, there is high uncertainty around these estimates. There has been no change in the total number of individual trees per square. Additional woody linear features data is available but has not been analysed to date.

Progress towards meeting Aim 4 (Contributing to a Regenerative Economy, Achieving Sustainable Levels of Production and Consumption)

The key opportunities taken up since SoNaRR 2020 comprise:

- Welsh Government's Sustainable Farming Scheme (SFS), which starts in 2026, aims to support farmers in the sustainable production of food whilst addressing both the climate and nature emergencies. It addresses the Sustainable Land Management objective in the Agriculture (Wales) Act 2023 to produce food and other goods sustainably.
- The Agricultural Soil Policy Statement was published and provides the aim of more sustainably managed agricultural soils across Wales (Welsh Government, 2025a).

Opportunities for Action Aim 4

The possible actions identified with respect to achieving Aim 4, relate to Nature based Solutions, Payments for ecosystem services Pollution management, Sustainable agriculture, forestry and fisheries, Sustainable construction, Sustainable transport and Renewable energy.

Action 18. Mitigate pressures from built development and infrastructure (including for renewable energy).

Action 19. Sustainable agriculture with appropriate grazing intensity to improve enclosed farmland ecosystem condition, biodiversity, produce high value produce and climate change mitigation co-benefits.

Action 20. Encourage investment in enclosed farmland ecosystems for Nature based Solutions for climate change adaption and for water / waste purification.

Action 21. Sustainable arable production using practices such as intercropping, complex multi-year crop rotations, cover crops, reduced tillage and integrated pest management.

Action 22. Sustainable livestock rearing through improving soil condition, sustainable forage management and livestock health.

Action 23. Promote Organic practices.

Action 24. Manage use of Organic manures to improve soil health and not overwhelm the Landbank.

Evidence Needs

Key evidence needs include baseline data on traditional orchards, hedgerows, veteran trees, and arable plant assemblages, as well as improved grassland. There is limited information on the condition of semi-natural habitats within farmland, such as species-rich arable land and wood pasture. Evidence is also needed to define what constitutes “good condition” for productive land and to assess species composition in wood pasture and orchards. Sustainable management practices, including water efficiency and nutrient use, require further investigation to support agro-ecological approaches that complement natural systems and work with nature. .

Evidence is needed on soil erosion, compaction, and carbon sequestration potential in grassland soils. The impact of maize crops for biomass, agroforestry systems, and emerging contaminants on ecosystem services is also under scrutiny. Behavioural change in landowners and contractors is a recurring theme, particularly regarding hedgerow management and restoration of wood pasture. These gaps highlight the need for targeted monitoring and policy development to enhance the resilience and sustainability of enclosed farmland in Wales.

A better understanding of the long-term and short-term trends in the establishment and pathways of Invasive non-native species (INNS) in relation to enclosed farmland is needed. There is also limited information on the detailed trends of indicators that are used to estimate the impact of schemes on addressing INNS. There is more evidence about general trends which tend to be similar at a global/EU and GB level and across most terrestrial ecosystems.

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Freshwater ecosystem

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Freshwater-based ecosystems occur wherever rainfall, snowmelt or groundwater collects into rivers and streams, standing waters, or associated bogs, fens, grazing marshes, wetlands and floodplains.

This freshwater assessment is one of eight ecosystem and three natural resource assessments that inform the overall SoNaRR2025 report. It builds on the findings of SoNaRR2020, drawing together updated evidence from subject experts, national datasets, and collaborative projects such as Four Rivers for LIFE, DeeLIFE and the Upper Wye Restoration project. This assessment is closely linked to the Water Assessment as well as to evidence in the Climate Change and Land Use Change assessments.

The assessment is structured around four interlinked aims that guide Wales' progress toward the sustainable management of natural resources (SMNR), helping to communicate the relationship between the environment, well-being, and the economy

Key messages

1. Freshwater ecosystems provide important ecosystem services including drinking water, renewable energy production, flood and drought mitigation, waste disposal, fisheries and recreation. However, their ability to do so is increasingly compromised.
2. The resilience of freshwater ecosystems has not improved since 2020, and some widespread species are undergoing further declines; salmon is predicted to be locally extinct in some Welsh rivers by 2030. There are huge pressures from climate change, rural and urban pollution, physical modifications, changes to flow, and invasive non-native species.
3. More frequent extreme weather events and increasing temperatures are a serious risk to freshwaters with floods and droughts causing degradation of habitat, wash out of species, changes in food availability, shifts in species composition and stranding of species.
4. Restoration projects across Wales are demonstrating the positive impact of interventions such as restoring gravels and boulders, putting large wood into rivers, removing bank protection and embankments, re-meandering straightened sections, creating wooded river corridors and addressing barriers. In total 854 km of river has been improved, protected or restored since 2020 and this is set to continue into the future.
5. We must take a collaborative approach to landscape scale catchment management, ensuring that the Sustainable Farming Scheme delivers for freshwater and improving our regulation of habitat degradation. Ultimately this relies on society's awareness of the environment and the impact of our behaviours.

Freshwater Ecosystem Summary SMNR Assessment

Aim 1: Stocks of natural resources are safeguarded and enhanced

Freshwater ecosystems in Wales face significant pressures from modification, regulation, pollution, invasive species, and climate change. Most freshwater species recently assessed under the Habitats Regulation are in unfavourable condition, with salmon and freshwater pearl mussel in serious decline. Invasive non-native species (INNS) such as Himalayan balsam and signal crayfish continue to threaten native biodiversity and riverbank stability. Pollution from nutrients, chemicals, and metals have historically degraded water quality, though some improvements have occurred. However, emerging contaminants like microplastics and pharmaceuticals pose new risks, and the future outlook remains uncertain.

Efforts to safeguard freshwater resources include habitat restoration, INNS control, and pollution management. Projects like 4 Rivers for LIFE and the Wales Metal Mines Programme are improving river habitats and reducing pollution. Constructed wetlands and weather stations help manage runoff and water quality. Water company investments are addressing storm overflow spills, and research into antimicrobial resistance is advancing understanding of waterborne health risks. These actions support species conservation and enhance ecosystem resilience.

Aim 2: Ecosystems are Resilient to Expected and Unforeseen Change

The resilience of freshwater ecosystems is their capacity to withstand external pressures. The mechanisms of resilience are generally quite well understood in freshwaters, although our understanding of the resilience of freshwaters in Wales is hampered by a lack of national level datasets to measure it.

The assessments of diversity, extent, condition, and connectivity across freshwater habitats reflect the way ecosystem resilience of freshwaters has been significantly compromised by human impacts on habitat structure such as invasive species, the extent of shade, weirs and dams, abstractions, and river-flood plain connectivity. Generally, assessments are lower in lowland freshwaters compared with those in upland areas, with upland lakes and rivers assessed higher for diversity and condition.

The main challenge in delivering SMNR for freshwater habitats and species in Wales is preventing further damage and identifying opportunities to restore natural ecosystem function in order to build resilience. Restoration projects like DeeLIFE and Salmon for Tomorrow have improved over 850 km of river environment and enhanced fish migration routes between 2020-2025. These efforts, alongside updated River Basin Management

Plans and targeted habitat measures, are stabilising measures of extent and connectivity and building resilience against climate change and other pressures.

Aim 3: Healthy Places for people, protected from environmental risk

Freshwater ecosystems support human health by purifying water and regulating extreme flows. In-stream and riparian processes retain significant amounts of sediment and nutrients, improving water quality. Constructed wetlands are being trialled to treat effluents and manage water flow, contributing to safer and cleaner environments.

These ecosystems also enhance well-being through recreation, cultural heritage, and education. Over 28 million visits were made to freshwater sites in 2021/22, offering physical and mental health benefits. Traditional fishing methods hold heritage value, and many freshwater sites support learning and research. However, minority groups remain underrepresented among visitors. Promoting equitable access and cultural services can strengthen the role of freshwater ecosystems in public health and well-being.

Aim 4: Contributing to a Regenerative Economy, Achieving Sustainable Levels of Production and Consumption

Freshwater ecosystems contribute to the economy through water purification, hydropower, and recreation. In 2023, hydropower generated 332 GWh, supporting Wales' renewable energy goals. Clean water reduces treatment costs for industries and utilities, and nature-based solutions like wetlands offer cost-effective alternatives to built infrastructure. Recreational activities linked to freshwater ecosystems support local economies, with tourism spending reaching £90 million in 2022.

Economic pressures leading to agricultural intensification, built development and water abstraction remain a concern, especially in the face of the changing climate. However, nature based solutions, restoration interventions and improved land management are promoting sustainable land use and enhancing the regenerative potential of freshwater ecosystems. In addition, planning controls are reducing nutrient inputs into key freshwater protected sites and rod/net licence exploitation controls have reduced pressure on salmon and sea trout.

Key changes since SoNaRR2020

Since SoNaRR 2020, new evidence has provided more confidence in the assessment of key freshwater species and a better understanding of the key pressures notably water pollution. A high proportion of water bodies are failing targets for nutrients and salmon are at risk of localised extinction.

The impacts of climate change are becoming more evident and increasing; new evidence shows complex interactions with salmonid spawning and survival as well as long term reductions in cool water stoneflies in response to warming temperatures.

The improved evidence base combined with high levels of public interest and awareness in the health of freshwaters is enabling a variety of regulatory and restoration responses. In particular, planning controls on nutrients are in place across riverine protected sites and we have several large-scale projects working to restore freshwater processes and features. Moving forwards, finding sustainable funding sources and working collaboratively across catchments are priorities to deliver long term solutions for nature and communities.

Freshwater ecosystem Full Assessment of SMNR

Aim 1: Stocks of natural resources are safeguarded and enhanced

The natural resources, as defined in the Environment (Wales) Act 2016. Section 2, most relevant to the Freshwater Ecosystem are Animals, plants and other organisms; Air; Water; Soil; Climatic features and processes.

Animals, plants and other organisms

Out of 16 freshwater species assessed as part of the Habitat Regulations 9A reporting, all but one (otter) are in unfavourable condition. Ten are the same status in 2024 compared with 2018, five have deteriorated and one has improved (NRW, 2026). Twaite shad is benefiting from work to improve fish passage in projects such as Unlocking the Severn (2019). Some species are unfavourable due to reduction in range and population as well as habitat, (for example salmon, freshwater pearl mussel and white clawed crayfish). Other species (river lamprey, brook lamprey and bullhead) are favourable in terms of range and population, but the habitat is of insufficient quality (NRW, 2026).

Salmon and Sea trout are in serious decline across Wales and are threatened. In 2023 all 23 principal salmon rivers in Wales failed their conservation limits and are classed as at risk (Cefas, Environment Agency, and NRW, 2024). Clean water species such as Dippers have recolonised previously polluted urban rivers in Wales as clean-water invertebrates have shown some recovery in recent years (Maznikova, Ormerod and Gómez-Serrano, 2024) .

Historically **Invasive, Non-Native Species (INNS)** have caused deterioration of freshwater animals, plants and other organisms. (1970 - 2025). The future outlook is that this is expected to continue. INNS introduce **pests and diseases** and outcompete or predate native species affecting their abundance and diversity in Wales' freshwater ecosystems (e.g. Signal crayfish) (Bubb, 2004; GB Non-native Species Secretariat, 2011b; JNCC, 2019). INNS cause structural instability in riverbanks (e.g. Himalayan Balsam) (GBNNSS, 2011a, 2011d; Greenwood, Gange and Kuhn, 2020). INNS increase localised flood risk by blocking channels, interfering with navigation and water supply (GB Non-native Species

Secretariat, 2011a, 2017a, 2017b). INNS are a potential future risk (e.g. Pink salmon and Topmouth gudgeon to Atlantic wild salmon stocks) (GBNNSS, 2011h; JNCC, 2019a; Spikmans et al., 2020). Climate change may exacerbate pressures for INNS in freshwater ecosystems.

Air Quality

Historically, **air pollution** has caused deterioration of air, water and soil quality in freshwater ecosystems. The future outlook is variable for different air pollutants. Air pollution causes acidification (deposition of sulphur dioxide, nitrogen oxides and ammonia leading to reduction in pH level). At a national level, acidification has reduced (1990 to 2025) and is expected to continue to reduce into the future.

Acidification is still a problem in some catchments for example above Llyn Cwellyn in the Afon Gwryfai SAC in North Wales. Diatom analysis suggests that Llyn Cwellyn has suffered from progressive but moderate acidification since the 1860s, with a decline of around 0.8 pH units. From the 1980s to 1995 subtle changes in diatom composition suggest a slight reversal, thought to be caused by a drop in sulphur deposition within the catchment.

The upstream waterbody in the Afon Gwyrfai a Llyn Cwellyn SAC (Gwyrfai - upstream of Cwellyn) failed targets for pH and acid neutralising capacity in the 2024 SAC compliance assessment (NRW, 2025a). This is likely to be due to a historic problem with moderate acidification in the upper catchment. Ongoing monitoring indicates a gradual improvement due to reductions in atmospheric deposition and changes in forestry practices (NRW, 2022).

Water

Historically, water pollution has caused deterioration of air, water and soil quality in freshwater ecosystems (1970 to 2025). The future outlook is variable for different water pollutants. Water pollution from nutrients, chemicals, metals and bacteria reduces water quality which impacts freshwater organisms, groundwater and drinking water. Invertebrate and water quality data indicates progressive long-term recovery from past effects of gross organic pollution in urban areas of Wales between the late 1980s and early 1990s although this has stalled in recent years. This could be due to a combination of climate change, emerging contaminants, CSOs, legacy contaminants and some locally underperforming sewage infrastructure (Pharaoh *et al.*, 2023).

Some nutrient pollution (e.g. orthophosphate and ammoniacal nitrogen) has reduced over the long term in Welsh rivers (1990 to 2023), whilst other nutrients (e.g. nitrates) show no clear trend. Chemical pollution (e.g. from cypermethrin) has reduced over the long term but over the short term there have been some increases (e.g. in diazinon).

Metal pollution (largely from abandoned metal mines) has remained constant over the long and short term, with some localised improvements seen as a result of site specific intervention. Bacteriological pollution has improved over the long term (1980 to 2024) with significant improvements in waste water treatment works, but storm overflows remain a source of pollution over the short term.

Heavy metals, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs) and polybrominated Diphenyl Ethers (PBDEs) that enter waterbodies are persistent and can be toxic and bioaccumulate in the food chain. Levels are likely to have increased during the 20th century due to the development and manufacture of new compounds and increasing population levels (Whelan *et al.*, 2022). Bans and restrictions have been put in place on the production and use of many of these persistent chemicals. Despite this the future outlook is unknown

New chemicals, pharmaceuticals and microplastics are of emerging concern for water pollution. The water environment could be a vector of Antimicrobial resistance to humans, and residual antimicrobial pollution may favour resistant strains. There is concern that they may impact on ecosystems directly as well as human health, but mechanisms are not fully understood.

Water Quantity is discussed in the SoNaRR 2025 Water assessment.

Climatic features and processes

Changes in intensity and frequency of weather events has negative impacts on freshwater ecosystems. The future outlook is that this is expected to continue. Wales is predicted to experience warmer, wetter winters and hotter, drier summers, with a greater frequency of extreme events including heavy rainfall events and more intense droughts (Lowe *et al.*, 2019). High river flows and heavy rainfall can increase pollution to freshwater ecosystems. Increased runoff from land increases the levels of contaminants and sewerage systems become overwhelmed more frequently.

High flows and flooding increase erosion which re-shapes river channels and affects sediment movement as well as affecting spawning success, juvenile survival and washing out rooted macrophyte plants. Low flows and drought affects migration, spawning success and mortality of fish. Droughts also cause species such as pearl mussels to be stranded; expose water plants to physical damage, ultraviolet light, heat stress or frost; and can increase concentrations of pollutants in the water.

Changes in water temperature also cause deterioration of freshwater ecosystems. The future outlook is that this is expected to continue. Between 1990 and 2006, river waters in England and Wales warmed by about 0.3°C per decade. (Orr *et al.*, 2015). Data from tributaries upstream of Llyn Brianne show a long-term reduction in invertebrate abundance over four decades which coincides with increasing temperatures (pers. comm, 2024). Fish species are also exhibiting a long term and short-term response to the changing climate. The decline of arctic charr populations is correlated with warming lake temperatures and the warm 2016 winter is linked to reduced salmon spawning and recruitment. Other long-term impacts recorded in Wales include phenological changes, increased incidence of INNS, shifts in community composition, reduction in water quality and increased algal blooms. All these impacts are likely to intensify as water temperatures continue to increase in future decades.

Pressures from economic activity (see Aim 4 for more detail)

Pressures arising more directly from economic activity are also negatively affecting natural resources in freshwater ecosystems and ecosystem resilience (see Aim 4 for more detail). These pressures are (in alphabetical order): abstraction of water; agricultural intensification; built development and infrastructure, freshwater fisheries; physical modifications.

Abstraction of water, especially from small watercourses and groundwater, combined with inefficient use, can severely impact ecosystems – particularly during dry periods – by reducing river flows, lowering lake and groundwater levels, drying wetlands, and degrading water quality. Elevated temperatures, increase in pollution concentration and reduced oxygen levels further threaten aquatic life, hindering fish migration and increasing vulnerability to disease and predation. See also Water Assessment.

Agricultural Intensification is identified as a concern with respect to the management of land used for farming, particularly in relation to the affects it has on land drainage, soil compaction, loss of riparian corridor habitat, erosion and pollution to watercourses.

Built development and infrastructure is also a pressure of concern leading to an increase in the risk of flooding and pollution, along with loss of habitats, species and connectivity between rivers and flood plains, and between rivers and ponds/lakes.

Freshwater fisheries has been a pressure in the past**.** Direct exploitation of salmon and eels is now not permitted anywhere in Wales.

Physical modifications have a detrimental effect on river and lake processes and overall ecosystem functioning and reduce ecosystem resilience to other pressures.

Progress to meeting Aim 1 - Stocks of natural resources are safeguarded and enhanced

The key opportunities taken up since SoNaRR2020 comprise:

- INNS management in collaboration with Bannau Brycheiniog National Park Authority and West Wales Rivers Trust, as part of 4 Rivers for LIFE. Providing benefits to SAC rivers through habitat improvement and reducing livestock access to the river, which reduces nutrient and sediment inputs.
- Constructed wetlands for water flow attenuation and treatment.
- 12 Weather stations installed across South Wales rivers between 2020 and 2025. They allow farmers to plan their farming activities, such as slurry spreading, herbicide spraying, grass cutting; to minimise the run-off from land into river.
- Water company investment to address environmental impact of discharges to the water environment include a significant programme to address storm overflow spills.
- The Wales Metal Mines Programme started in 2020 with an overall aim of reducing metal mine pollution to land and rivers. There are 25 projects in the pipeline to carry out measures at over 50 sites.

- Our understanding of Antimicrobial Resistance (AMR) in Wales has improved through a literature review on existing data and knowledge; risk mapping of AMR at catchment level; and Molecular analyses of wastewater and some river water for AMR genes.

Opportunities for Action Aim 1

The possible actions identified with respect to achieving Aim 1 in Freshwater ecosystems relate to INNS and other species management, Pollution management, Species conservation and enhancement, Research and technology, Resource protection, and Sustainable agriculture forestry and fisheries.

Action 1. Control INNS in freshwater ecosystems that introduce pests and disease, outcompete or predate native species, effect bank stability, cause flooding, reduce navigation and clog pipes.

Action 2. Protect and boost native species populations by enhancing native habitats.

Action 3. Research air pollution and its effects on freshwater ecosystems.

Action 4. Control water pollution and protect freshwater ecosystems from its negative effects.

Action 5. Remediation of contaminated waters, including ground water, effected by new chemicals, microplastics and pharmaceuticals.

Action 6. Adapt freshwater ecosystems (especially heavily modified areas) to increase resilience to changing climatic processes and support native species.

Action 7. Research the emerging contaminants in freshwater ecosystems, including groundwater.

Aim 2: Ecosystems are Resilient to Expected and Unforeseen Change

Ecosystem Resilience is assessed in SoNaRR by using four ecosystem attributes as proxies: diversity, extent, condition and connectivity for each of the seven habitat types that make up the Freshwater ecosystem. The seven habitat types are upland rivers, lowland rivers, upland (low nutrient) lakes, lowland (higher nutrient) lakes, marl lakes, ponds and flood plains. There is a large variation in data availability across each of the habitats making up the freshwater broad ecosystem. Many data gaps remain.

Diversity

Historically habitat and species diversity of freshwater ecosystems has declined over the long term (WWF 2018). The historic short term is a mixed picture, with urban streams showing some improvements (Pharaoh *et al.*, 2023). Rivers and most lakes are described as stable since 2014 (NRW, 2026). Marl lakes have deteriorated since 2014 (NRW, 2026).

Ponds have deteriorated between 2016 and 2023 (Emmett *et al.*, 2025) The current assessment of diversity is different across the habitat types. 4 habitat types have low diversity (upland rivers, lowland rivers, lowland lakes, flood plains), 2 have medium diversity (marl lakes, ponds) and 1 has high diversity (upland lakes). The future outlook is a mixed. Most lakes are assessed as deteriorating with marl stable to 2050 There is limited evidence to assess the future trends of rivers, ponds and flood plains (NRW, 2026). Habitat restoration measures such as growth of riverside trees and removal of barriers are expected to create improvements, but this will take some time to take effect.

Extent

Historically extent of freshwater ecosystems have declined over the long term with many rivers straightened and simplified to single channels with much reduced features and processes (NRW, 2021). However, very little, if any channelisation of rivers or filling in of lakes has occurred in Wales over the last 20-30 years and it is therefore highly unlikely that there has been a detectable change in area of freshwater habitats in recent years (JNCC, 2019, 2019).

The future outlook is a mixed picture for all river habitat types. All lakes are assessed as stable to 2050. There is limited evidence to assess the future trends of ponds and flood plains (NRW, 2026). In the absence of improvements to the current regulatory system, further gradual habitat loss is likely, especially for ponds and rivers. However, the use of the Stop Notices in cases of physical damage to rivers is having a positive impact (NRW, 2024c, 2024a) and the planned restoration work will increase the extent of river habitat (see opportunities Aim 2).

Condition

Historically over the long and short-term, the condition of freshwater ecosystems show a mixed picture (Emmett et al., 2025). There has been a general and widespread decline in the countryside, especially in lowland areas and a gradual improvement in the uplands due to ongoing recovery from acidification and marked recovery in post-industrial areas, largely due to mine closures and in some instances, mine water treatment. The condition of marl lakes has deteriorated over the long-term (1995 – 2024) and short-term (2014-2024). The current assessment of condition is different across the freshwater habitat types. Five habitat types are assessed as low for condition (lowland rivers, lowland lakes, marl lakes, ponds and flood plains), two are assessed as medium for condition (upland rivers, upland lakes) and none are assessed as high (Emmett et al., 2025; NRW, 2025b, 2026). The future outlook is a mixed picture for all habitat types except marl lakes, which is predicted to be stable to 2050. Whilst there is significant restoration activity across many catchments in Wales planned for future years, pressures are continuing and, in some cases, increasing.

Connectivity

Historically over the long term, the connectivity of freshwater ecosystems is deteriorating. Over the short-term it is a mixed picture. The current assessment of connectivity is different across the habitat types with two habitat types assessed as low (lowland rivers and flood plains), two habitat types assessed as medium (upland rivers and ponds). The future outlook to 2050 is a mixed picture for all relevant habitat types. There is increasing awareness of the importance of connectivity for freshwaters and this is starting to translate into practical restoration projects (NRW, 2024e, 2024b).

Progress towards meeting Aim 2 (Ecosystems are Resilient to Expected and Unforeseen Change)

The key opportunities taken up since SoNaRR 2020 comprise:

- Largescale freshwater restoration projects are addressing a range of pressures and making rivers more resilient. These include DeeLIFERiver, 4 Rivers for LIFE, Upper Wye; NRW's River Restoration Programme, Salmon for Tomorrow, Sustainable Fisheries Programme; and work by organisations such as the National Trust and Rivers Trusts across Wales through the Inland Fisheries Habitat Grant. Between 2020 and the end of 2024, these projects resulted in:
    - 854 km of river environment improved, protected or restored.
    - 100 ha of habitat created, protected or restored.
    - 77 barriers to migratory fish improved.
    - 954 km of habitat connectivity improved for migratory fish.
- Updated River Basin Management Plans were published for Wales in 2021
- Salmon and SeaTrout Plan of Action - National and Cross-border Byelaws implemented and enforced, Fish Eating Bird Review concluded, and implementation project initiated. Additional monitoring of salmon migration on the Usk. Habitat measures delivered through Salmon 4 Tomorrow and Inland Fisheries Habitat Restoration programmes.

Opportunities for Action Aim 2

The possible actions identified with respect to achieving Resilient Freshwater ecosystems relate to Ecosystem restoration, Ecosystem creation, Ecosystem protection, Integrated plans, strategies and delivery, Nature based Solutions, Pollution management Species conservation and enhancement, and Sustainable agriculture, forestry and fisheries.

Action 8. Improve connectivity of lowland rivers and flood plains

Action 9. Improve condition of lowland rivers, lowland lakes, marl lakes, ponds and flood plains

Action 10. Prevent habitat loss, particularly for ponds and rivers.

Action 11. Improve (species and habitat) diversity of upland rivers, lowland rivers, lowland lakes, flood plains

Action 12. Adapt rivers to increasing temperatures resulting from climate change (i.e., River shading via afforestation or riparian habitat)

Aim 3: Healthy Places for people, protected from environmental risk

Health protection

Freshwater ecosystems contribute to human health protection through the supply of the following regulating services:

- **Water purification services** contribute to cleaner water for people to consume and use for recreation. The supply of these services is dependent on context, including catchment sizes, morphology, climatic conditions, and topography. It is estimated that in-stream processes in catchments retain about 173 tonnes of nitrogen every year, while riparian habitats account for about 29 tonnes of retention (Economics for the Environment Consultancy and UK Centre For Ecology & Hydrology, 2022)

- **Water flow regulation services** - There is evidence that river restoration can slow flood flows through the reintroduction of features such as meanders and encouraging reconnection of rivers with their floodplains and enable the storage of floodwaters on floodplains (DEFRA *et al.*, 2025).

Health Improvement

Freshwater ecosystems contribute to human health improvement through the supply of the following cultural ecosystem services:

- **Recreation-related services** provide opportunities for people to enjoy in-situ interactions with nature and associated physical and mental health benefits. In 2021/2022, people in Wales made over 28 million recreational visits to freshwater ecosystems (PaNS 2021/2022, NRW analysis – subject to update) (e.g. walking, recreational fishing, open water swimming, boating and canoeing). The Office for National Statistics (2024) estimates that visits to freshwater ecosystems increased by approximately 12% between 2019 and 2022, with around 100,000 people gaining related health benefits from these visits per year in Wales (same as estimated for 2009) (Office for National Statistics, 2024). Recreational fishing of migratory fish is underpinned by the nursery population and habitat maintenance services that maintain fish stocks.

- **Recreation-related ecosystem services** are often enjoyed in combination with visual and sensory amenity services. In 2017, around 70% of inland waters are considered of high or outstanding landscape value in terms of their scenic quality, integrity, character, or rarity. (White Consultants, 2018)

- **Nursery population and habitat maintenance services** cause an increase in the supply of relevant provisioning and cultural ecosystem services used by people. Upland rivers and streams provide important spawning and nursery habitat for salmon Salmo salar and trout Salmo trutta and contribute to maintaining stocks important for recreational fishing. In 2023, Wales recorded the lowest catches of both salmon (252 nets, 848 rods) and sea trout (610 nets, 5,669 rods) since consistent records began in 1970s (Salmon Stocks and Fisheries in England and Wales 2023). There is an ongoing decline in the capacity of freshwater ecosystems to supply this service.

Cultural Well-being

Freshwater ecosystems contribute to people's cultural well-being through the supply of the following cultural services:

- **Spiritual, artistic and symbolic services:** Traditional methods of net fishing for inland fish species are recognised as having a heritage value (Russell *et al.*, 2011, p. 1020). In 2023 a total of 252 Salmon and 610 Sea trout were caught using these techniques (Cefas, Environment Agency, and NRW, 2024)

- **Education, scientific and research services**. There are multiple nature reserves, SSSIs and other freshwater ecosystem sites that provide learning and research opportunities for people in Wales. However, indicators for the scale of the use of this service are unavailable for freshwater ecosystems discretely.

Equitable access

Minority groups are under-represented among visitors to waterways, national parks, and heritage sites – for example, before the Covid-19 pandemic only ~1% of visitors to UK National Parks were from Black or Asian backgrounds (Welsh Government, 2024)
See SoNaRR 2025 Aim 3 assessment for equitable access and flood risk

Progress towards meeting Aim 3 (Healthy Places for people, protected from environmental risk)

The key opportunities taken up since SoNaRR 2020 comprise:

- Natural Resources Wales are working with the water industry and others on the use of constructed wetlands for a variety of uses ranging from flow attenuation to treatment. NRW has committed to work with Dŵr Cymru on two trials at Tremeirchion Sewage Treatment Works and Pontyfelin storm overflow aimed at providing evidence and potential solutions to treating effluents.

Opportunities for Action Aim 3

The possible actions identified with respect to achieving Aim 3 in the freshwater ecosystem relate to Access to nature, Nature based solutions, Payment for ecosystem services, and Pollution management.

Action 13. River restoration and wetland construction to improve water quality for recreational use and direct consumption

Action 14. River restoration and wetland construction to reduce flood risk where appropriate

Action 15. Increase opportunities to visit river ecosystems (especially of high visual and sensory value) to support health improvement

Action 16. Promote the role of freshwater ecosystems in contributing to cultural heritage and learning

Aim 4: Contributing to a Regenerative Economy, Achieving Sustainable Levels of Production and Consumption

Freshwater ecosystems contribute to economic well-being through the supply of the following regulating services:

- **Water purification services** (water quality regulation) - Reduced water treatment costs for water utility and industries that abstract water direct from rivers - The supply of these services are dependent on context, including catchment sizes, morphology, climatic conditions, and topography (Economics for the Environment Consultancy and UK Centre For Ecology & Hydrology, 2022)

- **Pollination services** - Increase in fertilisation and production of agricultural crops and commercial horticulture - The contribution of pollinators to crop production in Wales is not known (Welsh Government, 2019, p. 3), Freshwater ecosystems contribute to economic well-being through the supply of the following provisioning services:

- **Energy from Hydropowe**r - In 2023 the estimated hydropower generation in Wales was 332 GWh across 380 projects (Welsh Government, 2025)

- **Water supply** for distribution - 523 million cubic meters abstracted by Welsh Water in 2023 for the public supply (Office for National Statistics, 2024)

Freshwater ecosystems contribute to economic well-being through the supply of the following cultural services:

- **Recreation-related services** - over 28 million recreational visits to freshwater ecosystems (e.g., for walking, recreational fishing, open water swimming, boating, and canoeing) (Owen, Rhydderch and Williams, 2025). These visits are linked to the leisure economy and include around 37,000 rod licenses (Environment Agency, 2025, tbl. 22), participation in canoeing of 61,500 adults and 62,000 children and around 1,600 boats counted on canals in Wales (Canal and River Trust, 2024b, 2024a).

Economic drivers and their pressures on freshwater ecosystems

The key direct economic drivers within Wales directly related to the degradation of freshwater ecosystems relate to **Land and sea use and management change** and **Direct exploitation.** Climate change pressures are considered to be driven by global economic activity.

Land and sea use and management change

Historically (1970 – 2025) **agricultural Intensification** has negatively affected animals, plants and other organisms in freshwater ecosystems, particularly in areas of intensive dairy farming (for example in West Wales and the lower Dee catchment) (Pharaoh *et al.*, 2024). Over the shorter term (2020 to 2025) numbers of cattle, calves, sheep and pigs have decreased and numbers of poultry have increased. Pollution from agriculture and land management are amongst the top pressures on freshwaters in Wales in terms of impact and likely future development (NRW, 2024d). See Freshwater ecosystem Aim 1 for more information on pollution trends.
The future outlook is that there will be more pressure on the limited supply of land to meet the predicted increase in global demand for food and timber (Confor, 2022; Meat Promotion Wales, 2024). Agricultural Intensification can result in increased land drainage, soil compaction, loss of riparian corridor habitat, erosion and pollution to watercourses.

Historically (1970 to 2025) **built development and infrastructure** has led to deterioration of freshwater ecosystems. The Building in floodplains is a key concern due to the increase in the risk of flooding and pollution, along with loss of habitats, species and connectivity between rivers and flood plains, and between rivers and ponds/lakes.

Historically the pressure of **physical modifications** has been increasing (1970 to 2025). The number of incidents involving river modifications reported increased from approximately 100 per year between 2016 to 2020 to approximately 200 per year between 2021 and 2024 (NRW, 2024c). Physical modifications have a detrimental effect on river and lake processes and overall ecosystem functioning and reduce ecosystem resilience to other pressures. See Aim 2

Direct Exploitation

Direct exploitation of freshwater ecosystem services by the economy is as a result of direct **abstraction of water,** and **freshwater fisheries**.

Water is abstracted from surface waters and groundwater and is used for household water supplies, agriculture, amenities, crown estates, industry and the environment.

Small water courses and groundwaters that supply abstractions and groundwaters are particularly vulnerable during prolonged dry periods.

Historically (1995 to 2020) the volume of water supplied by Dŵr Cymru has reduced from 1000 Ml/d to 850 Ml/d. About half of this reduction is due to reduced leakage, the rest is due to reduced demand from heavy industry and customers increasing appreciation of the value of their water supply and subsequent reduction of usage. (Dŵr Cymru Welsh Water, 2024). Over the shorter term (2019 to 2024) the trend is less clear, with most sectors increasing their water demand but Industry reducing by 11% (licensed abstractions by sector).

Hafren Dwfrdwy predict a long-term decline in demand for water in North East Wales, driven by a falling population over the next 60 years (Hafren Dyfrdwy, 2024).

Considered to have had an impact on the freshwater ecosystem in the past, recent trends (2020 – 2025) show that **fisheries** as a pressure has reduced due to exploitation controls. Other pressures such as climate change are having a greater impact (ICES, 2022; Cefas, Environment Agency, and NRW, 2024). Harvesting of salmon and eels is no longer permitted anywhere in Wales. The last eel fisheries operating in Wales were closed in 2021. Byelaws in 2020 have addressed concerns about declining salmon and sea trout stocks across Wales. Legal exploitation is now at a low level for these species, and it is thought that illegal exploitation in rivers and estuaries is also at a low level.

The impact of climate change and the level of unreported or illegal fishing for salmon at sea and particularly in the high seas outside of Economic Exclusion Zones remains a key concern. Some scientists believe this may be one of the main causes of the continued decline in salmon (Dadswell *et al.*, 2022)

Contributions of Freshwater ecosystem to sustainable economic production and consumption

Electricity generated from hydropower and pumped hydropower facilities plays an important role in Wales in decarbonising the energy sector. 4% of all Wales renewable energy generation in 2023 was from hydropower (Welsh Government, 2025). Therefore, water plays an important role in supporting the transition to a circular economy and achieving net-zero emissions in Wales. However, the hydropower sector is associated with the highest land use intensity of energy generation (see Aim 4, Annex on Circular Economy Deep Dive). The Welsh Government has set a target for renewable electricity generation to be equivalent to 100% of annual electricity consumption by 2035. In 2023, renewable electricity generation in Wales was equivalent to 53% of its electricity consumption, including losses

Safeguarding and enhancing clean water resources will reduce chemical and energy costs associated with water treatment. Green (or nature based) solutions can contribute to these cost savings whilst also serving to build back the stocks of nature in catchments (Dŵr Cymru Welsh Water, 2023).

There is evidence that investment in river restoration and constructed wetlands in the right places improves water quality (Carstensen *et al.*, 2020), decreasing investments in treatment works, and mitigates flood risk (reducing the need for built infrastructure solutions). (DEFRA *et al.*, 2025)

Those visiting Freshwater ecosystems in Wales for tourism and recreation spent around £90 million in 2022 (Office for National Statistics, 2024), providing opportunities to boost the local economy..

Progress towards meeting Aim 4 (Contributing to a Regenerative Economy, Achieving Sustainable Levels of Production and Consumption)

The key opportunities taken up since SoNaRR 2020 comprise:

- Water meter uptake increased from 40% to 47% in the Dŵr Cymru area between 2019 and 2020/21. (Hafren Dyfrdwy customer research shows limited appetite for universal metering, as the area they serve is not water stressed)
- Welsh Government study identified potential abstraction hotspots for private water supplies.
- Various regulatory work as well as proactive projects such as the DeeLIFE and 4 Rivers for LIFE have been working to improve land management practices across catchments. Between 2020 and the end of 2024, the following has been delivered:
    - 500km of riparian corridor improved or created
    - More than 40000 trees planted
    - 120 farms visited.
    - 68 farm reports completed, advising on land management practices over 7,300 hectares.
    - On farm works carried out on 26 farms.

Opportunities for Action Aim 4

Action 17. The possible actions identified with respect to achieving Aim 4 relate to Access to Nature, Increase resource use efficiency, Nature based Solutions, Payments for Ecosystem Services, Pollution management, Research and technology, Sustainable agriculture, forestry and fisheries, and Sustainable construction, Increase participation in freshwater recreation to boost local economies

Action 18. Invest in river restoration and wetlands taking a nature based approach to improve biodiversity, water quality and flood protection where costs are beneficial

Action 19. Research, development and implementation of water efficiency measures across all sectors.

Action 20. Identify opportunities for water transfer schemes to contribute to a regenerative economy on a UK-wide scale

Action 21. Implement vision of the Climate Resilient Fisheries Strategy to ensure sustainable managed fisheries allow more people from more backgrounds to connect with nature.

Evidence Needs

There is a critical need to assess the current extent, condition and trends in freshwater ecosystems in Wales. Evidence gaps include the extent of physical modifications, the impacts of climate change and the vulnerability of freshwater-dependent species. Tools for measuring ecosystem health and the benefits of restoration interventions are also needed, alongside improved monitoring of species such as lamprey, frogs, and toads. These insights are essential for informing sustainable management and enhancing the resilience of freshwater ecosystems under increasing environmental pressures.

A significant number of evidence needs relate to understanding the sources and impacts of water pollution, including fine sediments, emerging contaminants, and agricultural runoff. There is a call for reliable source-apportionment methods and tools to quantify the ecological effects of pollutants on species like salmon and freshwater pearl mussels. Additionally, the role of regulatory practices, abstraction pressures, and water efficiency in shaping ecosystem health requires further investigation.

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Marine ecosystem

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The marine ecosystem includes the intertidal and subtidal inshore areas. The intertidal is the area between the high water mark and low water that is inundated with seawater at some stages of the tidal cycle. The subtidal is the area that is permanently immersed in seawater

This marine assessment is one of eight ecosystem and three natural resource assessments that inform the overall SoNaRR2025 report. It builds on the findings of SoNaRR2020, drawing together updated evidence from subject experts, national datasets, and collaborative projects such as the Marine Climate Change Impacts Partnership. This assessment is closely linked to the Coastal Margins ecosystem assessment and Water assessment.

The assessment is structured around four interlinked aims that guide Wales' progress toward the sustainable management of natural resources (SMNR), helping to communicate the relationship between the environment, well-being, and the economy

Key messages

1. Wales has a rich and diverse marine ecosystem which can provide many important services for people and the economy, including food, energy, blue carbon and recreation. Some of these services could be developed as nature-based solutions for the people and economy of Wales through habitat restoration and enhancement.
2. Around half of the species and habitats assessed in Welsh marine protected areas (MPAs) are in unfavourable condition. There are multiple causes; one of the main causes is water pollution. The condition of habitats outside MPAs is thought to be an equally mixed picture.
3. Climate change is leading to increasing pressures affecting Welsh marine ecosystems, including sea level rise and increased temperatures. Expansion of offshore renewable energy to meet net zero targets needs careful management to meet the requirements of both the climate and nature emergencies.
4. Effective marine management to reduce pressures, actions to restore habitats, and a collaborative approach to landscape scale catchment management to tackle multiple sources of pollution, are required to improve resilience of marine ecosystems.

5. Addressing many of the known pressures requires a collaborative, strategic and multi-faceted approach, for example through marine planning, building the evidence base, and influencing behaviour change through engaging people with the sea.

Marine ecosystem Summary SMNR Assessment

Aim 1: Stocks of natural resources are safeguarded and enhanced

Welsh seas contain a rich variety of natural resources. Populations and habitats show mixed trends, and key pressures affecting their condition and extent include climate change, disease, water pollution, invasive species and marine activities. Climate change is a growing threat with increasing sea temperatures, accelerating sea level rise and increasing ocean acidification. Climate induced changes in species distributions and survival, and the extent and condition of coastal habitats are already being observed.

Water pollution remains a persistent issue. Excess levels of nutrients in estuaries (point and diffuse, e.g. from agriculture), are impacting condition, and contaminants like mercury and PCBs are still present at harmful levels in some areas. Marine litter, especially plastics, remains widespread despite some short-term improvements. Although there is low confidence in the data available for more recent trends of marine Invasive Non-Native Species (INNS), they continue to impact biodiversity and marine industries. Anthropogenic underwater noise is widespread and likely to increase with expanding marine development. Highly Pathogenic Avian Influenza has led to sharp declines in internationally important seabird populations since 2021.

Funding mechanisms are being developed to support delivery of actions to safeguard and enhance species and habitats (e.g. Marine Fund Cymru), and there is a growing emphasis on developing and communicating evidence to help target effort to support positive outcomes. Going forwards, SMNR and strategic planning need to be climate-smart, taking account of predicted changes and adapting approaches to meet the implications of a changing climate.

Aim 2: Ecosystems are Resilient to Expected and Unforeseen Change

Marine ecosystem resilience is assessed through diversity, extent, condition, and connectivity. There is a mixed picture for diversity in Welsh seas. Declines have been noted in some specific areas, such as the intertidal habitats in Milford Haven and the horse mussel beds in Pen Llŷn A'r Sarnau Special Area of Conversation, although diversity of many habitats remains stable. Marine habitat extent also shows a mixed picture in long and short term trends. For intertidal habitats, the long term trend is a decrease in extent, but the short term trend is more variable. The picture for subtidal habitats is also mixed although there are known decreases in extent of maerl beds.

Over the long-term, condition of habitats has been deteriorating in the intertidal zone linked to pressures including overgrazing, water pollution, coastal development and activities like bait digging. Condition of subtidal habitats show mixed trends. Connectivity across marine habitats is generally high and stable.

Actions to enhance resilience of marine ecosystems are gaining momentum, this includes recovery of habitats and species through the removal of pressures and active restoration. Work is also progressing to fill evidence gaps to understand the factors which are impacting resilience, and to identify which areas are most suitable for recovery and restoration to target action and deliver positive outcomes.

Aim 3: Healthy Places for people, protected from environmental risk

Marine ecosystems support human health by regulating climate, protecting coasts, and purifying water. Crucially, Welsh marine habitats store over 113 million tonnes of carbon, comparable to Welsh forests, and sequester thousands of tonnes annually. Seagrass and kelp help reduce coastal erosion and flood risk. Bathing water quality is high, with 94% of designated sites rated Excellent or Good in 2025.

Marine ecosystems play an important role in well-being through recreation. A 2021/22 report showed people in Wales made approximately 20 million visits to the marine environment, and research shows that most people recognise the positive impact on their mental and physical health. Marine ecosystems also support cultural services including education, research, and spiritual value. Access remains unequal, with inland and lower-income communities facing barriers, though the connection of local communities to their coastal areas remain strong. Wales is the first country in the UK to publish an Ocean Literacy Strategy (published in 2025), with a range of actions proposed to strengthen people’s connections with the marine environment.

Aim 4: Contributing to a Regenerative Economy, Achieving Sustainable Levels of Production and Consumption

The offshore renewables sector in Wales provides an important contribution to the economy; offshore wind investment in Wales reached £103 million in 2023, with future projects expected to create thousands of jobs. Tourism and recreation contribute significantly to the economy, with nearly 20 million marine visits annually. Sustainable tourism could help regenerate ecosystems and communities if managed well. The marine environment also contributes to Wales’ economy through providing a means of global trade, seafood, sand for construction and coastal protection.

Pressures from renewable energy infrastructure, and recreational activities are likely to increase, but evidence, guidance and mapping tools are being developed to support sustainable marine planning. Fisheries management plans and monitoring systems are being implemented to help ensure long-term sustainability. Strategic planning aims to balance development with environmental protection, addressing both the climate and nature emergencies as well as supporting the economy**.**

Key changes since SoNaRR2020

Since SoNaRR 2020, new evidence has provided more confidence in the assessment of marine habitat condition and a better understanding of the key pressures which include water pollution. The condition of marine intertidal habitats and the extent of subtidal habitats have deteriorated. Seabird populations have suffered sharp declines due to Highly Pathogenic Avian Influenza.

The effects of climate change are becoming more evident and increasing for marine and coastal ecosystems, and new evidence predicts significant effects due to coastal squeeze. The planned expansion of offshore renewable energy has accelerated since the introduction of net zero targets and this presents both opportunities and challenges in responding to the climate and nature emergencies.

The improved evidence base is supporting the development of more targeted actions to enhance the resilience of marine and coastal ecosystems. These restoration and recovery agendas are receiving increased and needed attention, and identifying and developing sustainable funding mechanisms to support delivery is a priority. The publication of an Ocean Literacy Strategy for Wales in 2025 represents an opportunity to increase capacity and engagement, promote behaviour for sustainable use of marine resources and increase access to well-being benefits.

Marine ecosystem Full Assessment of SMNR

Aim 1: Stocks of natural resources are safeguarded and enhanced

Animals, plants and other organisms

Seabirds: 2019 -2025: Deteriorating. We reported in SoNaRR2020 that auks, gannet, Manx shearwater, and terns had healthy population increases. There have been reductions since 2000 in most gull species except Great black-backed gulls and a reduction in shags and cormorants. Since avian influenza arrived in the UK in 2021, populations of gannets, terns and guillemots have been hit by mass mortalities. For example, in 2023, Northern gannets on the third largest colony in the world, Grassholm, declined by 57%, Sandwich tern decreased by 42% in Wales and common tern decreased by 39% in Wales. Reductions in black-headed gull and guillemots are yet to be assessed (Tremlett, Morley and Wilson, 2024).

Wintering Waders: 2010/11 - 2020/21: Deteriorating. Wales has seen large declines in grey plover, bartailed godwit and black-tailed godwit. The UK has seen an increase in black tailed godwit and smaller declines in grey plover and bar-tailed godwit. Wales and the UK have also seen a similar decline in oystercatcher, curlew, and dunlin. Knot have increased over the UK but have seen a decline in Wales whilst Wales has seen an increase in redshank compared to a decrease across the UK (Austin *et al.*, 2023).

Wintering Wildfowl: 2010/11 - 2020/21: Deteriorating. Wales has seen decreases in Greenland white-fronted geese, wigeon, teal and great crested grebe similar to the UK but often these decreases are greater. Wales has also seen decreases in Pintail and Shoveler whilst these have increased across the UK. Wales has seen an increase in Gadwall and shelduck whereas these have declined across the UK (Austin *et al.*, 2023).

Grey Seal 1992 to 2025: Improving. Over the long-term, the grey seal population at monitored sites in Welsh waters has shown an upward trend in pup production(Strong *et al.*, 2006; J. C. Bull *et al.*, 2017; J.C Bull *et al.*, 2017; Morgan, Morris and Stringell, 2018; Bull *et al.*, 2021; Robinson *et al.*, 2023; Büche and Bond, 2024).

Harbour Porpoise 2005 to 2022: Unknown in Welsh inshore waters. Significant decline between 2005 and 2022 in Celtic and Irish Seas. The harbour porpoise population in the Celtic and Irish Seas Management Unit are subject to high levels of fisheries bycatch. (Hammond *et al.*, 2013, 2021; Rogan, E *et al.*, 2018; Gilles A *et al.*, 2023; Paradell *et al.*, 2024).

Bottlenose Dolphin 2001 to 2024: Stable in Cardigan Bay. The population associated with the coast of Wales has been generally stable over the longer term with several hundred individuals. There is some evidence of a population decline in the last decade or so from a peak in 2008/2009 but a slight upswing in recent years. Future outlook is that the population in Wales will continue to be stable (Lohrengel *et al.*, 2017, 2025; Geelhoed *et al.*, 2022; Inter-Agency Marine Mammal Working Group, 2023).

Increases in **water temperature** are leading to an apparent northward shift in some warmer water cetacean species around the UK. This is resulting in novel food-web interactions, increased predation risk and competition for prey species. Evidence continues to show that changes in summer algal blooms and zooplankton affect important prey species such as sand eels (Martin, Banga and Taylor, 2023). Increases in warm-water fish species in UK waters continue to be observed, along with local declines of some cold-affinity species. Several species of cephalopods have shown noticeable increases in abundance and geographical spread in UK waters due to ocean warming (Fox *et al.*, 2023).

The number of **Invasive Non-Native Species (INNS)** in Wales has generally been increasing since the 18th century and accelerated from the 1950s due to increased trade and travel globally (Seebens *et al.*, 2023), which is likely to be reflected in marine INNS. Data collected more recently suggests there is some conflict in the data available for more recent trends of INNS in marine ecosystems. One assessment notes rates of new introductions is stable (from 2009-14) and decreasing (2015-2020) (OSPAR Commission, 2017; Stæhr *et al.*, 2022; Cefas, in prep). Other sources for general INNS indicate a general continuous increase for INNS. Marine pathways for INNS in Wales are unlikely to change substantially in the medium term (2025 to 2070) (Dewey, N. *et al.*, 2021).

Invasive Non-Native Species (INNS) impact on biodiversity and ecosystem resilience through competition with native species, predation, disease, altering structure of ecosystems, genetic impacts such as hybridisation, spreading disease or interfering with the genetic integrity of native species (Welsh Government, 2017; Tillin *et al.*, 2020; Roy *et al.*, 2023). INNS can have economic costs for marine sectors such as fisheries (Eschen *et al.*, 2023), due to increased cleaning time and restriction on movement of stock. Many other sectors can be negatively affected, such as the marine recreation sector and industry (GB Non-Native Species Secretariat, 2024).

Pests and diseases have affected marine animals. The Highly Pathogenic Avian Influenza (HPAI) is a new and major threat to internationally important seabird populations in the UK (Tremlett, Morley and Wilson, 2024). HPAI caused mass mortality of seabirds in the UK and Wales in 2022 and 2023. Recent evidence suggests that the avian flu virus is changing and adapting to infect mammals, including marine mammals (Plaza *et al.*, 2024). In the future there is a risk that this emerging pathogen could impact new environments and species.

Water

Historically, there is a mixed picture for **water pollution** in marine ecosystems (1980 to 2025). This has not changed over the short term (2020 to 2025) and is likely to continue in the future (to 2030). Types of water pollution include nutrients, chemicals, metals, bacteria, suspended solids, warm water, and litter (which reduces water quality or leads to entanglement, ingestion and bioaccumulation which impact marine organisms). See SoNaRR 2025 Water assessment.

There are excess levels of nutrients in transitional waters (particularly estuarine) as a result of point source or diffuse pollution mainly from agriculture, which is impacting marine feature condition. For the 20 habitat features across the marine SACs in unfavourable condition, 9 had a primary failure for water quality (nutrients (DIN only)) (45%) (Hatton-Ellis, *et al.*, 2025). Some of these may also have failed for other water quality indicators such as contaminants, phytoplankton or nuisance algae. 44 of the 56 (79%) transitional and coastal waterbodies assessed in the WFD 2024 cycle 3 interim assessment were classified with a less than Good status for the overall waterbody classification (NRW, 2025c).Contaminants, including metals, show a mixed picture over the long-term (1980 to 2025). Concentrations of pollutants in stranded marine mammals along the coast of Great Britain have declined over the last three decades, although persistent organic pollutants are still present at concentrations that are likely to significantly impact marine mammal health (Williams *et al.*, 2023).

Over the shorter term, heavy metals and other persistent pollutants in sediments and biota are stable or have declined in UK waters since 2019 (DEFRA *et al.*, 2024). Some contaminants, such as mercury and the very toxic PCB CB118, exist at levels in the biota in the Irish Sea which are likely to cause damage to marine organisms (DEFRA *et al.*, 2024). Trend analysis of PBDEs, a class of fire retardants, and PCBs, a group of persistent organic pollutants has been carried out as part of the UK’s Clean Seas Environmental Monitoring Programme (Marine Scotland, 2022). The Irish Sea and Celtic Regions include monitoring sites within Welsh Seas but also include some English and

Scottish sampling points. The data shows that the majority (99%) of time series show no trend or downward trend for PBDEs and PCBs between 2014 and 2019. (Marine Scotland, 2022)

Restrictions have been put in place on the production and use of many persistent chemicals (NRW, 2022). It is expected that levels in the environment will gradually reduce.

Historically, bacteriological pollution has improved over the long term (1980 to 2024) with significant improvements in wastewater treatment works, but storm overflows remain a source of pollution over the short term (Whelan *et al.*, 2022; NRW, 2024).

Concentrations of suspended particulate matter deteriorated between 1998 and 2015 in the Western English Channel and Celtic Seas (summer) and Irish Sea (spring) (Silva, Biermann and Rees, 2016).

Marine litter in the Celtic Seas Region has improved over the short-term (2015 – 2020) (OSPAR, 2023). The UK has not yet achieved Good Environmental Status for marine litter (add ref), and overall trends across the OSPAR regions show that, beach litter levels remain high, with plastic items dominating. Results from Marine Conservation Society volunteer surveys in 2024 give some high level indications of trends in beach litter. There was a 4% increase in litter in Wales compared to 2023; 99% of beaches surveyed found drinks litter, however there was a decrease of 24% in drinks-related litter in Wales compared to 2023 (Marine Conservation Society, 2024). The current annual global production of plastics is predicted to double by 2045 (Enevoldsen, Isensee and Lee, 2024). The influence of climate change on atmospheric and ocean circulation may affect some of the pathways for and retention of marine litter.

Historically, **underwater noise** has increased in marine ecosystems globally (1960 to 2025). Trends since the 1990s are less known (Merchant et al., 2016). Underwater sound is the most pervasive input of human-caused energy in the marine environment and is omnipresent in the seas around the UK (Tasker et al., 2010). Over the shorter term (2018 to 2024), there is a mixed picture. Shipping noise increased in the Celtic Seas Region between 2018 and 2022 (DEFRA *et al.*, 2024) . Levels of impulsive noise have remained stable in the Celtic Seas region since 2017 (DEFRA *et al.*, 2024). Between 2022 and 2024 there has been minimal impulsive noise in harbour porpoise SACs in Wales (JNCC, 2024a). In Welsh waters, anthropogenic underwater noise is widespread and likely to increase with expanding marine industrial development. For instance, impact piling associated with offshore windfarm construction and other built infrastructure are identified as particular disturbance concerns for marine mammals in the UK (Sinclair *et al.*, 2023)

Climatic features and processes

Historically, changes in **intensity and frequency of weather events** have been a mixed picture in relation to effects on marine ecosystems (1990 to 2020). The future outlook is that this is expected to lead to further deterioration to 2100.

Strong winds, heavy rain and rough seas have been shown to impact reproductive success and overwinter survival for some breeding seabirds (Burton *et al.*, 2023). Some intertidal reef biotopes are likely be highly vulnerable to changes in wave exposure by 2049 (Oaten *et al.*, 2021). Projected increases in rainfall over winter months towards the middle and end of the century may be linked with changes in water quality around the coast (Oaten et al., 2021). Direct impacts from changes in severe weather events are likely increase in the future for coastal habitats (Burden *et al.*, 2020), and for seabirds and waterbirds (Burton *et al.*, 2023).

Water temperature has increased over the long-term (1990 to 2020). The future outlook is that this is expected to continue. Between 1960 and 2020, the Irish Sea region warmed by 0.3°C per decade, with values since 2000 being consistently above the 1991–2020 average (Cornes *et al.*, 2023). Water temperature is predicted to increase by 0.3°C per decade to 2049 and between 0.25°C and 0.4°C per decade to 2100. The main effects on mobile species (marine mammals and birds) around the UK continue to be geographic range shifts, reduction in suitable habitats, food web alterations and increased prevalence of disease (Burton *et al.*, 2023; Martin, Banga and Taylor, 2023).

Historically, over the long term (19951995 to 2020) **Ocean Acidification** has deteriorated. The North Atlantic contains more anthropogenic CO_2 than any other ocean basin, and ocean surface measurements between 1995 and 2013 show increasing acidity of 0.0013 units per year (MCCIP, 2020). Some fin-fish larvae may be sensitive to changes in ocean acidification. Ocean acidification is predicted to increase to 2050. The rate of change in coastal waters is projected to be faster in some areas (such as the Bristol Channel) than open sea areas (such as the Celtic Sea). It is predicted that by 2050, half of the subtidal reef communities in Pembrokeshire Marine SAC will be highly vulnerable to changes in pH, with the full extent of the maerl bed in Milford Haven being of medium vulnerability. (Oaten *et al.*, 2021).

Historically, **sea level rise** has increased between 1990 and 2020. Mean sea level around the UK has risen by about 12–16 cm since 1900 and evidence suggests that the rate of sea level rise in the UK is increasing (Kendon *et al.*, 2021), It is predicted that by 2049 all Saltmarsh communities around the Welsh coast will be highly vulnerable to sea level rise, along with coastal lagoons in Pembrokeshire Marine SAC. Sea level around Wales is projected to rise by around 1m by the end of the century. This will mean that by 2099 intertidal features of marine SACs (including intertidal areas of reef, intertidal aspects of estuaries, mudflats and sandflats not covered by seawater at low tide and sea caves along the coast), and all saltmarsh communities will be highly vulnerable to sea level rise (Oaten *et al.*, 2021).

Pressures from economic activity (see Aim 4 for more detail)

Pressures arising more directly from economic activity are also negatively affecting natural resources in marine ecosystems:

- **Infrastructure development** is a growing pressure due to offshore windfarms. The overall marine footprint of an Offshore Wind Farm can be considerable. This is in addition to anthropogenic underwater noise, which is widespread and likely to increase with expanding marine industrial development.

- **Physical modifications** such as coastal defences, railway infrastructure and port infrastructure are a pressure on intertidal ecosystems. They have the potential to prevent habitats from migrating landwards in response to sea-level rise, causing coastal squeeze (See SoNaRR 2025 Coastal margins assessment)
- Of **Access, sport and recreational activity,** sea angling, boating, bait digging and collection of living resources, and foot access have the potential to have the most impact on marine ecosystems

There is not sufficient evidence at a Welsh scale to describe the effect of **Fisheries** on the Welsh marine ecosystem. A number of quota fish species in the Celtic and Irish Seas continue to be fished beyond recommended scientific advice (Cefas, 2024). While the vast majority of these fish are caught outside of Welsh waters by non-Welsh boats their status reflects on populations within Welsh waters.

Progress to meeting Aim 1 - Stocks of natural resources are safeguarded and enhanced

The key opportunities taken up since SoNaRR2020 comprise

- Reporting indicators developed for all our European marine sites (SACs and SPAs).
- Condition assessments completed for all the Welsh only European marine site features.
- New conservation advice packages for 12 marine sites
- Marine protected area Condition Improvement Programme to
    - Develop a strategic forward plan setting out management requirements for maintaining and improving the MPA Network across Wales.
    - Pull together evidence associated with pressures and threats affecting marine protected areas feature condition.
    - Identify and develop marine projects currently being delivered under the Welsh Governments funded Nature and Climate Emergency Programme (2022-2025).
    - Work with external stakeholders to share information and advice to support the delivery of projects that aim to improve marine protected area features across Wales.
- The Wild Oysters Conwy project to restore a native oyster reef in Conwy Bay.
- Wales Native Oyster Restoration Project (WNORP) between 2020 and 2023 focussed on establishing and monitoring restoration plots in Milford Haven to establish the feasibility of restoration. Native oysters were released to re-establish a historic biogenic reef in Milford Haven in Spring 2024. Funding has been secured to deliver Natur am Byth! which will scale up the trials from WNORP and implement management measure that should enable to recovery of seagrass at Porthdinllaen.

- Rumney Great Wharf Polders project, funded through Nature Networks. The capital works were implemented in 2024 to restore saltmarsh along the Rumney Great Wharf by reinstating and extending the sedimentation polders.
- NRW projects to better understand the contribution of marine habitats to carbon sequestration and storage in Wales. (Armstrong *et al.*, 2020; Brook *et al.*, 2022; Robbins, Armstrong and Frost, 2022; Robbins *et al.*, 2022; Gihwala *et al.*, 2024; Gihwala, Frost and Upson, 2024)

Opportunities for Action Aim 1

The possible actions identified with respect to achieving Aim 1 in marine ecosystems relate to INNS and other species management, Pollution management, Research and technology, Species conservation and enhancement, Sustainable Agriculture, Fisheries and Forestry, and Sustainable construction .

Action 1. Monitor and control INNS and diseases, particularly Avian Bird Flu, in affected areas.

Action 2. Control pollution of marine waters, with particular focus on storm water overflows, nutrient enrichment from terrestrial sources and litter, including beach litter, in affected areas.

Action 3. Manage noise impacts on marine animals from construction of offshore built development and infrastructure, its operations and wider maritime activities.

Action 4. Protect and boost native species populations by monitoring, protecting and restoring key habitats.

Action 5. Protect and boost native species populations by reducing by-catch.

Aim 2: Ecosystems are Resilient to Expected and Unforeseen Change

Ecosystem Resilience is assessed in SoNaRR using four ecosystem attributes as proxies. Diversity, extent, condition and connectivity are assessed for each of the two zones that make up the marine ecosystem. The zones are Intertidal, which is high water to low water, and Subtidal, which is permanently immersed in seawater from low water to 12 nautical miles offshore.

Diversity

Marine Protected Area condition assessments for many habitats show no concerning patterns in species richness and diversity indicators. Historically, diversity has been deteriorating at some localised sites. This includes a steep decline in species diversity at Bais Bank South sandbank, and the Modiolus beds in Pen Llŷn a’r Sarnau SAC. There have also been large declines in sponge species richness in Menai Strait & Conwy Bay

SAC and declines in red sea fingers and pink sea fan at Skomer MCZ. There has been a decrease in species richness and diversity at Milford Haven Inlets since 2015, as well as issues with the species composition of communities indicator within the Milford Haven waterway (NRW, 2025a). The historic short term is deteriorating for subtidal habitats and a mixed picture for intertidal habitats. The current assessment of diversity is medium across both habitat types. Specific localised declines in diversity are likely to continue; however, many habitats are likely to remain stable in diversity.

Extent

Over the historic long-term (1995 to 2024), while the range is stable the area of assessed Intertidal and subtidal habitats has decreased (NRW, 2026). Over the shorter term (2013 to 2024), while the range is stable for all habitats, the area of mudflats, sandbanks and reefs has decreased giving an overall mixed picture (NRW, 2026) . The current assessment of extent is medium for both intertidal and subtidal. The future outlook to 2036 is a mixed picture (NRW, 2026). The range is expected to remain stable for all habitat types except maerl beds which has a very negative future trend, while the area of most intertidal and subtidal habitats is expected to decrease. The long term trend for the area of large shallow inlets and bays is overall stable. (NRW, 2026)

Condition

Over the historic long-term (1995 to 2025), the condition of Subtidal habitats is a mixed picture, and the condition of Intertidal habitats is deteriorating. Various historical impacts have led to deterioration of condition in intertidal habitats. For example, bait digging has. resulted in significant impacts on the fauna of intertidal mudflats and sandflats (Evans *et al.*, 2015). Many intertidal habitats are in unfavourable condition due to excess nutrients (Hatton-Ellis, *et al.*, 2025). The short-term trend (2013 to 2024) is a mixed picture for both zones. (NRW, 2026). The current assessment of condition is Low for intertidal and medium for subtidal. The future outlook is a mixed picture to 2036 (NRW, 2026). Programmes, measures, and policies are in place with the aim of improving the management of the marine environment including the MPA network and the condition of its features. Investigations into failures of Water Framework Directive elements will be carried out and measures to improve water body status are being identified for the next River Basin Management Plans.

Connectivity

Historically connectivity of marine ecosystems has shown a mixed picture in the long and short-term. Between 1995 and 2025 there has been some localised disruption to connectivity through alterations to hydrological processes. Overall intertidal habitats remain well connected. There have been no major changes to connectivity of intertidal and subtidal habitats in recent times although there has been some localised disruption. The current assessment of connectivity is High across both zones. Marine Protected Areas protecting intertidal habitats are well connected overall, with a small gap in the connectivity of littoral rock and some, localised alterations to hydrological processes in nearshore areas. Future outlook is stable across both zones. There are not considered to be any barriers to connectivity across intertidal habitats in the near future unless there are major changes due to coastal developments. It is unknown whether there will be any barriers to connectivity either locally or on a larger scale across subtidal habitats. There may be a deterioration in connectivity if there are changes in oceanic currents or frontal systems.(NRW Expert judgement).

Progress towards meeting Aim 2 (Ecosystems are Resilient to Expected and Unforeseen Change)

The key opportunities taken up since SoNaRR 2020 comprise:

- The Welsh Marine Protected Areas Network Completion Project identified Areas of Search - smaller areas are being identified for designation to address key gaps in species and habitats to complete the MPA network, predominantly in offshore waters.
- Wales National Marine Plan includes policy ENV_01: Resilient Marine Ecosystems which includes a mandatory element based around the mitigation hierarchy; to avoid, minimise or mitigate adverse impacts on ecosystem resilience. Alongside this, ENV_01 encourages proposals which restore or enhance marine ecosystems, including both dedicated nature positive projects, as well as the inclusion of restoration and enhancement actions in development projects.
- We are working to develop strategic mapping of the opportunities for enhancing the resilience of marine and coastal ecosystems.
- We have published an evidence report "Restoring marine and coastal habitats in Wales: identifying spatial opportunities and benefits".
- We have developed a marine and coastal restoration work programme which seeks to develop guidance, advice and evidence that will help ensure appropriate activities take place in the most suitable location to contribute to building the resilience of marine and coastal ecosystems in Welsh waters (NRW, 2025b).
- Project Seagrass have teamed with several other partners to create the Seagrass Ocean Rescue project. Their current project in North Wales is currently the largest active seagrass restoration project in the UK and is pioneering seagrass restoration methodologies (Swansea University, no date)
- We are involved in the ReMeMaRe Programme which is an initiative in England seeking to restore 15% of their priority habitats (Saltmarsh, Seagrass and Native Oysters) by 2043. Sitting within the group provides opportunities to share knowledge across all nations that benefit all within the group e.g. development of the restoration project platform at a UK level.

Opportunities for Action Aim 2

The possible actions identified with respect to achieving Resilient Freshwater ecosystems relate to Ecosystem creation, Ecosystem protection, Ecosystem restoration, and Species conservation and enhancement.

Action 6. Improve condition of Intertidal and subtidal habitats

Action 7. Prevent further declines and increase extent of intertidal habitats.

Action 8. Address localised declines in diversity through identifying and managing pressures

Aim 3: Healthy Places for people, protected from environmental risk

Health protection

Marine ecosystems contribute to the protection of human health through the supply of the following regulating services:

Global climate regulation services contribute to reduced concentrations of Green House Gases in the atmosphere leading to reduced climate change impacts on people. Welsh marine habitats store at least 113 million tonnes of Carbon over the long term (equivalent to 10 years of Welsh emissions of Carbon), making them a significant carbon store alongside Welsh woodlands and forests (Armstrong *et al.*, 2020). (Armstrong *et al.*, 2020). Welsh SAC Annex I features contribute almost 10% of the total carbon storage across all habitats in the Welsh National Marine Plan area. Their rate of sequestration accounts for approximately 47% of the total carbon sequestered within Welsh habitats (12,300 t of carbon per year) (Robbins *et al.*, 2022).

Coastal protection services contribute to reduced risk of flooding to households in coastal areas. Seagrass meadows and kelp forests can help to stabilise marine sediments and reduce the erosive power of waves and can act as a nature-based solution to reduce coastal flood and erosion risk (Smith and Chausson, 2021). See Coastal Margins assessment for the contribution of Saltmarsh to this service.

Health Improvement

Marine ecosystems contribute to human health improvement through the supply of the following cultural ecosystem services:

Recreation-related services contribute opportunities for people to enjoy in-situ interactions with nature and associated physical and mental health benefits. This service is likely to be used in combination with the visual and sensory amenity service in **marine** (and associated coastal margin) settings. In 2021/2022, people in Wales made 19,927,591 visits to marine ecosystems for recreation (21,922,081 visits to coastal margins) (Owen, Rhydderch and Williams, 2025).

Outdoor swimmers in Wales reported that they swam for their mental health, fun or exercise (McAllister, 2023; Palma and Marks, 2023). 84% of people believe visits to the marine environment are good for their mental health and 78% report that such visits are good for their physical health (Atkinson *et al.*, 2022). The Office for National Statistics estimate that visits to Welsh Coastal and marine ecosystems for recreation decreased by approximately 32% between 2019 and 2022, although the associated number of people gaining related health benefits from these visits remained stable at around 200,000 (Office for National Statistics, 2024)

In 2025, 102 of Wales' 109 designated marine or coastal bathing waters were assessed to be of Excellent or Good quality (based on microbiological parameters). Of the reminder 5 were considered 'Sufficient' and 2 'Poor' quality(NRW, 2024; Welsh Government, 2025). In 2025, 21 Welsh beaches achieved a Blue Flag Award.13 beaches in Wales were awarded the Green Coast Award. 15 beaches in Wales achieved the Seaside Award (Keep Wales Tidy, 2025). Efforts to maintain and improve bathing water quality and beach amenities are not only crucial for human health but also for local economies . **Water purification services** contribute to cleaner water for people to use for recreation. Restoration of marine habitats would improve water quality through the removal of pollutants and nutrients from the water column and by lowering turbidity rates. Shellfish in particular play a key role through filtering algae and suspended particles out of the water column and the removal of excess nutrients and contaminants (Armstrong *et al.*, 2021). Recreational fishing is underpinned by the **nursery population and habitat maintenance services** that maintain fish stocks.

Cultural Well-being

Marine ecosystems contribute to people's cultural well-being through the supply of the following cultural services:

Spiritual, artistic and symbolic services: According to the Ocean Literacy in Wales report, the overriding emotional response to the marine environment is concern (48%) followed by wonder/awe (41%) (Atkinson *et al.*, 2022). In their evaluation of the use of marine ecosystem services at 151 UK marine sites, Bryce et al (2016) identify multiple service benefits that contribute to (subjective) cultural well-being. These include engagement with nature, place identity and therapeutic value.

Education, scientific and research services: Several leading universities in Wales deliver world-leading marine courses at undergraduate and postgraduate level, attracting students and research activity in Wales that has significant economic value. Multiple dimensions of biodiversity, as found in rock pools, can enhance human interest and conservation initiatives that maintain and/or restore biodiversity could also help stimulate interest in ecosystems with wider educational and recreational benefits (Fairchild *et al.*, 2018).

Equitable access

There is limited evidence with respect to equitable access to marine ecosystems. Generally, those with higher disposable incomes will have greater ability to travel to marine ecosystems from inland areas. At the same time, Acott *et al.*, (2023) highlight the strong relational values and personal connections held by people towards their local coastal environments through case studies along the UK coast (not in Wales). Using a Community Voice Method, they found that despite levels of relative deprivation in the case study locations, interviewees expressed strong relational values and connections to the coast despite material changes and transformations in people's lives and the places they live which they argued should be reflected more in coastal management.

Progress towards meeting Aim 3

The key opportunities taken up since SoNaRR 2020 comprise:

- An Ocean Literacy working group under the Coasts and Seas Partnership has developed a Strategy for Ocean Literacy in Wales. Work is underway to secure resource to support further engagement around and delivery of actions under the draft strategy (Atkinson *et al.*, 2022).

Opportunities for Action Aim 3

The possible actions identified with respect to achieving Aim 3 relate to Access to nature, Nature based solutions, Payment for ecosystem services, Pollution management, and Research and technology.

Action 9. Protect and restore Marine habitats to increase carbon sequestration, reduce coastal flooding and improve water quality

Action 10. Maintain and improve access to marine ecosystems for recreation, learning and wider cultural well-being.

Aim 4: Contributing to a Regenerative Economy, Achieving Sustainable Levels of Production and Consumption

Marine ecosystems contribute to economic well-being through the supply of the following regulating services:

Coastal protection services reduce the risk of flooding damaging infrastructure in coastal areas; agricultural land and impacting on other businesses. (Smith and Chausson, 2021) See SoNaRR 2025 Coastal margins assessment for details.

Marine ecosystems contribute to economic well-being through the supply of the following provisioning services:

Wild fish and other natural aquatic biomass: There has been a reduction in Welsh and non-Welsh shellfish landings over the last 7-8 years, with finfish landings remaining small but stable. Landings from non-Welsh boats reduced from 3220t in 2021 to 213t in 2023 due to fish now being landed direct to EU member states (Seafish, unpub.).This period of reduced catches coincides with significant impacts to the fishing industry from EU exit, the Covid pandemic and the cost-of-living crisis.

The number of active Welsh vessels reduced from 263 in 2020 to 223 in 2023, with the number of people working in the fishing industry reducing from 129FTEs to 109FTEs in the same period. Gross Value Added (GVA), and Operating profits reduced from £8.69m and £2.96m respectively in 2020 to £5.99m and £2.08m in 2023 (Seafish, unpub.). In 2022 the combined GVA of fishing and aquaculture to the economy in Wales was £13 million (Welsh Government, 2024). (Welsh Government, 2024). The Wales National Marine Plan identified both these sectors for development (Welsh Government, 2019) (Welsh Government, 2019) In this regard, future shifts in fish species ranges due to climate change could lead to new opportunities for fisheries (Fox *et al.*, 2023).

Energy from Wind and tidal power: £103.4 million of spending and investment was made in marine renewable energy in Wales in 2023, nearly four times the figure recorded in the past 5 years (since 2018).

The industry sustains 440 full time equivalent jobs (Marine Energy Wales, 2023). Floating offshore wind is expected to play an increasing part of Wales' offshore energy mix in the future. f Test and demonstration projects off the south Pembrokeshire coast provide the capability to generate more than 400MW of electricity capacity. Project Development areas have recently been announced by the Crown Estate which could unlock a further 4.5GW in the Celtic Sea, with the first 1GW estimated to create 3,000 full-time equivalent jobs and £682 million in supply chain opportunities in Wales and SW England (Welsh Government, 2023a)

Marine ecosystems contribute to economic well-being through the supply of the following cultural services

Recreation-related services: Expenditure by the 19,927,591 visits to marine ecosystems and the 21,922,081 visits to associated coastal margins (Owen, Rhydderch and Williams, 2025) contributes to the economy locally and nationally. The ONS (2024) estimate that the combined number of visits to marine and coastal ecosystems fell from around 56 million in 2010 to 38 million in 2022 (-32%). They also estimate the overall expenditure associated with these visits (e.g., travel costs) was around £120 million in 2022, approximate £3 per visit in 2022.

Börger *et al.*(2021) estimated the willingness of people to pay for recreational visits to blue spaces across 14 European countries to be considerably higher at € 41.32 per visit, and € 50.55 per visit for the UK specifically. They also find a one-level improvement in water quality can lead to a nearly 7 % increase in visits, whereas a one-level deterioration leads to around 20% fewer visits.

Outdoor activity providers contribute £272.87 million net to the Welsh economy each year. £205 million remains within Wales. The total net impact on the Welsh economy is estimated at £1.6 billion and supports around 31,000 jobs (the report does not focus specifically on coastal and marine outdoor sector providers but those in the sector as a whole across Wales) (Miller *et al.*, 2023).

Economic drivers and their pressures on marine ecosystems

The key direct economic drivers within Wales likely to be connected to the degradation of marine ecosystems relate to **Land and sea use and management change. Climate change pressures** are considered to be driven by global economic activity, and the specific economic drivers of pollution pressures are assessed via the relevant natural resource assessments**.**

Land and sea use and management change

Built development and infrastructure associated with marine renewable energy generation has become an increasing pressure on marine ecosystems since the commissioning of the UK's first commercial scale offshore windfarm (North Hoyle) off the North Wales coast in 2003. The overall marine footprints of an Offshore Wind Farm (OWF) can be considerable. Gwynt y Mor OWF, further off the North Wales, coast has a footprint of around 124 km^2 ,including the export cable corridor. These developments can also change physical processes (e.g., currents), create collision hazards and other forms of disturbance (e.g., noise as highlighted in Aim 1). (Marine Energy Wales, 2023)

Whilst the pressure of infrastructure development is stable over the short-term (2020 to 2025), the UK government's commitment to achieving 50 GW of offshore wind generating capacity by 2030 means offshore renewable development will progress at a rapid pace over the next five years at least.

The Crown Estate are looking at a range of scenarios with a maximum generating capacity of 140GW from offshore wind by 2050 (The Crown Estate, 2023).

Over the long-term (2005 to 2025), physical modifications have caused a deterioration of intertidal ecosystems due to habitat loss associated with their footprint, restricting habitat movement due to sea level rise and hydrodynamics and sediment transport. This is expected to continue in the future (to 2105). 29% of the Welsh coast (719km) has some form of linear or shore-parallel structure (a coastal defence, railway infrastructure, port infrastructure) which could prevent habitats from migrating landwards in response to sea-level rise, causing coastal squeeze. (Oaten, Finch and Frost, 2024). Several coastal defence schemes have been completed, especially since the winter storms of 2013/4 which caused widespread damage to infrastructure and communities around the Welsh coast (NRW, 2014). Over the recent shorter term (2020 to 2025) more coastal defence structures have been built than during the preceding 5-10- years, due to the multiple funded schemes under Welsh Government's Coastal Risk Management Programme.

Physical modification of the Welsh sea bed due to dredging and disposal has been relatively stable between 2005 and 2017. There were 13 open disposal sites designated for the disposal of material dredged under licences determined by NRW (as of end 2017). These sites receive a combined average of 3,008,129 wet tonnes material per annum (across all open sites) (Clarke and Rees, 2020). The future **trends are unknown.**

Access, sport and recreational activities such as sea angling, boating (anchoring, mooring and launching), bait digging and collection of living resources, and foot access have the potential to affect marine ecosystems in Wales (Roberts *et al.*, 2020) . In 2021/2022, people in Wales made 19,927,591 visits to marine ecosystems for recreation (21,922,081 visits to coastal margins) (Owen, Rhydderch and Williams, 2025).

There is limited data for Wales on trends in the effects of recreational activities on marine (and coastal) ecosystems. At the OSPAR level it is a challenge to obtain standardised quantitative environmental information about recreational impacts on marine and coastal ecosystems (Pachernegg, 2021). It is also important that the potential of tourism to contribute to the sustainable management of marine natural resources is realised.

Direct Exploitation

Historical trends for the pressure of **fisheries** on marine ecosystems in Wales are not available. At a UK level, in 2020, 56% of quota fish stocks were fished within acceptable mortality ranges, increasing from 11% in 1990 (JNCC, 2024b). Over the shorter term, 33 out of 43 stocks in 2022 in ICES Celtic Seas Ecoregion were fished at or below Maximum Sustainable Yield compared to 30 out of 45 in 2019 (ICES, 2022, sect. 7.1). Implementation of a range of Fisheries Management Plans by 2028 will improve our understanding of the sustainability of many of the marine fisheries in Welsh waters. Marine fisheries can affect target species and non-target species through bycatch, prey depletion and disturbance, and the wider marine ecosystem through habitat interactions. The evidence to determine whether marine fisheries in Welsh waters are sustainable or not is limited.

Aggregate Extraction off the South Wales Coast and in Liverpool Bay has continued at approximately the same rate between 2011 and 2020 (The Crown Estate and MPA Marine Aggregates, 2022). Future demand is unknown.

Contributions of marine ecosystems to sustainable economic production and consumption

Electricity generated from offshore renewable energy is playing an increasingly important role in Wales in decarbonising the energy sector. Whilst this is directly supporting the transition to a circular economy and achieving net-zero emissions in Wales, development of associated infrastructure needs to be planned in a way that minimises pressures on marine wildlife and wider ecosystem services. To support the environmentally sustainable development of offshore renewable energy, We have produced the following guidance:

- Natural Resources Wales / Marine renewable energy developments

- Natural Resources Wales / Offshore wind developments

We are collaborating on a number of projects, consultations, reviews and initiatives at a strategic level. Key external partners include Welsh and UK Government, The Crown Estate, National Grid and Marine Energy Wales. These include input to:

- WG's Renewable Energy Deep Dive, Strategic Locational Guidance, Marine Energy Programme Board, Tidal Lagoon Challenge, WNMP Spatial Approach and End to End Marine Licensing review.
- UK Government's Consultation on Compensatory Measures, Strategic Environmental Assessment, Offshore Energy Plan, National Policy Statements, British Energy Security Strategy 2022 Offshore Wind Environmental Improvement Package, Offshore Wind Environmental Standards and Offshore Wind Strategic Compensation.
- The Crown Estate's Offshore Wind Evidence & Change Programme, Pathways to Growth Initiative, Strategic Enabling Actions Programme, Round 4 Plan Level work and Round 5 Areas of Search.
- OFGEM / National Grid Holistic Network Design and Offshore Transmission Network Review.
- Marine Scotland's Cumulative Effects Framework.

We also plays a key role in delivering the Consenting Strategic Advisory Group (CSAG) Action Plan and contributing to the CSAG Science and Evidence Sub-Group alongside Marine Energy Wales, The Crown Estate, Welsh Government and other stakeholders

The Welsh National Marine Plan highlights the role that the tourism and recreation sector can play in contributing to sustainable development by protecting and promoting access to the coast and improving the quality of the visitor experience (Welsh Government, 2019). The high-level panel for a sustainable ocean economy, also highlights that coastal and marine tourism is highly dependent on the quality of coastal and marine ecosystems (Northop, 2022, p. 5). In their report, the High-Level Panel recognise the need to manage pressures, such as **access, sport or recreational activity** and the negative environmental effects. At the same time, the report highlights the important role sustainable tourism can play in generating revenue to reinvest in and regenerate ecosystems, local markets and communities and build resilience to future threats and future shocks and crises. Given there are approximately 42 million recreational visits per year to coastal margins and marine ecosystems by people in Wales, there is clearly a big potential for this sector to contribute to a regenerative economy if appropriately managed.

After EU exit mussel aquaculture declined by over 90% due to changes in export regulations. Oyster aquaculture has remained steady but small-scale (Seafish, unpub.). Seaweed aquaculture is in its infancy, with a single farm in west Wales, but there is growing interest in this industry. The Welsh National Marine Plan identifies aquaculture as a sector to develop in Wales (Welsh Government, 2019). Developing the sector could reduce reliance on imported aquaculture products, with potentially high carbon footprints.

Progress towards meeting Aim 4

The key opportunities taken up since SoNaRR 2020 comprise:

- Welsh Government have been working with stakeholders to develop their spatial approach to marine planning, focusing on understanding more about which marine activities are likely to be appropriate in a particular place, while also understanding what we need to do to protect and enhance the marine environment.
- Welsh Ministers committed to developing understanding and planning tools to provide greater spatial direction for development through marine planning, balancing protecting the marine environment with supporting thriving coastal communities and marine industries (Welsh Government, 2023b).
- We have developed maps showing environmental considerations for strategic marine planning. The maps, now available on data map Wales, bring together currently available data for birds, marine mammals, seabed habitats and fish to support WG and others to explore potential future opportunities for sustainable use and management of the Welsh marine area. Maps have been developed for the following sectors: aggregates; aquaculture; cabling; floating offshore wind; tidal range energy; tidal stream energy; and wave energy.
- In 2023, The Crown Estate commenced work on their Whole of Seabed Programme which is mapping seabed space needed to meet future demand for a wide range of industries, infrastructure, and habitats to 2050. They are exploring their role as steward of the seabed and coast, to forward plan how the seabed is managed to support nature recovery, jobs and regeneration, and net zero priorities.
- The Blue investment working group under the Coasts and Seas Partnership is working on the establishment of MARINE Fund Cymru, to secure funding from a variety of sources to support priority actions for the sustainable management of marine natural resources, particularly around nature recovery.
- The new UK Fisheries Act 2020 and the nine emerging Welsh Fisheries Management Plans provide a long-term plan to achieve and report on sustainable fishing. In addition, the recording of daily landings by under 10m vessels fishing vessels and the requirement for inshore vessel monitoring systems (iVMS) on all under 12m vessels will improve data associated with fishing. Several permitted fisheries undergo annual Habitats Regulation Assessment including cockle, whelk and scallop fisheries. The Assessing Welsh Fishing Activities (AWFA) project has delivered an evidence base on impacts on protected features from various fishing gears to Welsh Government.
- With support from the EU, we have produced a tool to help guide site selection for aquaculture activities (seaweed and fish) in an environmentally sustainable way (NRW, no date).

Opportunities for Action Aim 4

The possible actions identified with respect to achieving Aim 4relate to Awareness raising, Increase resource use efficiency, Nature based Solutions, Pollution management, Renewable energy (worldwide), Research and Technology, Sustainable agriculture, forestry, and fisheries, Sustainable construction, and Sustainable transport.

Action 11. Monitor and develop the fisheries and aquaculture sector in an environmentally sustainable way

Action 12. Develop offshore renewable energy to decarbonise the energy sector where appropriate and in an environmentally sustainable manner

Action 13. Minimise impacts effects on marine species and habitat from Industry and development opportunities

Action 14. Minimise impacts effects on marine species and habitats from physical modifications such as coastal defences, ports and coastal railways and shipping

Action 15. Develop sustainable tourism and recreation opportunities in marine ecosystems

Evidence Needs

One of our key evidence needs in the marine ecosystem is to have a better understanding of the extent and condition of our habitats and species and the underlying physical conditions and processes that support them. These gaps hinder the ability to evaluate ecosystem condition, biodiversity, and the effectiveness of Marine Protected Areas. Other evidence needs for the marine ecosystem in Wales focus heavily on understanding pressures and impacts from human activities. Key gaps include the extent, distribution, and effects of commercial and also recreational fishing, including bycatch of marine mammals, impacts on fragile habitats, and the sustainability of fisheries. There is also a need to assess the consequences of nutrient inputs and invasive non-native species.

Further evidence is required to understand ecological functions and services, such as carbon sequestration, sediment and other physical processes. Addressing these gaps will support more robust assessments of the state of marine environments and inform sustainable management strategies under SoNaRR.

Marine ecosystem References

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Mountain, moorland and heath ecosystem

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Mountainous habitats are those above the climatic tree-line. Moorlands and heaths include upland and lowland heathlands, moorlands, blanket bog, montane habitats (including ffridd), inland rock habitats and stands of bracken in the lowlands. This ecosystem is often interspersed with other ecosystems such as Semi-natural grasslands, Woodlands and Freshwater. Coastal and dune heathlands are covered in the Coastal margins assessment

This Mountain, Moorland and Heath assessment is one of eight ecosystem and three natural resource assessments that inform the overall SoNaRR 2025 report. It builds on the findings of SoNaRR2020, drawing together updated evidence from subject experts and national datasets such as the Habitats Regulations 9A Report for Wales, due to be published in January 2026; *ERAMMP Report-105: Wales National Trends and Glastir Evaluation, ONS Natural Capital Accounts and the National Peatland Action Programme*. This assessment is closely linked to the Soils assessment and the evidence we have set out in the Land and sea use and management change evidence.

The assessment is structured around four interlinked aims that guide Wales' progress toward the sustainable management of natural resources (SMNR), helping to communicate the relationship between the environment, well-being, and the economy

Key messages

1. This ecosystem comprises a diverse range of habitats of high biodiversity importance and provides key benefits including carbon storage, flood mitigation, food, fibre and some of Wales' most iconic species and landscapes. Peatlands, in healthy condition, are particularly effective at carbon sequestration covering just 4% of the land and storing 30% of our land-based carbon.
2. The majority of MMH ecosystems occur in the uplands, which accounts for 19.3% of the Welsh land. In contrast, the lowland peatlands and heathlands are frequently small, highly fragmented and heavily impacted by neighbouring land uses.
3. Key pressures come from climate change, INNS, air and groundwater pollution, changes in land use, and land management practices especially agricultural intensification, historic afforestation, drainage and declines in traditional grazing.
4. Action must be taken to manage protected sites to improve the condition of their features, and to build wider ecosystem resilience by restoring priority habitats and addressing pressures such as nitrogen pollution.
5. Action to meet renewable energy and tree planting targets will need careful management to meet the requirements of both the climate and nature emergencies. As peat soils are now confined to just 4% of the Welsh landscape, it is essential to avoid any further losses through development pressure.

Mountain, Moorland and Heath Summary SMNR Assessment

Aim 1: Stocks of natural resources are safeguarded and enhanced

Mountain, moorland and heath (MMH) ecosystems in Wales support iconic species such as red grouse, ring ouzel, and the Snowdon beetle, alongside rare plants like Alpine saxifrage and three-lobed water crowfoot. However, pressures from invasive non-native species (INNS), nitrogen pollution, and land-use change have degraded habitats. *Rhododendron ponticum* alone has spread across 2,000 hectares in Snowdonia. Air and water pollution continue to exceed critical thresholds, particularly in peatlands and heathlands, with nitrogen deposition and agricultural runoff contributing to habitat decline. Climate change intensifies these pressures through increased droughts, storms, and wildfires, threatening carbon-rich soils and biodiversity.

Efforts to safeguard resources include the National Peatland Action Programme (NPAP), which restored over 3,600 hectares of peatland, improving carbon storage and habitat condition. Local projects like the Carneddau Landscape Partnership and Celtic Rainforest LIFE have targeted INNS control and afforestation impacts. Monitoring networks and citizen science initiatives support data collection and community engagement. Despite progress, further action is needed to manage protected sites, reduce pollution, and prevent development on vulnerable peat soils, which store 30% of Wales' land-based carbon but cover only 4% of its area.

Aim 2: Ecosystems are Resilient to Expected and Unforeseen Change

Resilience in MMH ecosystems is assessed through diversity, extent, condition, and connectivity. Species diversity is medium in upland heath and rock habitats but low in alpine and peatland areas due to nitrogen deposition and overgrazing. Habitat extent has deteriorated long-term, especially in lowland areas, though upland heathland shows signs of recovery. Peatland extent may be increasing due to restoration, but mapping challenges remain. Condition is generally poor, with five of seven habitat types assessed as low. Connectivity is weakest in fragmented lowland habitats, while upland peatlands show better integration.

Restoration efforts under NPAP and LIFE Quaking Bogs have improved hydrology, erosion control, and vegetation management across thousands of hectares. Future resilience depends on continued habitat restoration, sustainable grazing, and collaborative land management. The Sustainable Farming Scheme proposes cooperative approaches for peatland stewardship. However, climate change poses ongoing risks, including altered species ranges and increased carbon emissions from degraded peat. Maintaining and enhancing habitat condition, especially outside protected sites, is essential to support resilient ecological networks.

Aim 3: Healthy Places for people, protected from environmental risk

MMH ecosystems protect human health by regulating climate, air, and water. Peatlands store significant carbon but release greenhouse gases when degraded. Restoration has reduced emissions by over 6,000 tonnes of CO_2-equivalent annually. Vegetation filters air pollutants, preventing premature deaths and life years lost. Peat and organic soils regulate water flow, reducing flood risk. However, damage from past land use has weakened these services. NPAP's hydrological improvements over 2,110 hectares help restore these functions.

These landscapes also support cultural and recreational well-being. Over 17 million visits were made to MMH areas in 2021/22, with Yr Wyddfa alone attracting over 540,000 visitors. MMH ecosystems offer educational opportunities and preserve cultural heritage, including peat-cutting traditions and archaeological remains. Despite widespread Open Access, physical environment deprivation persists in some areas. Recreational pressures—such as erosion and disturbance—require integrated management to ensure sustainable use and equitable access for local communities.

Aim 4: Contributing to a Regenerative Economy, Achieving Sustainable Levels of Production and Consumption

MMH ecosystems support sustainable economic activity through water purification, grazed biomass, pollination, and tourism. Peatland restoration improves water quality and reduces treatment costs. Less Favoured Areas, mainly MMH, host 25% of Welsh farms, though profitability relies on subsidies. Heather-rich habitats support pollinators and high-value honey production. Recreation generates £40 million annually and supports jobs in tourism and outdoor leisure.

However, economic pressures—intensive grazing, afforestation, and renewable energy development—threaten ecosystem integrity. Windfarm construction on peatlands causes habitat loss and hydrological disruption. Drainage remains a concern, though ditch-blocking has improved conditions. NPAP aims to restore 45,000 hectares of peat by 2030. Sustainable land management, appropriate grazing, and mitigation of recreational impacts are key to balancing economic use with ecological regeneration. Harnessing tourism to fund restoration and community benefits offers a promising path forward.

Key changes since SoNaRR2020

Overall, there appear to have been few significant changes to Mountain, moorland and heaths since SoNaRR2020 in terms of drivers and pressures, resilience, ecosystem services and benefits and progress towards SMNR. This is not unexpected, given the time it may take for many drivers of change to generate a response in such extensive and complex ecosystems and also given limitations in evidence to demonstrate change. One major change is the unparalleled rise in Renewable Energy applications with the potential to impact upon peatland habitats, peat soils and other semi-natural upland habitats. Woodland creation to meet national targets may also have undesirable impacts on these ecosystems, and climate change remains a universal pressure. Peatland restoration and management to improve condition has increased through the National Peatland Action Programme and LIFE projects. The forthcoming Sustainable Farming Scheme offers opportunities for ecosystem improvements to mountain, moorland and heath and better achievement of SMNR.

Mountain, Moorland and Heath Full Assessment of SMNR

Aim 1: Stocks of natural resources are safeguarded and enhanced

Animals, plants and other organisms

The Welsh uplands, including Eryri) has lost many key species including nesting eagles and dotterel, but other species still characterise the Welsh upland such as ravens and red grouse, while on the mountain fringes and in the fridd, ring ouzel and whinchat populations are found. High screes still retain populations of rainbow leaf beetle (the so-called Snowdon beetle), and the rare ground beetle *Leistus montanus* has recently been rediscovered here. On lowland peatlands, the rosy marsh moth thrives on Cors Fochno and southern damselfly responds to careful management in Pembrokeshire and Anglesey. Relict arctic-alpine plants, including tufted saxifrage *Saxifraga cespitosa*, Alpine saxifrage, S. nivalis, and the ferns Alpine woodsia *Woodsia alpina*, oblong woodsia W. *ilvensis*, survive, mostly in Snowdonia, though some are found in Bannau Brycheiniog. Wet heathlands, for example, support three-lobed Water crowfoot *Ranunculus tripartitus*, restricted to the western fringes of Wales, while Ivy-leaved Bellfower *Wahlenbergia* hederacea is fairly widespread on heaths and ffridd.
In recent years, the importance of some uplands for the rapidly declining water vole has been highlighted (Walsh and Hall 2005, Parry 2018). In Y Migneint (in Eryri National Park) they avoid the non-native mink which have predated them elsewhere on lowland watercourses. Water vole also retain strongholds in lowland wetlands on Anglesey where mink are still rare.

Historically **Invasive Non-Native Species (INNS)** have negatively affected animals, plants and other organisms in Mountain, Moorland and Heath (MMH) ecosystems. Over the short term (2020-2025) this deterioration has continued and is expected to continue into the future. Rhododendron ponticum in Eryri National Park has spread to over 2,000 hectares since it spread from gardens and estates in the 19th century (Jackson, 2008). The total extent of other INNS such as cotoneaster and Himalayan balsam have not been mapped but are known to have increased at specific sites. The spread of plant INNS has been exacerbated in the historic short term by changing land management practices, particularly decreased grazing. It is likely that the global trend for an increase in the number and abundance of INNS will be reflected in the MMH habitats and that this will largely be exacerbated by climate change, changes to land management practices and the lack of strategic national control plans for Wales. There are local strategies for the control of rhododendron. Modelling in Eryri suggests that the distribution range of this species may contract as a result of predicted climate change and land use changes (Manzoor *et al.*, 2018).

Air

Historically **air pollution** has negatively affected animals, plants and other organisms in MMH ecosystems. Over the short term (2020-2025) this deterioration has continued and is expected to continue into the future. The area of exceedance of nitrogen critical loads (NCL) for MMH habitats has not improved between 2010 and 2024. For heathland and montane habitats, 100% of the habitat extent lies within an area where NCL has been exceeded (NRW, 2026). The data shows an increase in acidity on dwarf-shrub heaths soil possibly as the result of nitrogen deposition (Emmett *et al.*, 2025). Despite projected reductions in the overall deposition loads of reactive nitrogen in the UK, air pollution is expected to remain a high pressure and threat to MMH habitats in Wales. It is estimated that nitrogen will continue to accumulate in peat until at least 2030 (Payne, 2014).

Water

Historically **water pollution** has negatively affected animals, plants and other organisms in MMH ecosystems. Over the short term (2020-2025) this deterioration has continued and is expected to continue into the future. Inorganic nitrogen concentration continue to exceed site-specific threshold for nitrogen in groundwater for some fen (lowland peatland) habitats, with agriculture the most likely immediate sources. This is reflected by the currently ‘poor’ overall status for a number of key sites, including the Corsydd Mon and Llŷn Peninsula fens. Diffuse water pollution is also cited as a key pressure for transition mires e.g. Cors Crymlyn and Corsydd Eifionydd. The latest ERAMMP report (Emmett *et al.*, 2024) shows both a long-term and short-term decline in fen marsh and swamp habitats. The future outlook suggests a continuing of this deterioration as the resolution of this continuing pressure requires comprehensive catchment-level integration of a range of measures aimed at reducing nutrient inputs for MMH habitats. These interventions are not currently underway.

Climatic features and processes

Historically (2010 - 2025), there has been a deteriorating trend to **changes in intensity and frequency of weather events** affecting MMH ecosystems over the short and long term. A deteriorating trend is expected to continue in the future (2030 – 2050). Observed and recorded increases in the intensity and frequency of weather events, namely droughts, floods and storms, over the long and short-term, have a negative impact on MMH ecosystems. Habitats that are dependent on high or intermittently high-water tables, such as habitats with peaty soils, are likely to suffer disproportionately (NRW, 2021a).

Additionally, wildfire incidence has increased in the short-term with 7% more occurring in 2022/2023 compared to 2021/2022 (Welsh Government, 2023a). Heathland is considered to be more susceptible than peatland to wildfire after drought (Grau-Andres et al., 2018). Over the coming decades it is predicted that the frequency of extreme weather events will increase in Wales (Lowe *et al.*, 2019). This may increase the frequency of wildfire occurrences on heathland.

Other impacts are expected for MMH ecosystems in the future, such as the reduction of bog mosses, increases in vascular plants and changes in vegetation phenology. In the long-term changes in the vegetation will impact on carbon sequestration and will further affect climate through changes in carbon dioxide and methane flux (Antala *et al.*, 2022). The release of dissolved inorganic carbon from peatlands is also predicted to increase until 2049, due to prolonged droughts and late summer and autumn storms (Lee *et al.*, 2020). Modelling evidence indicates it will become progressively harder to restore blanket bog from modified land-cover types as climate change progresses (Bell, Naumann and Medcalf, 2020).

Historically (1961 – 2025), there has been a deteriorating trend to **changes in air temperature** affecting MMH ecosystems over the short and long-term. A deteriorating trend is expected to continue in the future (2025 - 2100). Rises in temperature may alter the bio-climatic envelope for MMH species, particularly at high altitudes as many of these species have a minimum altitude where the species is viable. A mean temperature increase of 1°C could be equivalent to a rise in minimum altitude of 130m, leading to potentially large reductions in area for some montane heath or grassland species (Holden and Rose, 2011; Turner, 2020). Average temperatures in Wales have increased between 2020 and 2025 with UK average temperature increase in 2023 exceeding 1.4°C (Met Office, 2023). In the future, it is predicted that temperatures will continue to increase in Wales (Lowe *et al.*, 2019). This will likely have a predominantly negative effect on peatland, heathland and montane habitats. Upland woodland habitats are likely to expand but changes in species composition may occur.

Pressures from economic activity (see Aim 4 for more detail)

Pressures arising more directly from economic activity are also negatively affecting natural resources in MMH ecosystems (See Aim 4 for more details). These comprise:

Intensive grazing (agricultural intensification) impacts MMH habitats by resulting in the loss of species diversity and conversion of heathland, montane and peatland habitats to species-poor grasslands e.g. acid and marshy grassland and grassland habitats on deep peat.

Afforestation: Historic afforestation in the uplands, particularly the planting of conifers in the post war years, included the planting of significant areas of peat soils. The planting of deep peat is no longer permitted but legacy issues associated with afforested deep peat and the self-seeding of conifers from these areas into open habitat remain, impacting the MMH ecosystem.

Reduced management intensity: Livestock grazing is essential to maintain the structure and floristic composition of many MMH habitats, particularly against the current backdrop of atmospheric nitrogen deposition. However, too much or too little grazing or grazing at the wrong time of year with unsuitable livestock can cause the decline of habitat structure and composition and increase species-poor vegetation, for example upland acid-grassland or *Molinia*-dominated peatlands (NRW, 2021b). Burning has been a traditional practice on some MMH habitats particularly upland heathland. Controlled burning can be used to mimic the natural fire cycle and reduce nitrogen. However, it can negatively impact on fire sensitive habitats and habitat mosaics. Some upland birds prefer areas of more open vegetation, short grassland and managed moorland e.g. chough, ring ouzel and curlew and may continue to decline without appropriate management.

Unmanaged access, sport and recreational activity: Access and recreation pressures have been recorded on heathlands. Impacts include footpath erosion, vehicle damage, disturbance, especially by dogs, to livestock and breeding birds, and fouling which causes localised soil enrichment. Recreational impacts on subterranean fauna are generally poorly understood, but hibernating bats are particularly sensitive to human disturbance.

Built development and infrastructure: This pressure refers to the construction of windfarms on MMH specifically blanket bog in the uplands. Wind-power generation poses two immediate pressures: loss of habitat beneath the footprint of infrastructure (including turbine footings, crane pads, tracks and quarries) and impacts on areas of peatland adjacent to infrastructure posed by hydrological and fragmentation issues. Wind-farms have the potential to alter existing grazing. Management practices, though Habitat Management Plans can represent positive impacts.

Drainage: This pressure is particularly problematic for and relevant to peatlands where drainage causes habitat change, changes to the hydrological system, erosion, increased run-off, and increased greenhouse gas emissions. Grazing livestock losses also occur in drainage ditches.

Progress to meeting Aim 1 (Stocks of natural resources are safeguarded and enhanced)

The key opportunities taken up since SoNaRR2020 comprise:

- Carneddau Landscape Project has demonstrated community engagement in INNS (Himalayan balsam) control. Local Record Centres continue to collect data from volunteers (Carneddau Partnership, 2025).
- The North Wales Wildlife Trust's Limestone grassland restoration Nature Networks Fund project tackles cotoneaster on sites with limestone grassland and heath (North Wales Wildlife Trust, 2025)
- The Celtic Rainforest Life project has supported work to remove rhododendron ponticum and Sitka spruce (European Commission, 2024b)
- Development of Scorecard approach on Common Land. Additional SAC monitoring undertaken. Tir a Môr Llŷn Project (Llyn Landscape Partnership) and National Trust developed a trial Payments by Results scheme for the coastal habitats. Although this included lowland heathlands non were included in the trial. The trial completed in 2024 and is searching for funding for 2025 (Gwynedd Council, no date; National Trust, no date).
- Wales plant health sentinel site network was established to monitor for plant pests and diseases (including some INNS) (Welsh Government, 2022c).).
- National Peatland Action Programme is a 5-year plan of peatland restoration in Wales, 2020 – 2025. The Welsh Government funded, Natural Resources Wales managed, National Peatland Action Programme (NPAP) was initially established as a five-year Programme of peatland restoration in Wales 2020 – 2025 (NRW, 2020). As a nature-based solution some key benefits identified through NPAP’s restoration objectives were tackling the Climate and Nature emergencies. Following the successful delivery of 3600ha peatland restoration ahead of target (NRW, 2025e), promising records on some key species, and establishing the strategic foundations for upscale, Welsh Government has indicated the aim for NPAP to treble its restoration targets by 2031. This ambition for beyond 2025 brings with it added capacity - including Delivery, Monitoring, Data and Evidence capacity – which will enable NPAP to operate with significantly greater impact and to coordinate with partners more extensively to achieve its objectives.
- LIFEquake is a five-year project funded by EU LIFE which aims to restore peatland, quaking bogs and their wider supporting wetland landscapes to favourable conservation status .

Opportunities for Action Aim 1

The possible actions identified with respect to achieving Aim 1 relate to INNS and other species management, Pollution management, Research and Technology, Species conservation and enhancement, Soil protection, and Sustainable agriculture, forestry and fisheries and.

Action 1. Support Control of Agricultural Pollution Regulations 2021 and additional measures to protect highly vulnerable sites from nutrient/nitrate pollution.

Action 2. Undertake research within the ecosystem to better understand the structure, function, fertility and nutrient cycles of its soils and historical changes therein.

Action 3. Use citizen science to collect INNS data, and community engagement to undertake INNS management.

Action 4. Continue restoring peatlands and other soils key to maintaining carbon storage and reducing GHG emissions (NPAP)

Aim 2: Ecosystems are Resilient to Expected and Unforeseen Change

Ecosystem Resilience is assessed in SoNaRR by using four ecosystem attributes as proxies: diversity, extent, condition and connectivity for each of the seven habitat types that make up the mountain, moorland and heath (MMH) ecosystem. The habitat types are lowland heathlands, lowland peatlands, upland heathlands, upland peatlands, upland rock habitats, alpine and boreal heath and grassland, wider upland matrix. There is a large variation in data availability across each of the habitats making up the mountain, moorland and heath broad ecosystem. Many data gaps remain.

Diversity

The **current assessment** of species diversity is **Medium** for four MMH habitat types (lowland heathland, lowland peatlands, upland heathland, and upland rock habitats). The highest diversity of lowland heathland is found on coastal, limestone and wet heaths, whereas inland heaths and heath within the Ffridd have lower diversity. There has been a minor positive change in species diversity of lowland peatland due to restoration of the hydrological integrity of some raised mire, the absence of peripheral lag fen remains an issue. Many upland heathland sites continue to exhibit limited floristic and structural diversity as a result of past management, the more atlantic heaths are typically more species rich. For upland rock habitats there has been reports of some decrease in the total species richness in inland rock (Emmett *et al.*, 2025), which typically have high species diversity within Special Areas of Conservation (SACs).

The **current assessment** of species diversity is **Low** for three MMH habitat types (upland peatlands, alpine and boreal heath and grassland, wider upland matrix). The range of morphological and ecological variation of upland peatlands is low due to the impact of past management. There has also been a recent reported decrease in Sphagnum which suggests a loss of diversity (Emmett et al., 2025) . Diversity is **low** for alpine and boreal heath and grassland mainly due to reactive nitrogen deposition and overgrazing. Historic loss of macro lichens has not been reversed but there has been a small but not significant recovery of Racomitrium lanuginosum (upland moss) (Turner, 2020). The wider upland matrix is characterised by low species and structural diversity, but they have wider species benefits, particularly for specialist birds.

There has been no significant change in the species diversity of MMH ecosystems in the historic short-term (2020-2025) for any habitat type. There is no long-term historical trend or future outlook diversity assessment available for MMH Ecosystems.

Extent

The **current assessment** of extent for two MMH habitat types (lowland heathland and lowland peatland) habitat type is **low**. Many sites for both habitat types have reduced in extent and ongoing losses due to poor management are known to be an issue.

The **current assessment** of extent for three MMH habitat types (upland peatlands, upland rock habitats, alpine and boreal heath and grassland) is **medium**. EU Habitats Directive Article 17 recorded 42 ha of Alpine and Boreal habitat extent in 2019 (Turner, 2020). There is around 9,900 hectares of upland rock habitat, the extent of rock substrate is largely unchanging (NRW, 2021b). Revised Peatland Map shows 81,927 ha of peatland (Welsh Government, 2022b). ERAMMP shows an increase in total bog of 29% which may reflect restoration or previous difficulties in mapping this habitat type (Emmett et al., 2025).

The current assessment of extent for two MMH habitat types (the upland heathland and the wider upland matrix) is **high**. Upland heathland remains a major component of the MMH ecosystem (Emmett et al., 2025; NRW, 2025b). In the wider upland matrix, semi-natural grasslands cover over 140,000 hectares and continuous bracken around 3600 hectares. (Emmett et al., 2025)

Over the historic **long-term** (1945-2025) the extent of MMH ecosystems has **deteriorated** for all habitat types. Lowland and upland heathlands and peatlands had substantial post war losses. For peatland this was due mainly to forestry in the uplands and agricultural improvement in the lowlands (Emmett et al., 2025). There is less information available for the long-term trends of upland rock habitats, alpine and boreal heath and grassland and the wider upland matrix. It is likely that quarrying has affected upland rock habitats since 1945, however long-term quarry faces have also developed natural vegetation.

The **short-term** (2020-2025) historic trend in extent for lowland heathland is **deterioration**. The extent of lowland heathland continues to decline as a result of bracken, scrub and woodland invasion (NRW, 2025b). The **short-term** (2020-2025) historic trend in extent for upland heathland is **improving**. There are indications that the habitat is beginning to spread because of reduced grazing (Emmett et al., 2025; NRW, 2025b, 2025c)The short term (2020-2025) historic trend in extent for all other habitat types is unknown. An increase in total bog (lowland and upland peatland) has been recorded by ERAMMP. This may reflect restoration, but also the difficulties of attributing satellite images to this broad habitat. Major projects have focused on improving condition, not extent (Emmett et al., 2025)

The **future outlook** (to 2030) for extent of lowland heathland and peatland is a **deterioration**. For lowland peatland, the future prospects assessment of four Annex 1 habitats with a lowland presence indicates a status of “poor”. A reduction of grazing on lowland heathland is likely to lead to losses because of increasing tree and scrub cover (NRW, 2025c, 2025b).

The **future outlook** (to 2030) for extent of upland heathland and peatland is a **mixed picture**. For blanket bog (the dominant upland peatland) the prospects for habitat area have been scored as ‘positive’ (NRW, 2018). In the longer term, climate change will present a challenge to the extent of upland peatlands, but this may be tempered by managing for improved ecosystem condition and resilience. Upland Heathland extent is limited by heavy sheep grazing. If grazing continues to decline in the uplands, then heathland would be expected to increase. However, some losses would occur to woodland regeneration on existing heathland.

The **future outlook** (to 2030) for alpine and boreal heath and grassland is **stable**. Upland rock habitats and the wider upland matrix is unknown. There is little evidence available for these habitat types, due to this, the future trends are considered not predictable.

Condition

The **current assessment** of condition for five MMH habitat types (lowland heathland, lowland peatland, upland peatland, alpine and boreal heath and grassland, wider upland matrix) is **low**. For lowland heathland, a high proportion of the resource is in poor condition, often under grazed and unmanaged, although there are some local improvements particularly along the coast. EU Habitats Directive Article 17 reporting in 2019, used in SoNaRR 2020 concluded unknown or poor condition for lowland and upland peatlands., There has been no evidence to suggest an improvement in overall condition (Emmett et al., 2025). For alpine and boreal heath and grassland, there has been no evidence to suggest significant change in condition since SoNaRR 2020, but there has been some localised recovery in areas with low grazing pressure. The wider upland matrix is known to have large blocks of uniform habitat which suits some species such as Chough and Wheater, whereas other species (e.g. Stonechat) would prefer a more varied mosaic.

The **current assessment** of condition for two MMH habitat types (upland heathland and upland rock habitats) is **medium**. For upland heathland, the condition of SSSIs and SACs is poor, but improvements have been detected at some upland sites although overall these sites remain unfavourable (NRW, 2025b, 2025c). The ERAMMP data suggest overall stability in dwarf-shrub heath condition but with an increase in soil acidification which is of concern (Emmett et al., 2025). For upland rock habitats, total species richness has reportedly decreased, and condition is variable but generally considered to be fair (Emmett et al., 2025).

Connectivity

The **current assessment** of connectivity for three MMH habitat types (lowland heathland, lowland peatland, alpine and boreal heath and grassland) is **low**. There has been no evidence of significant change for these three habitat types since SoNaRR 2020. Lowland heathlands are highly fragmented and survive in unconnected parcels. Lowland peatlands have poor connectivity between habitat blocks (NRW, 2022) . Alpine and boreal heath and grassland are inevitably tightly restricted to their bioclimatic envelope but are further constrained by pollution and over-grazed acid grassland and scree/boulder fields (Turner, 2020).

The **current assessment** of condition for four MMH habitat types (upland heathland, upland peatland, upland rock habitats, wider upland matrix) is **medium**. There has been no evidence of significant change for these four habitat types since SoNaRR 2020. Upland heathland is one of the most extensive upland habitats. Upland peatland is the most interconnected of the peatland resource, primarily due to extensive development of blanket bog. These two upland habitats have significant potential to enhance connectivity. For upland rock habitats, connectivity is not a relevant indicator as the occurrence of rock substrate is governed by geological and geomorphological processes. The wider upland matric covers large areas but poor condition limits connectivity.

Trends in Condition and Connectivity

The **long-term past trend** (2012-2025) in condition and connectivity for three habitat types (lowland heathland, lowland peatland and alpine and boreal heath and grassland) is **deteriorating**. For lowland heathland, SoNaRR 2020 reported no lowland heathland in favourable condition and generally poor connectivity. There has been no new evidence. For lowland peatland, ERAMMP reports in bogs and blanket bogs a decline of 10% Sphagnum cover and an increase in topsoil acidity. In fen, marsh and swamp, total species richness and plants favouring high moisture levels have declined (Emmett *et al.*, 2025). The most recent monitoring of alpine and boreal heath and grassland shows unfavourable condition (NRW, 2025d).

The **long-term past trend** (2012-2025) in condition and connectivity for three habitat types (upland heathland, upland peatland and upland rock habitats) is a **mixed picture**. The condition of upland heathland has been unfavourable, with only one site (Rhinog SSSI) consistently recorded as favourable, but connectivity remains high (NRW, 2025b, 2025c). Despite unfavourable condition assessments, there has been some improvement in condition for upland peatland through the National Peatland Action Programme (NRW, 2025a). Evidence for SoNaRR 2020 suggested a mixed picture for upland rock habitats, due to a mixture of favourable and unfavourable SAC condition assessments. No new evidence is available.

There is no long-term past trend for the wider upland matrix.

The **short-term past trend** (2020-2025) in condition and connectivity for two habitat types (lowland heathland and upland rock habitats) is **deteriorating**. The short-term historic trend of lowland heathland reflects the long-term historic trends. For Upland rock habitats, ERAMMP 2024 reports a decrease in the total species richness in inland rock (Emmett *et al.*, 2025).

The **short-term past trend** (2020-2025) in condition and connectivity of three habitat types (lowland peatland, upland heathland and alpine and boreal heath and grassland) is a **mixed picture**. There have been some recent lowland peatland improvements in the historic short-term through the National Peatland Action Programme. The short-term historic trend for upland heathland reflects the long-term historic trend. Although overall alpine and boreal heath and grassland habitat remains in unfavourable condition, recent monitoring suggests some improvement because of declining grazing in a few locations (NRW, 2025d).

There is no short-term historic trend for upland peatland.

The **future outlook** of condition and connectivity for two habitat types (lowland heathland, alpine and boreal heath and grassland) is **deterioration**. For lowland heathland, continued reduction in grazing and other management in the lowlands is likely to lead to loss of lowland heathland because of increasing tree and scrub cover. Article 9A records future prospects for alpine and boreal heath and grassland as deteriorating due to unfavourable condition, atmospheric deposition of nitrogen and climate change (NRW, 2025b, 2025c, 2025d).

The **future outlook** of condition and connectivity for four habitat types (lowland peatlands, upland peatlands, upland heathlands, upland rock habitats) is a **mixed picture**. There has been no new evidence with which to assess the future outlook of peatlands since SoNaRR 2020. As with the future extent of upland heathlands, increased connectivity and condition of this habitat type in the future is dependent on grazing decline. If this continues, it will require careful management to maintain the populations of some upland birds that require a more open habitat (cough ring ouzel, curlew) (NRW, 2025b, 2025c). Despite reports of declining species richness for upland rock habitats, the sample size remains too small to change the SoNaRR 2020 assessment of future outlook for this habitat type.

Progress towards meeting Aim 2 (Ecosystems are Resilient to Expected and Unforeseen Change)

The key opportunities taken up since SoNaRR 2020 comprise:

- The National Peatland Action Programme (NRW, 2020) identified ultra modified peatlands as a priority action theme listing the following national actions:

  1. Assess the scale suitability and potential sites for restoration
  2. Establish collaborative dialogue with private land managers
  3. Establish field-scale trials (feasibility & viability) for wet agriculture and paludiculture techniques.

- The National Peatland Action Programme 2020-2025 (NRW, 2020) has delivered:
    - Hydrological management over a footprint of 2110 ha
    - Erosion control over a footprint of 715 ha
    - Vegetation management over a footprint of 435 ha
    - Grazing management over a footprint of 638 ha
    - Tree removal over a footprint of 770ha
- Life Quaking bogs (2022 – 2026) (NRW, 2024a) has so far delivered:

    - Mown 52 hectares of peatland
    - Removed 72 hectares of scrub
    - Installed 66km of fencing
    - Completed 64 hectares of scrapes to bog surface.
- The sustainable farming scheme (SFS) includes tier 3 cooperative schemes that could establish incentives to encourage cooperation between neighbouring holdings on peatlands, but these are not scheduled to start until the end of the decade.

Opportunities for Action Aim 2

The possible actions identified with respect to achieving Aim 2 relate to Ecosystem restoration, Ecosystem creation, Ecosystem protection, Species conservation and enhancement, Nature based Solutions, Sustainable agriculture, forestry and fisheries and Community engagement.

Action 5. Establish local community examples to demonstrate ecosystem resilience at appropriate scales.

Action 6. Maintain and enhance habitat outside protected sites, particularly Priority Habitat, (s7 Environment (Wales) Act 2016) which must, at very least, be protected from loss and damage.

Action 7. Manage protected sites towards favourable conservation status, enabling these sites to 'function as core areas of a resilient ecological network.'

Action 8. Work in collaboration with the SFS to encourage cooperation between neighbouring holdings on peatlands.

Action 9. Restore the natural altitudinal tree line where appropriate.

Aim 3: Healthy Places for people, protected from environmental risk

Health protection

MMH ecosystems contribute to the protection of human health through the supply of the following regulating services:

- **Global climate regulation services**: Peatlands occupy around 4% of the land mass in Wales and store between 30% and 15% of the carbon stored in Wales, depending on evidence source (Smith *et al.*, 2007; Williamson, Fitch and Evans, 2019). Due to habitat damage from activities such as afforestation and overgrazing, Welsh peatlands (including areas converted to other land cover types) release around 500 kt CO2-equivalent (CO2eq) every year (Evans *et al.*, 2017). Peatland bodies under intensive grassland and arable cropland have the highest greenhouse gas emissions from peatlands in Wales (Welsh Government, 2022b). It is predicted that recent work to block 771km has reduced GHG emissions by 6,030 t CO_2-eq (Williamson, Fitch and Evans, 2019).

- Air filtration services: Around 4 million kilograms of air pollutants have been removed by Wales' MMH vegetation each year between 2007 and 2023. In 2023, the benefit realised prevented 23 life years lost from long-term exposure to particulates (PM2.5 and PM10) and 3 life years lost from long-term exposure to NO2. In 2022 the avoided burden on mortality is estimated at 5 fewer deaths from short term exposure to Ozone (Office for National Statistics, 2024).

- Water flow regulation services create lower peak flows in wet periods reducing risk of flooding to households. MMH habitats, particularly on peat and organic soils, retain large amounts of surface water, slowing discharge and regulating flow; damage leads to more rapid run-off. Direct exploitation of peatlands in the past have reduced this service. The National Peatland Action Programme has improved hydrological management over 2110 ha and reduced erosion over 715 ha (see Aim 2 and Aim 4 for further information).

Health Improvement

MMH ecosystems contribute to human health improvement through the supply of the following cultural services:

- **Recreation-related services** are provided by MMH ecosystems. In 2021/2022, people in Wales made 17,437,539 visits to MMH ecosystems for recreation (Owen, Rhydderch and Williams, 2025) . Almost all the land area included within the MMH ecosystem is Open Access as defined by the Countryside and Rights of Way Act 2000 (CRoW Act). Eryri National Park visitor monitoring figures (2022) for the mountainous areas indicate that over 540,000 thousand people alone visited Yr Wyddfa itself and 75,500 visited Cader Idris (Eryri National Park, 2023). The Office for National Statistics estimate that visits to Welsh MMH ecosystems for recreation increased by 15% between 2019 and 2022, with the associated number of people gaining related health benefits from these visits remaining the same at around 100,000. (Office for National Statistics, 2024)
- **Visual and sensory services** providing local sensory benefits enjoyed by people, these services are enjoyed in combination with recreation-related services. A total of 333 km^2 of Heathland (Dwarf shrub heath) landscapes are evaluated as outstanding or high, and recognised as nationally and regionally important in Wales' LANDMAP Landscape Habitats (Cottrell and Medcalf, 2019).

Cultural Well-being

MMH ecosystems contribute to people's cultural well-being through the supply of the following cultural services:

- **Spiritual, artistic and symbolic services** are provided by MMH ecosystems, There is ground-based and documentary evidence of the traditional method of peat cutting, with over 930 peat cutting and possible peat cutting locations recorded, and a further 517 records for other physical remains, including peat stacks and peat stands (Royal Commission on the Ancient and Historical Monuments of Wales, 2021). Peatlands play a unique role in preserving archaeological remains and recording the development of the landscape and the influence of humans (Hughes, 2010). Historic poetry (Hedd Wyn and Llwyd, 1994) and contemporary poetry such as ((Rhys, 2007) reflects the ongoing strong cultural and spiritual inspiration provided by Welsh peatlands.
- **Educational services** are provided by MMH ecosystems. MMH areas are frequently used for educational and research purposes. The National Parks are particularly popular with education trips; however, the number of trips and participants is not routinely recorded. The uplands provide Welsh universities with research and educational opportunities, for example Pwllpeiran at Aberystwyth University is a research centre dedicated to the uplands.

Progress towards meeting Aim 3 (Healthy Places for people, protected from environmental risk)

The key opportunities taken up since SoNaRR 2020 comprise:

- The National Peatland Action Programme 2020-2025 (NRW, 2020) has delivered Hydrological management over a footprint of 2110 ha. As a nature-based solution some key benefits identified through NPAP's restoration objectives were tackling the Climate and Nature emergencies as well as mitigating against flood and fire risks.
- Some awareness has been raised about the state of montane heath via Cymdeithas Eryri magazine.
- Blue Cross has worked with the Welsh Government to produce a course aimed at reducing livestock worrying (Blue Cross, 2023)

Opportunities for Action Aim 3

The possible actions identified with respect to achieving Aim 3 relate to Access to nature, Community engagement, Education and Awareness, and Integrated plans and strategies

Action 10. Increase awareness and education about the condition of the ecosystem.

Action 11. Establish an integrated approach to managing recreational pressures to ensure sustainable use of the MMH habitat resource. Assess the impacts of large Challenge Events and specific activities on key habitats and species to inform decisions and management.

Action 12. Sustainable Land Use and Land Management Change. Create a coherent and integrated approach to land use and management change priorities across all ecosystems at appropriate scales. This could help to support place-based delivery for our Public Services Boards and via Area Statements.

Aim 4: Contributing to a Regenerative Economy, Achieving Sustainable Levels of Production and Consumption

Contributions of Mountain, moorland and heath to sustainable economic production and consumption

MMH ecosystems contribute to economic well-being through the supply of the following regulating services:

- **Water purification services:** The uplands are crucial for improving the quality of water reaching lowland river systems. Peatland restoration offers a potentially cheaper and more sustainable option to improve the quality of raw water arising from peaty catchments, avoiding costly treatments and the use of chemicals. It is suggested that re-establishing Sphagnum on degraded peatlands could reduce costs and improve efficiency (Ritson *et al.*, 2016).

MMH ecosystems contribute to economic well-being through the supply of the following provisioning services:

- **Grazed biomass provisioning services:** 79% of land in Wales is designated as a Less Favoured Area (LFA), mainly in MMH areas. Cattle and sheep farming on LFA land is the most common farm type in Wales, accounting for 25% of all farms. LFA cattle and sheep farming is completely reliant on income from subsidies (basic payments and agri-environment payments) and diversification, as farming is not profitable on LFA land (Welsh Parliament Senedd, 2022). There has been a small reduction on the number of sheep and cattle in Wales in 2024 compared to previous years ((Welsh Government, 2024)
- **Pollination services:** Habitats with a high proportion of heathers provide a nectar source for pollinators over a long season. ERAMMP 2024 (Emmett *et al.*, 2025) reports pollinator indicators stable for MMH. Heathlands have long been an important resource for beekeepers and 'heather honey' has twice the value of other domestic honeys (UKNEA, 2011).
- **Water supply services** for direct household consumption is an important provisioning service provided by upland areas. Around 93% of the water supplied to consumers in Wales originates from surface water or is abstracted from rivers with large upland catchments (Dee, Usk, Severn, Tywy and Wye). (NRW, 2021b)

MMH ecosystems contribute to economic well-being through the supply of the following cultural services:

- Recreation-related services: In 2021/2022, people in Wales made over 17 million visits to MMH ecosystems for recreation (Owen, Rhydderch and Williams, 2025) These visits support employment in tourism and outdoor leisure related activities. The ONS value tourism to these areas at £40 million in 2022 (Office for National Statistics, 2024). It is estimated that the three Welsh National Parks are visited by 12 million people each year (Auditor General for Wales, 2022).
- **Education, scientific and research services**: MMH ecosystems provide opportunities for schools, businesses and research organisations to use the environment for intellectual interactions. The National Parks are particularly popular with education trips; however, the number of trips and participants is not routinely recorded so it is difficult to get an overall picture.

Economic drivers and their pressures on MMH ecosystems

The key direct economic drivers within Wales related to the degradation of MMH ecosystems relate to **Land and sea use change** and **Direct exploitation.** Climate change pressures are considered to be driven by global economic activity.

Land and sea use change

Intensive grazing (agricultural intensification) impacts MMH habitats by resulting in the loss of species diversity and conversion of heathland, montane and peatland habitats to species-poor grasslands e.g. acid and marshy grassland and grassland habitats on deep peat.

- **The long-term trend (1990-2020) is deterioration**. Heathland habitats have become highly fragmented as a result of past intensification particularly in the lowlands (Blackstock *et al.*, 2010). Past conversion of lowland raised bog and fen habitats to agricultural land continues to impact the remaining peat body through changes to the hydrological system. There has been a widespread loss of semi-natural vegetation (ffridd) and net replacement by improved grassland (Milsom *et al.*, 2003). There is **insufficient monitoring data to provide a short-term trend (2020-2025)** however intensive grazing remains a localised issue in lowland peatlands and a widespread issue in upland peatlands. For heathland, intensive grazing is recorded as a reason for failure on the Eryri SAC (Harrison, 2024a). Dry heath has been shown to be recovering from overgrazing on Llanllechid Common in the Eyri SAC (Harrison, 2024b) although overall the site remains overgrazed in agricultural terms and grazing hotspots persist (NRW, 2025c). Intensive grazing remains a key reason for the unfavourable condition of montane habitats although there is evidence of reduced grazing in some locations (Turner, 2020; Turner and Harrison, 2022).

- **The future outlook is a mixed picture.** Historic intensification will continue to impact on MMH habitats through the effects of fragmentation, eutrophication and changes to hydrological systems. Further conversion of habitat to improved agricultural land should be prevented by the environmental impact assessment (agriculture) (Wales) Regulations 2017. The National Peatland Action Programme (NRW, 2020) has identified hyper-modified peatlands as a priority action theme.

Afforestation: Historic afforestation in the uplands, particularly the planting of conifers in the post war years, included the planting of significant areas of peat soils. The planting of deep peat is no longer permitted but legacy issues associated with afforested deep peat and the self-seeding of conifers from these areas into open habitat remain, impacting the MMH ecosystem.

- **The long and short-term historic trend (1990-2025) is improving. Heathland has been restored following forestry removal in a few locations over the past 20 years. Examples include restoration of lowland heath at Penlan Forest in Pembrokeshire, and the restoration of upland heath on the lower slopes of Llwytmor, Carneddau within the NRW Abergwyngregyn Forest. No extent data is available. The National Peatland Action Programme has removed trees from 7770ha of deep peat (NRW, 2024b). This figure is for the total land area where management has taken place. The density of trees removed will vary from site to site.**

- The future outlook is a mixed picture. Wales' ambition around new woodland creation means that woodlands are likely to be created within the MMH ecosystem in the future. Given the current controls around woodland creation, such as policy, regulation and guidance, it should be well designed and planned to support the MMH ecosystem. The current focus of the National peatland Action Programme is to restore areas of peatland with low yield class plantations (Natural Resources Wales, 2024). However, to deliver the overall target of 45,000 ha of peat restoration required to attain the Net Zero ambition, an expanded focus of our more modified peatlands will be required as part of the 2030 target for 1800 ha of peat restoration per annum (Welsh Government, 2022a

Th.**Reduced management intensity:** Livestock grazing is essential to maintain the structure and floristic composition of many MMH habitats, particularly against the current backdrop of atmospheric nitrogen deposition. However, too much or too little grazing or grazing at the wrong time of year with unsuitable livestock can cause the decline of habitat structure and composition and increase species-poor vegetation, for example upland acid-grassland or *Molinia*-dominated peatlands (NRW, 2021b). Burning has been a traditional practice on some MMH habitats particularly upland heathland. Controlled burning can be used to mimic the natural fire cycle and reduce nitrogen. However, it can negatively impact on fire sensitive habitats and habitat mosaics.

- **The long and short-term historic trend (1990-2025) is a mixed picture.** In 2024 the number of sheep and lambs in Wales was 8.7 million, similar to the 2023 figure. This is the lowest level since 2011. Under grazing has been cited as a current pressure across 8 of the 9 peatland/wetland Annex 1 habitats (NRW, 2026). Recent declines in grazing levels in the uplands have initiated the slow recovery of vegetation in some areas (Turner, 2020; Harrison, 2023, 2024b)) though many habitats still show impacts of heavy grazing, including the suppression or loss of heathers, the prevalence of grasses and loss of plant species diversity. The National Peatland Action Programme 2020-2025 (NRW, 2020) has delivered work to address under-management issues. Cutting on blanket bog or heathland is an alternative to burning but has more resource implication, rewetting reduces the need for resource intensive cutting.

- **The future outlook (2025 to 2100) is a mixed picture.** Heather cutting and controlled burning are likely to decline unless there is a commercial reason to carry on (grouse moors). A decline in management will have positive effects, for example, recovery of fire-sensitive habitats and species, and negative effects for example the potential for more frequent and severe wildfire. Decreasing grazing will tend have a negative impact on lowland heaths resulting in poorer structural and floristic diversity but is likely to be positive in the uplands with heathland spreading into acid grassland, improvements in the condition of montane habitats and the increase in woodland cover.

Unmanaged access, sport and recreational activity: Access and recreation pressures have been recorded on heathlands. Impacts include footpath erosion, vehicle damage, disturbance, especially by dogs, to livestock and breeding birds, and fouling which causes localised soil enrichment. Some of these effects are positive; for example, footpaths can create firebreaks and maintain open ground micro-habitats on heathland, but dogs can discourage graziers from turning out livestock. Impacts on rock-based habitats include footpath erosion across scree fields and localised damage to sensitive cliff and ledge vegetation from climbing and (occasionally) ice climbing. Caves have more specific issues which include the impact of increased CO2 levels associated with respiration on delicate cave formation. Recreational impacts on subterranean fauna are generally poorly understood, but hibernating bats are particularly sensitive to human disturbance.

- **The long-term historic trend is a mixed picture.** For example, Eryri National Park figures for visitor numbers on Y Wyddfa show a decline on some paths whilst there is an increase in visitor numbers on all paths on Cader Idris (Eryri National Park, 2023). In the high montane environment damage from recreational pressure is site specific, for example on the path from Llyn y Cŵn to Y Garn in the Glyderiau where an area of montane habitat has been partially destroyed (Turner, 2020).

- **The future outlook is a mixed picture.** Recreational pressure is likely to continue to have an impact in “honey pot” areas or where habitats are particularly sensitive. The two upland National Parks (Eryri and Bannau Brycheiniog) have strategies for managing visitors and repairing eroded paths in the uplands (Bannau Brycheiniog National Park, 2007; Eryri National Park, 2022). Cwm Idwal in Eryri is one of the most important areas for arctic alpines in Wales and is also a popular winter climbing location.

Built development and infrastructure: This pressure refers to the construction of windfarms on MMH specifically blanket bog in the uplands. Wind-power generation poses two immediate pressures: loss of habitat beneath the footprint of infrastructure (including turbine footings, crane pads, tracks and quarries) and impacts on areas of peatland adjacent to infrastructure posed by hydrological and fragmentation issues. Wind-farms have the potential to alter existing grazing. Management practices, though Habitat Management Plans can represent positive impacts.

- **The long and short-term trend (2000 to 2025) is deteriorating.** The generation of energy from renewable sources, mainly wind and solar has been increasing over the last 15 years. There were 754 onshore wind projects in 2023 (Welsh Government, 2025). Whilst the location of these is not specific a proportion will be constructed on

MMH and have an impact on peatland habitats. The number of windfarm developments on peat is greatest in Ceredigion and Powys whilst the density of turbines is greatest in South Wales. (Chico *et al.*, 2023). Despite Planning Policy Wales Edition 12 (2024) promoting the avoidance of both peat soils and peatland habitats several recent schemes overlapping with peat have been approved and many more are likely to be forthcoming. Renewable Energy Generation is cited as a High priority pressure and threat for blanket bog (NRW and JNCC, 2026).

- **The future outlook (2025 to 2050) is Deteriorating**. The Welsh Government target is to meet 70% of Wales' electricity demand from Welsh renewable electricity sources by 2030. In addition to the 2030 target, in 2023 the Minister for Climate Change proposed an additional target of achieving 100% renewable electricity generation in Wales by 2035 (Welsh Government, 2023b). There are a number of schemes at the planning stage which are likely to have a negative impact on blanket bog habitat and the deep peat resource.

Direct Exploitation

Drainage: This is particularly problematic for and relevant to peatlands where drainage causes habitat change, changes to the hydrological system, erosion, increased run-off, and increased greenhouse gas emissions. Grazing livestock losses also occur in drainage ditches.

- The long-term trend (2000-2024) is improving. Considerable ditch blocking has been undertaken across Wales over the last 20 years e.g. the Life Active Blanket Bog in Wales project (2006-2011) blocked 485 kilometres of drains on the Berwyn and Migneint SACs (European Commission, 2024a). An estimated total length of open drainage channels of 1,512 km remained across the Welsh peatland landscape in 2019 (Williamson, Fitch and Evans, 2019). The ERAMMP report (Emmett et al., 2025) shows an improving long-term trend for blanket bog whilst the report does not specify what activities have led to the improving condition ditch blocking over the last 20 years will be a contributory factor to this trend. However, the short-term trend (2020-2025) is a mixed picture. The 2025 Habitat Regulation 9a assessment finds that the overall conservation status of blanket bog (H7130) is "unfavourable bad", with a trend of "deteriorating" (NRW and JNCC, 2026).
- The future outlook is a mixed picture (2025-2030), moving to uncertain over the long term (2030-2100). Welsh Governments Climate Adaptation Plan (2024) includes , 'we will' commitments concerning the restoration of 45,000 ha of peat, with an annual delivery programme of 1,800 ha/annum by 2030. The National Peatland Action programme is currently being upscaled to continue to deliver action for peatlands. The environmental impact assessment (agriculture) (Wales) Regulations 2017 should prevent any new drainage of peatlands, but this is not certain.

Progress towards meeting Aim 4

The key opportunities taken up since SoNaRR 2020 comprise:

- The winter monitoring equipment set up by us and BMC in 2013 to provide live temperature data on the turf was updated in 2023 as part of the Tlysau Mynydd Eryri Natur am Byth project (The British Mountaineering Council, 2023). This aims to encourage climbers not to use ice axes and crampons when the turf is too warm to avoid damage to sensitive alpine-arctic communities. There is a presumption against publicising some areas where recreational pressures are currently fairly low in order to protect sensitive habitats e.g. the Rhinog in Eryri (NRW, 2024c)
- Glastir agreements have enabled some managers to deliver more appropriate, reduced grazing levels. However, the interim Wales Habitat Scheme has received fewer applications than expected and payment rates, especially to large upland farms may have discouraged some applicants.

Opportunities for Action Aim 4

The possible actions identified with respect to achieving Aim 4relate to Education and Awareness, Payments for Ecosystem Services Pollution management, Renewable energy (worldwide), Sustainable agriculture, forestry and fisheries, Sustainable construction, Sustainable transport, and Waste prevention.

Action 13. Adapt land management systems and practices. Work to maintain healthy soils to increase the ecosystem's resilience to the effects of climate change.

Action 14. Mitigate pressures from built development and infrastructure (including for renewable energy)

Action 15. Sustainable agriculture with appropriate grazing intensity to ecosystem condition and biodiversity to deliver high value products and climate change mitigation co-benefits

Action 16. Mitigate impact of recreational pressure on "honey pot" areas or where habitats are particularly sensitive.

Action 17. Harness sustainable tourism to fund regeneration of MMH ecosystems and communities.

Evidence Needs

Evidence needs for the mountain, moorland and heath ecosystem focus heavily on understanding and enhancing ecosystem resilience and condition. Key gaps include the current health and trends of MMH habitats, condition on protected sites, identifying drivers of change such as climate, land use, and pollution, and evaluating the effectiveness of restoration techniques.

A second theme centres on ecosystem services and sustainable management. Evidence is needed to map shallow peat and organic soils, quantify carbon sequestration benefits, and assess the greenhouse gas balance of transition mires. Further gaps include understanding the provisioning of genetic and timber resources, visual and sensory amenity values, and the role of MMH in water regulation and flood mitigation. Barriers to peatland restoration and landowner engagement also require exploration to support policy and practical interventions.

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Semi-natural grassland ecosystem

Evidence lead: Stuart Smith

Semi-natural grasslands fall into five broad categories, developed in response to local climate, soil, hydrology, geology, and management: acid, neutral, calcareous, marshy and the rare calaminarian grassland. Semi-natural grasslands occur in both upland and lowland situations.

This semi-natural grassland assessment is one of eight ecosystem and three natural resource assessments that inform the overall SoNaRR2025 report. It builds on the findings of SoNaRR2020, drawing together updated evidence from subject experts, national datasets, and assessments. Related assessments include Enclosed farmland and Mountain, Moorland and Heath as well as evidence about drivers of environmental change, such as Land and sea use and management change.

The assessment is structured around four interlinked aims that guide Wales' progress toward the sustainable management of natural resources (SMNR), helping to communicate the relationship between the environment, well-being, and the economy

Key messages

1. Semi-natural grasslands are vitally important for biodiversity and provide a range of key ecosystem services such as pollination, clean air and water, and a supply of sustainably produced food. They capture and store large amounts of soil carbon and have the potential to retain even more if managed to restore their natural diversity of plants and soil fungi.
2. The resilience of semi-natural grasslands has not improved since 2020. Grassland priority habitat is still being lost, and site condition, especially in the lowlands, is generally poor, mainly due to under-grazing. Semi-natural grasslands remain the most fragmented of all ecosystems.
3. Semi-natural grasslands are impacted by a wide range of ongoing pressures, in particular undermanagement, as well as agricultural intensification, atmospheric nitrogen pollution and climate change. Areas of unmapped grassland habitat are highly vulnerable to land use change, including for forestry, energy generation and housing.
4. The condition, protection and monitoring of grassland sites urgently requires increased investment and focus. Many sites which were identified as needing 'priority protection' decades ago are still not legally protected; even within protected sites, only 9% of all grassland features are considered to be in 'favourable condition'.
5. There have been notable successes from local grassland projects and initiatives, but a lack of a coordinated approach to improving grassland resilience at scale and over the long term. The Sustainable Farming Scheme is a key opportunity for

improving grassland resilience across Wales, should it be sufficiently resourced and well targeted.

Semi-natural grassland ecosystem Summary SMNR Assessment

Aim 1: Stocks of natural resources are safeguarded and enhanced

Semi-natural grasslands in Wales continue to be lost through agricultural intensification, although the rate of those losses is thought to have reduced in recent years.

There are also recent examples of grassland habitat being lost through land-use change, including from afforestation and built development/infrastructure, although woodland verification and planning controls generally limit such losses.

Undermanagement remains the main cause of poor condition of semi-natural grasslands, and grassland habitats are under sustained pressure from invasive species, air pollution, and climate change. Non-native plants like cotoneaster and Himalayan balsam threaten native biodiversity, with their spread expected to worsen if there is insufficient intervention. Airborne pollutants such as ammonia and nitrogen oxides exceed critical loads across most grassland types, altering soil chemistry and reducing species diversity. Climate change is disrupting plant and animal life cycles, with evidence of mismatches between flowering times and pollinator activity and declines in moth and bryophyte populations. These pressures collectively degrade the ecological integrity of grassland habitats.

Efforts to safeguard and enhance semi-natural grasslands include management interventions on statutory sites and via agri-environment schemes, targeted invasive species control, pollution reduction, and climate adaptation strategies - however progress is often limited by insufficient resources. Only 10% of grassland priority habitat is under statutory protection, and new SSSI designations since 2020 have been limited. Regulatory improvements and clearer guidance need to be more fully implemented. Without increased investment and management, the outlook to 2050 remains one of continued deterioration, particularly in the face of intensifying climate impacts and land-use pressures.

Aim 2: Ecosystems are Resilient to Expected and Unforeseen Change

Resilience in semi-natural grasslands is assessed through diversity, extent, condition, and connectivity.

Lowland semi-natural grasslands are much reduced in their extent compared to less than 100 years ago and remain the most fragmented of all ecosystems. The grassland habitat patches that remain are often affected by poor condition, with management neglect/undermanagement, and under grazing in particular, the main cause.

Reduced extent, poor connectivity, and poor condition all effect diversity, for example low connectivity means that less mobile grassland species cannot move easily through the landscape. Diversity is currently low in lowland areas and medium in the uplands, with both showing declining trends.

Grassland habitat extent in upland areas remain relatively stable, although only around 1% of grassland priority habitat is in the uplands.

Recent actions aimed at improving habitat condition and connectivity include several restoration projects funded though Nature Networks Fund, site management improvements by local teams in NRW and Plantlife-led initiatives, all aided by updated ecological network maps. However, restoration needs to be significantly scaled up and enacted over longer timescales. The Sustainable Farming Scheme could offer a turning point, but its success will hinge on uptake and resourcing. Overall, resilience remains low, with mixed prospects for improvement.

Aim 3: Healthy Places for People, Protected from Environmental Risk

Semi-natural grasslands provide vital services that protect and enhance human health. They store significant amounts of soil carbon—more than improved grasslands—and can begin sequestering carbon within two years of restoration. They also filter air pollutants, reducing respiratory health risks, produce much less water pollution than intensive agriculture, and regulate water flow, helping to mitigate flood risks. These benefits are especially pronounced in floodplain grasslands, which can retain large quantities of water during heavy rainfall events, usually with minimal impact on sward diversity and growth.

Grasslands also support mental and physical well-being through recreation, amenity, and cultural services. Over 23 million visits were made to these habitats in 2021/22, contributing to public health and local economies. According to polls, landscapes rich in wildflowers and structural variety are particularly valued by people. Despite these benefits, only a small proportion of grasslands are protected, and equitable access remains poorly understood. Continued investment in protection and restoration is essential to maintain these habitats, the wellbeing services they provide and ensure they are accessible to all.

Aim 4: Contributing to a Regenerative Economy, Achieving Sustainable Levels of Production and Consumption

Semi-natural grasslands support a regenerative economy by delivering ecosystem services that underpin sustainable agriculture. They are of particular importance for bees and other pollinating invertebrates, and have a key role in pest control, soil quality regulation, and water purification. Semi-natural grasslands reduce soil erosion and contribute to natural flood management. Their low-input management reduces pollution and supports biodiversity, while producing high-quality, nutrient-rich food. Traditional practices like haymaking also preserve cultural heritage, and grassland habitats are a key genetic resource for crop breeding.

Economic pressures such as agricultural intensification, infrastructure development and afforestation continue to threaten semi-natural grasslands. However, low-intensity farming is increasingly recognised as a viable economic model. The upcoming Sustainable Farming Scheme is expected to incentivise better management but must be well-resourced and widely adopted. Integrating grassland restoration into broader land-use planning can deliver co-benefits for nature, people, and the economy, supporting a shift from grey infrastructure to nature-based solutions.

Key changes since SoNaRR2020

There has been little or no improvement in the resilience of semi-natural grasslands in Wales since SoNaRR 2020. The main drivers of change noted in 2020, such as agricultural intensification, undermanagement, atmospheric pollution and climate change, remain significant.

No real improvement in the extent or connectivity of semi-natural grasslands has been detected. Similarly, there is little or no evidence of recent improvement in semi-natural grassland condition, with neglect/undermanagement still the main issue. As a result, grassland diversity has continued to decline.

New evidence suggests that grassland habitats and species are even more vulnerable to the effects of climate change than previously thought. Rates of atmospheric nitrogen deposition have continued to decrease but all forms of semi-natural grassland remain impacted by critical load levels exceedance, and dry ammonia deposition has increased in some areas.

There has been limited progress in additional statutory protection of grassland habitats since 2020, although progress may improve given the Welsh Government's '30 by 30' objective for 'an accelerated SSSI notification programme'. Several separate projects have benefitted grassland resilience locally but work urgently needs to be scaled up and operate over the longer term.

Semi-natural grasslands Full Assessment of SMNR

Aim 1: Stocks of natural resources are safeguarded and enhanced

Animals, plants and other organisms

Declines in grassland-associated species are evident across multiple taxa including plants, invertebrates and birds.

The State of Nature report 2023 indicated continuing decline in plant species of semi-natural grasslands, including 'steep declines' in species associated with calcareous grassland (Burns *et al.*, 2023). The flowering plants Atlas 2020 shows continuing decline of lowland grassland species to the extent that they are likely to be considered threatened in any GB red list review (including *Silaum silaus*, *Succisa pratensis*, *Genista anglica*, and *Genista tinctoria)* (Botanical Society of Britain & Ireland, UK Centre For Ecology & Hydrology, and Biological Records Society, 2020).

ERAMMP reports a 58% decline in pollinator abundance in unimproved neutral grasslands and a 48% decline in calcareous grasslands. Butterfly populations show similar trends with significant declines in both abundance and species richness in marshy and calcareous grasslands, and reduced mean butterfly abundance in unimproved neutral and acid grasslands (Emmett *et al.*, 2025).

ERAMMP reports a 18% decline in grassland bird species (Emmett *et al.*, 2025), and all of Wales' grassland breeding waders, including the Eurasian curlew (*Numenius arquata*) and northern lapwing (*Vanellus vanellus*), remain in significant decline (Danby I *et al.*, 2021).

Reporting on the marsh fritillary butterfly for Regulation 9A of The Conservation of Habitats and Species Regulations 2017 indicated a decline of >1% per year on average over the short term (2010-2024)(NRW and JNCC, 2026).

Invasive non-native species are a threat to grassland habitats in Wales, and this has been a worsening trend over the last 30 years. Species of particular concern include non-native cotoneaster in calcareous grasslands (Sherry, 2019). Himalayan balsam is known to have expanded in wet grasslands but there is a lack of monitoring data to quantify this. The proliferation of these plants is a threat to grassland species as they can smother native vegetation and lower species diversity. The future outlook (to 2050) is for this trend to continue deteriorating. Although control measures have been effective in some sites, eradication may not be achievable without huge resources (Sherry, Korn and Kehoe, 2020).

Recent evidence shows that conifer species can invade open habitats hundreds of metres from the seed source (NRW, unpublished data), and a number of grassland sites are known to have been impacted.

Air

There is a long-term trend (2010 to 2019) of deteriorating **Air** quality that has affected semi-natural grasslands as a result of associated atmospheric deposition of pollution. This is one of the principal threats to grassland ecosystems, with pollutants of concern including nitrogen oxides and ammonia that increase soil nutrient levels and cause acidification. This pressure is widespread, with nitrogen critical loads exceeded on 91% of acid grasslands and 100% of calcareous grasslands (by area) in Wales (Rowe *et al.*, 2022). Rowe et al (2022) report a 12% increase in the area of land in Wales exceeding ammonia critical load (1 µg m-3) between 2010 and 2018.

Regulation 9A reporting under the Conservation of Habitats and Species Regulations (2017) concluded that atmospheric nitrogen deposition was a high-ranking pressure for all seven forms of grassland reported on, with critical load exceedance ranging from 47% to 100% of mapped extent (NRW, 2026).

Climatic features and processes

Long-term **changes in intensity and frequency of weather events** are observed over the last 10-50 years. These are characterised by increases in periods of dry weather or drought, or very wet weather, which have affected grassland ecosystems in a variety of ways, either through direct effects or by promoting damaging land use and land management changes. Increased drought conditions have been found to reduce grassland seedbanks and impact on species abundance, community structure and flowering and fruiting. The effects of this may take years to become obvious but may ultimately be severe. Short-term deteriorating trends have also been observed over the last five years (NRW, 2024a). For instance, prolonged periods of flooding at one grassland site have led to significant changes in plant diversity, with tall sedges becoming dominant (NRW, 2024b). The future outlook (to 2050) is for these deteriorating trends to continue as climate change worsens and the longer-term effects of changes in intensity and frequency of weather events become more significant.

Associated long-term changes in air temperature due to climate change are also observed over the last 10-50 years. These changes are altering the timing and performance of plant reproduction of grassland plant species with knock-on effects on other species, particularly invertebrates and some bird species. Changes in plant phenology are a risk for pollinating and herbivorous invertebrates (Beard *et al.*, 2019) and nesting times for bird species may become mismatched with peaks in invertebrate food sources (Burns *et al.*, 2023). Climate change is highlighted as a major cause of decline in moth populations (Fox *et al.*, 2014; Martay *et al.*, 2016) and may also have a negative impact on some bryophyte species (Pakeman *et al.*, 2022). It is not possible to assess these trends over the recent short-term but it is expected to continue deteriorating, with the effects on some grassland species expected to be profound (Staddon, P.L., Thompson, P and Short, C, 2023).

Pressures from economic activity (see Aim 4 for more detail)

Pressures arising more directly from economic activity are also negatively affecting natural resources in semi-natural grassland ecosystems (see Aim 4 for more details). These pressures are (in alphabetical order): afforestation, agricultural intensification, built development and infrastructure, and reduced land use or management intensity

Over the past 30 years, **afforestation** of semi-natural grasslands has not been a major pressure on the ecosystem (Beauchamp *et al.*, 2020). However, tree planting is likely to increase in line with Welsh Government targets and this needs to be appropriately managed as some unprotected grassland habitats have not been identified and mapped. Afforestation has been listed as a 'high pressure' for 'species-rich Nardus' habitat for reporting under Regulation 9A of The Conservation of Habitats and Species Regulations 2017. This is a predominantly upland habitat, often occurring as small areas intermixed with upland acid grassland which is being targeted for tree planting (NRW, 2026). **Agricultural intensification** was the principal cause of the more than 90% decline in extent of semi-natural grassland in Wales in the latter part of the 20th century. Along with climate change it has been identified as the main cause of species population change since the 1970s (Burns *et al.*, 2023). Semi-natural grasslands are highly sensitive to elevated soil nutrient levels, such as through fertiliser application, and are severely damaged by ploughing and widespread herbicide use. Evidence suggests that this trend has continued over the last decade (Welsh Government, Unpublished); although the deterioration may have slowed somewhat, the ecosystem remains very vulnerable to loss. The outlook to 2035 is uncertain and may present a mixed picture, reflecting continuing losses but perhaps also some positive impacts from the Sustainable Farming Scheme.

Land development for new roads, quarrying, housing and power generation infrastructure has negatively affected semi-grassland habitats over at least the last 20 years, resulting in loss and fragmentation of habitats. This trend has slowed in the past few years, but the future outlook is deteriorating given Welsh Government targets for renewable energy growth and housing, although '30 by 30' targets should lead to protection of some additional grassland sites.

Reduced land use / management intensity has negatively affected semi-natural grasslands for at least the last 30 years. Over the last five years this trend has continued, with undermanagement being the principal cause of poor condition assessments on statutory protected sites (including SSSIs). Inadequate management (mainly under grazing) was found to be the main cause of poor condition on unprotected sites in England (Hewins *et al.*, 2005), and, despite a lack of comprehensive data, this is also likely to be the case in Wales. Under-grazing has been listed as a 'high pressure' for four out of seven grassland habitats reported on under Regulation 9A of The Conservation of Habitats and Species Regulations (2017) (NRW, 2026). The outlook to 2050 is poor given current trajectory of the drivers for climate change and reduced management (Burns *et al.*, 2023), although the importance of appropriate management has been recognised by the Welsh Government's Biodiversity Deep Dive recommendations.(Welsh Government, 2022)

Progress to meeting Aim 1 (**Stocks of natural resources are safeguarded and enhanced)**

Three new grassland SSSIs have been notified since 2020 (up to 31st December 2024) and only around 10% of grassland priority habitat is on statutory protected sites. Statutory protection safeguards sites from a range of damaging activities. However, restrictions on the setting up of Section 16 management agreements has limited efforts to improve condition on these sites, and there remains a sizable number of sites awaiting notification. The current SSSI review is, among other things, assessing how notifications will be prioritised and resource requirements going forward.

Opportunities for Action Aim 1

The possible actions identified with respect to achieving Aim 1 relate to INNS and other species management, Pollution management, Species conservation and enhancement, and Sustainable Agriculture, fisheries and forestry.

- Action 1. Widespread and sustained control of INNS, particularly cotoneaster and Himalayan balsam.
- Action 2. Improve condition of grassland flora by tackling the root causes of poor air quality linked to ammonia.
- Action 3. Support grassland adaptation to reduce impacts of change in intensity and frequency of weather events, particularly drought and dry weather.
- Action 4. Support grassland adaptation to reduce impacts of changes in air temperature, such as altered timing and performance of plant reproduction.

Aim 2: Ecosystems are Resilient to Expected and Unforeseen Change

Ecosystem Resilience is assessed in SoNaRR by using four ecosystem attributes as proxies: diversity, extent, condition and connectivity for each of the two broad habitats that make up the semi-natural grassland ecosystem. The habitat types are lowland semi-natural grassland (calcareous, neutral, acid, marshy, calaminarian) and upland (calcareous, acid, calaminarian). There is a large variation in data availability across each of the habitats making up the semi-natural grassland broad ecosystem. Many data gaps remain.

Diversity

Semi-natural lowland grasslands are naturally very diverse habitats but, due to historic losses of diversity, current diversity is assessed as low. This deteriorating trend is also seen in upland grasslands, although diversity is naturally lower than in the lowlands and there have been less severe changes in diversity. Current diversity for upland semi-natural grasslands is assessed as medium. This trend in deteriorating diversity is expected to continue in the future as the key pressures on semi-natural grasslands increase.

In the lowlands, many grassland species are adversely affected by the very poor levels of ecological connectivity, as well as small habitat patch size, particularly those with low dispersal ability. This can cause decline in grassland diversity both now and in the future, as isolation can cause loss of species as a consequence of extinction debt (the future extinction of species due to events and pressures in the past).

Extent

Historically Wales has experienced huge losses in lowland semi-natural grassland extent, with over 90% lost in the latter half of the twentieth century, due mainly to agricultural intensification driven by land-use policies. Extent of upland grassland is assessed as high, as this has changed little in recent history and is constrained by underlying bedrock and soils. The outlook to 2035 for lowland grassland extent is a mixed picture. Land use pressures are set to increase markedly, with government targets to increase tree planting, renewable energy and house building, while the impact of the Sustainable Farming Scheme remains uncertain. However, 30 by 30 targets indicate a greater government focus on improving ecosystem resilience, which may counter some of the increasing pressures on grasslands.

Condition

The condition of semi-natural grasslands has deteriorated over time, with evidence of decline since at least the start of this century. The condition of lowlands semi-natural grasslands overall is assessed as low in both protected and unprotected sites, due largely to undermanagement. The picture for upland grasslands is less well-known, and condition is assessed as medium. The future outlook to 2035 is judged to be a mixed picture; the immediate prospects for condition appear to be poor, given the limited availability of resources for introducing or maintaining appropriate management, and the impact of the Sustainable Farming Scheme is uncertain.

Connectivity

Due to major historic losses in extent, lowland semi-natural grasslands are the least well connected of all ecosystems, with major implications for species which cannot move easily through the landscape. There is evidence of a recent increase in connectivity (Hudson J, 2023) but this starts from a baseline of very poor grassland connectivity and requires monitoring to see if the trend continues. The outlook for connectivity of lowlands semi-natural grasslands is mixed as pressures continue to grow, and improvement would require significant resources; the impact of the SFS is yet uncertain.

Connectivity of uplands grasslands on the other hand is relatively high, probably little changed in recent decades and not likely to change considerably in the next few decades (NRW, 2021).

Progress towards meeting Aim 2 (Ecosystems are Resilient to Expected and Unforeseen Change)

The key opportunities taken up since SoNaRR 2020 comprise:

- Progress in remapping ecological networks, which enables grassland creation and restoration to be more spatially targeted to enhance important ecological networks. Our Grassland Ecological Network maps have been updated (2022) and are available on DataMapWales (NRW, 2025) These maps are being used and further developed by local NRW teams (for example in South West and South Central areas). The ecological network maps are also widely used in country planning and woodland creation.
- There have been a range of small projects which have supported management on protected sites to achieve good condition. These include Nature Networks funded cotoneaster control projects run by North Wales Wildlife Trust between 2021 and 2023 (North Wales Wildlife Trust, 2025); Glaswelltiroedd Gwydn (3 year Plantlife-led project started in 2023); and more recently the Crypitc Creatures project focused on invertebrates in limestone grassland in north Wales (started in 2024). Other successful recent projects are highlighted in https://naturalresources.wales/media/3eohpzaj/programme-for-sn-grasslands-in-wales-nrw-608-2022.pdf
- NRW land management agreements are in place to deliver better grassland condition on some SSSIs, but insufficient resourcing to deliver and renew agreements has led to only a minority of grassland features being thought to be in good condition.
- Three new SSSIs with grassland features have been designated since 2020. These are now protected from a range of damaging activities. However, current resource availability limits the setting up of new management agreements aimed at improving condition on these and existing SSSIs. Only 10% of grassland Priority Habitat is currently on protected sites, considerably lower than the Convention on Biological Diversity (Aichi) target of 17% (of terrestrial areas on protected sites).
- A number of projects are underway, planned or completed which are targeted at improving ecological connectivity, resilience and ecosystem service provision (also see Aim 3). These include NRW BERF funded work on statutory sites and some non-statutory pilot sites; and WG/HLF Nature Networks Fund projects.

Opportunities for Action Aim 2

The possible actions identified with respect to achieving Aim 2 relate to Ecosystem creation, Ecosystem protection, Ecosystem restoration, INNS and other species management, Pollution management, and Species conservation and enhancement.

Action 5. Increase extent and connectivity of lowland grassland habitats, particularly through spatially targeted creation and restoration to enhance ecological networks.

Action 6. Increase diversity and condition of lowland grassland habitats by addressing pressures such as INNS, air pollution and reduced management.

Action 7. Increase protection of vulnerable grasslands from damaging activities by increasing designations and promoting the setting up of management agreements for protected sites.

Aim 3: Healthy Places for people, protected from environmental risk

Health protection

Semi-natural grassland ecosystems contribute to the protection of human health through the supply of the following regulating services:

- **Global climate regulation services** contribute to reduced concentrations of greenhouse gases in the atmosphere, leading to reduced climate change impacts on people. Much more carbon is stored in soils than in vegetation and Wales' grassed areas collectively are estimated to sequester in excess of 600,000 tonnes CO2 equivalent per year (Office for National Statistics, 2024a). These grassed areas (swards) include areas within the enclosed farmland (e.g., pastures) and mountains, moors and heath (e.g., heather grasslands) ecosystem types, as well as semi-natural grasslands. However, semi-natural grasslands contain higher levels of soil carbon than improved swards, so converting swards from improved to semi-natural could have a huge carbon benefit if enacted over a large area (Chen *et al.*, 2020; Anderson *et al.*, 2021; Norton *et al.*, 2022)(. These benefits in carbon capture can start within two years (faster than woodlands for example which may take 30 years) (Anderson, 2021). Also, regularly-flooded floodplain grasslands are particularly significant for storing soil carbon (Floodplain Meadows Partnership, 2018).

- **Air filtration services** contribute to reduced concentration of air pollutants which benefits human health. According to ONS data, around 24 million kilograms of air pollutants have been removed by Wales semi-natural grasslands each year between 2007 and 2023, the most by any semi-natural habitat. In 2023, the 'benefit realised' prevented 71 life years lost from exposure to particulates (PM2.5 and PM10) and In 2023 the avoided burden on mortality is estimated at 18 fewer deaths from short term exposure to Ozone (Office for National Statistics, 2024a).

- **Water flow regulation services** reduce peak flows during wet periods and associated risks of flooding to households and industry. Semi-natural grasslands have a greater capacity to store water than intensively managed grassland, having less compacted soils, more varied sward structure and a wider range of plant species rooting depths (NRW, 2020). Semi-natural floodplain grasslands in particular can store large amounts of water during high rainfall events (Rothero E, Lake S, Gowing D (eds)., 2016), compared to more intensively managed grasslands (e.g., pastures).

Health Improvement

Semi-natural grassland ecosystems contribute to human health improvement through the supply of the following cultural ecosystem services:

- **Recreation-related services** are supplied by grasslands across Wales and offer opportunities for people to enjoy in-situ interactions with nature and associated physical and mental health benefits. In 2021/2022, people in Wales made over 23 million visits to semi-natural grasslands for recreation (Owen, Rhydderch and Williams, 2025) .
- **Visual and sensory services** providing local sensory benefits enjoyed by people, these services are enjoyed in combination with recreation-related services. Surveys show that people prefer areas with structural variation and an abundance of flowers, as provided by semi-natural grasslands, over monotonous landscapes. At a local level, varied landscapes and aesthetic value help to provide a sense of place and link to traditional, cultural and heritage practices (NRW, 2020).

Cultural Well-being

Semi-natural grassland ecosystems contribute to people's cultural well-being through the supply of the following cultural services:

- **Spiritual, artistic and symbolic services** contributing to cultural and spiritual identity and acting as a source of inspiration for artistic expression. Tranquillity, wildness, naturalness and aesthetic appreciation are associated valued cultural services and benefits of this category. Semi-natural grassland is associated with a number of traditional management practices with high cultural and heritage value, such as hay making and grazing with rare livestock breeds (NRW, 2020). Wildflower-rich meadows have long been and remain an inspiration for artists (e.g., ‘Meadow Art’ by the Floodplain Meadows Partnership).

- **Education, scientific and research services** contributing to intellectual development and advancement of knowledge. Many schools and other educational establishments make occasional use of grassland sites for learning purposes; the amount of use often depends on proximity to an appropriate site. For example, Great Orme’s Head receives around 200 school groups per annum, not including unofficial visits, many of which engage in environmental activities on the site (NRW, 2020).

Progress towards meeting Aim 3 (Healthy Places for people, protected from environmental risk)

The key opportunities taken up since SoNaRR 2020 comprise:

- UK research has provided clarity on the important role of soil carbon storage in semi-natural grasslands. Important evidence includes ONS (2024a), (for a wider set of grassland types), Anderson et al. (2021), Beechener et al. (2021) and Gregg et al. (2021).
- Some recent articles have outlined the carbon storage disbenefits of planting trees on organic soils, including shallow peats, which underly many marshy grasslands (Brown, 2020; Friggens *et al.*, 2020; Matthews *et al.*, 2020)
- Increased activity and collaboration around floodplain grasslands, including work by the Floodplain Meadows Partnership and NRW. For example, one wide-ranging project included actions around clarifying extent of species-rich floodplain meadow in Wales, modelling of restoration potential, developing local networks and influencing policy.

Opportunities for Action Aim 3

The possible actions identified with respect to achieving Aim 3 relate to Access to nature, Nature based solutions, Payment for ecosystem services, , Pollution management and Research and technology

Action 8. Protect and restore semi-natural grassland habitats to increase carbon sequestration

Action 9. Protect and restore semi-natural grassland habitats to increase air filtration services

Action 10. Protect and restore semi-natural grassland habitats to increase water flow regulation.

Action 11. Maintain and improve access to semi-natural grassland ecosystems of high amenity value for recreation, health improvement, learning and wider cultural well-being.

Aim 4: Contributing to a Regenerative Economy, Achieving Sustainable Levels of Production and Consumption

Semi-natural grassland ecosystems contribute to economic well-being through the supply of the following regulating services:

- **Biological control services** reduce the impacts of pests and disease on agricultural production. Semi-natural grasslands provide valuable habitat for predatory invertebrates which are crucial for natural agricultural pest control and as a genetic resource for crop breeding used to improve pest resistance (NRW, 2020).

- **Pollination services** contribute to increased fertilisation and production of agricultural and horticultural crops. Semi-natural grasslands are of particularly high importance for pollinating invertebrates, with calcareous and neutral grasslands having among the highest nectar levels of all habitats. Marshy grasslands had the highest density of bumblebees and butterflies of ten broad habitats assessed during Glastir Monitoring and Evaluation Programme. Pollination services are greatly enhanced by closeness of a habitat to the crop (NRW, 2020). ERAMMP (Emmett et al., 2025) reported declines in pollinator abundances in all grassland types over approximately the past decade.
- **Soil quality regulation services** contribute to fertile soils for carbon sequestration and agricultural production. Soil quality is benefited by low intensity agricultural production and semi-natural grasslands have a particularly high diversity of soil animals. Intensive grassland management reduces soil animal biodiversity, including earthworms, and may therefore threaten soil functioning in agricultural systems (NRW, 2020).
- The supply of **water purification services** from semi-natural grasslands is relatively high compared to intensively managed grasslands (e.g., pastures in enclosed farmland). Low input semi-natural grassland management produces much less water pollution than intensive agriculture due to minimal use of soil enrichers such as artificial fertilisers and farm slurry, lower livestock densities, and less use of machinery (NRW, 2020). This can lead to reduced water treatment and pollution management costs for the water sector,
- The supply of **soil and sediment retention services** from semi-natural grasslands is relatively high compared to intensively managed grasslands in other ecosystem types (e.g., pastures in enclosed farmland). As semi-natural grasslands are not ploughed, they have lower levels of soil erosion and soil loss. As such, maintaining semi-natural grasslands can contribute to avoiding sedimentation of water courses / resources and land slippage (NRW, 2020). This can benefit both the water sector (i.e., with respect to managing sediment inputs to water resources) and the agricultural sector over the long term (i.e., with respect to manging soil losses).
- **Water flow regulation services** reduce peak flows during wet periods and associated risks of flooding to households. Semi-natural grasslands have a greater capacity to store water than intensively managed grassland, having less compacted soils, more varied swards structure and a wider range of plant species rooting depths (NRW, 2020). Semi-natural floodplain grasslands in particular can store large amounts of water during high rainfall events (Rothero E, Lake S, Gowing D (eds)., 2016), compared to more intensively managed grasslands. As such, they can potentially contribute to natural flood management solutions at landscape scale (particularly in floodplains). Semi-natural grassland ecosystems contribute to economic well-being through the supply of the following provisioning services:
- **Grazed biomass provisioning services**: Semi-natural grasslands generally deliver higher livestock production levels than other semi-natural habitats (e.g., bog, heathland), and where grassland soil fertility is low to moderate, higher plant species diversity promotes higher productivity (NRW, 2020; Schaub et al., 2020).

- Crop provisioning services: semi-natural neutral grasslands cut for hay provide fodder for feeding livestock over winter. Although largely replaced by silage production, traditional meadow management remains widespread in Wales, and dried hay is generally favoured by horse owners over silage. (Zhu et al., 2021).
- Genetic material services: Semi-natural grasslands are of high importance in the conservation of Crop Wild Relatives (CWRs) which are an important genetic resource for crop breeding used, for example, to improve pest and disease resistance, increase tolerance to environmental stress, and improve yield. Such species have increased importance as climate change increases the need for crops to be resilient to extreme environmental conditions (NRW, 2020).

Semi-natural grassland ecosystems contribute to economic well-being through the supply of the following cultural services:

- Recreation-related services: In 2021/2022, people in Wales made over 23 million visits to semi-natural grassland habitats for recreation (Owen, Rhydderch and Williams, 2025) These visits support employment in tourism and outdoor leisure related activities. A few grassland sites are of particular importance for tourism, notably Great Orme's Head, which receives more than half a million visitors per year (Conwy County Borough Council, 2013).

Economic drivers and their pressures on semi-natural grassland ecosystems

The key direct economic drivers within Wales directly related to the degradation of semi-natural grassland ecosystems relate to Land and sea use and management change. Climate change pressures are considered to be driven by global economic activity, and the specific economic drivers of pollution pressures are assessed via the relevant natural resource assessments.

Over the past 30 years, **Afforestation** of semi-natural grasslands has not been a major pressure on the ecosystem (Beauchamp *et al.*, 2020). Over the shorter term (last 5 years) there are indications that this pressure has increased, with a number of recent cases of planting on priority grassland habitat recorded but it is unclear how widespread this is. The future outlook (to 2050) is likely to be a deteriorating one, as tree planting is likely to increase in line with Welsh Government targets. To mitigate this, effective controls for tree planting need to be in place.

Agricultural intensification was the principal cause of the more than 90% decline in extent of semi-natural grassland in Wales in the latter part of the 20th century. Along with climate change it has been identified as the main cause of species population change since the 1970s (Burns et al., 2023). Semi-natural grasslands are highly sensitive to elevated soil nutrient levels, such as through fertiliser application, and are severely damaged by ploughing and widespread herbicide use. ERAMMP results (Emmett et al., 2025) suggest that issues of concern over condition of all types of semi-natural grassland over the short term (2013-16 to 2021-23) might be due to high management intensity. The future outlook (to 2035) for this pressure is mixed picture, reflecting continuing losses but perhaps also some positive impacts from the Sustainable Farming Scheme.

Built development and infrastructure for new roads, quarrying, housing and power generation infrastructure has negatively affected semi-grassland habitats over at least the last 13 years. Installation of wind and solar renewable energy infrastructure has increased substantially in Wales, however there is evidence that both solar and wind output on semi-natural grasslands increased only very slightly between 2017 and 2022 (Office for National Statistics, 2024b). House building rates in Wales remained fairly static between 2014/15 and 2019/20 (at around 6000 to 7000 new dwellings per year) and have slowed thereafter (Welsh Government, 2025) . This is mostly affecting semi-natural grassland in the south and south-eastern part of Wales, where most of the country's house building takes place. The future outlook is deteriorating. Increases in onshore wind/solar and house building can be expected in response to renewable energy and housing targets. At the same time, targets for protecting 30% of terrestrial ecosystems by 2030 (30 x 30) should lead to protection of some additional grassland sites.

Reduced land use / management intensity has negatively affected semi-natural grasslands for at least the last 30 years. In SoNaRR2020, undermanagement was highlighted as the principal cause of poor condition of grassland SSSI features assessed between 2004 and 2017 (affecting 80% of the features). Based on survey data from England, the main cause of this appears to be under-grazing (Hewins *et al.*, 2005). An assessment of the condition of qualifying features on protected sites was also undertaken by NRW in 2020 (NRW, 2023), with undermanagement or scrub expansion the causes of poor condition for 107 features out of 138 (78%). Over the last five years this trend has continued, with undermanagement being the principal cause for poor condition assessments. Given the current trajectory of the indirect drivers which cause reduced management, particularly economic drivers, the future outlook for this pressure is one of continuing deterioration (to at least 2050). However, the importance of appropriate management has been recognised by the Welsh Government's Biodiversity Deep Dive recommendations, and in coming years, the Sustainable Farming Scheme (SFS) is expected to be a key part of delivering better semi-natural grassland condition.

Contributions of semi-natural grassland ecosystems to sustainable economic production and consumption

There is a growing appreciation that low intensity farming can be an economic option for farmers (Norton *et al.*, 2022; Plantlife, 2023) enabling the production of food within a more sustainable agricultural system. The management practices of low intensity, semi-natural grassland agriculture generate co-benefits associated with reduced pollution and climate change mitigation, whilst contributing to protecting and maintaining soil functioning over the long-term. In addition, the capital costs of farming semi-natural grassland are markedly lower than for intensive grassland management, largely due to much lower spending on fertilisers and farm chemicals. The products themselves can also contribute to healthier consumption, as meat produced from semi-natural grasslands has higher nutrient content and lower fat levels than that produced from agriculturally improved grasslands. However, there is work to be done to help land managers better recognise the value and advantages of semi-natural grasslands (Michaud *et al.*, 2020).

As part of an integrated landscape management approach, investing in improving grassland condition and extent can also be effective in improving water quality and mitigating flood risk with appropriate design. These are examples of how grassland investment can support transitioning away from investment in 'grey' built infrastructure solutions to Nature based Solutions (NbS) that deliver co-benefits for nature and people.

Progress towards meeting Aim 4 (Contributing to a Regenerative Economy, Achieving Sustainable Levels of Production and Consumption)

The key opportunities taken up since SoNaRR 2020 comprise:

- There has been more sustainable management, including reinstated grazing, at some sites. This has enabled sustainable food production and increasing other ecosystem benefits. There is hope that the Sustainable Farming Scheme (SFS), due to start in 2026, will provide the step change in better management of grassland habitat that is required. Unfortunately, the closure of PONT (a grazing knowledge-sharing organisation) in March 2024 has removed a significant resource for delivering grazing management on nature conservation sites.
- It is hoped that the Sustainable Farming Scheme (due to start in 2026) will deliver more sustainable grassland management across Wales, focused away from mainly food production to multiple ecosystem service provision, delivered by more low-intensity management: reducing pollution levels, providing pollinator habitat, reducing flood risk, etc., and providing high-quality food in a sustainable way. The SFS will need to have significantly higher coverage than Glastir, which only covered 12% of semi-natural grassland Priority Habitat in Advanced grassland options 2020-23, and will need to be sufficiently resourced, with incentives sufficient to encourage high uptake of grassland habitat.

Opportunities for Action Aim 4

The possible actions identified with respect to achieving Aim 4, relate to Awareness raising, Integrated plans strategy and delivery, Nature based Solutions, Pollution management, Research and technology, Sustainable agriculture, forestry, and fisheries, and Sustainable construction.

Action 12. Mitigate pressures from built development and infrastructure (including for renewable energy and housing).

Action 13. Sustainable agriculture with appropriate grazing intensity to improve semi-natural grassland ecosystem condition, maintain soils and biodiversity (including pollinators, invertebrates that control pests and wild crop relatives), produce high value produce and deliver climate change mitigation co-benefits.

Action 14. Encourage investment in semi-natural grasslands as part of an integrated landscape management strategy for delivering Nature based Solutions to purify water and reduce flood risk, alongside other development objectives.

Evidence Needs

The lack of recent information on extent and condition is a major hinderance to improving resilience of semi-natural grasslands in Wales. Existing information on extent is mainly based on survey from late last century, while recent condition assessment covers a minority of grassland SSSI features and is very sparce for non-statutory sites. There is also a need to better evaluate the success of agri-environment schemes and grassland creation projects, and to monitor trends in grassland species diversity, particularly for uncommon vascular plants and invertebrates.

More research is needed to better quantify grassland ecosystem services such as carbon storage, water regulation and flood prevention. This includes understanding the impact of varied management regimes, species diversity and root structures on soil carbon and water dynamics. Climate change impacts on species composition and ecosystem service delivery are also a priority. Further evidence is sought on the effects of atmospheric pollution, tree planting, and land-use changes on grassland resilience, and to identify optimal locations for new grassland creation to enhance connectivity and ecosystem benefits.

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Urban ecosystem

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The urban ecosystem is the built environment - which includes buildings, roads, gardens, parks and informal greenspaces, waste sites and any other structure or space installed for human activities.

This urban assessment is one of eight ecosystem and three natural resource assessments that inform the overall SoNaRR 2025 report. It builds on the findings of SoNaRR2020, drawing together updated evidence from subject experts, national datasets, and collaborative projects. This assessment is closely linked to the assessments for Air, Water and Freshwater.

The assessment is structured around four interlinked aims that guide Wales' progress toward the sustainable management of natural resources (SMNR), helping to communicate the relationship between the environment, well-being, and the economy

Key messages

1. Our towns and cities are struggling to cope with climate change due to increased risk of heat stress and flooding, and we expect this to get worse.
2. Over 80% of Wales' population live in built-up areas, which provide essential ecosystem services for people and the economy.
3. Pollution is a major pressure on our urban ecosystems and human health, including air, water, soil, noise and light pollution.
4. We need more street trees, rain gardens and other green infrastructure to keep the places where we live habitable in the face of pollution and climate change.
5. To tell if our actions are working, we need a monitoring network in each urban area to track changes in air pollution, light pollution, rainfall, temperature and wildlife.

Urban ecosystem Summary SMNR Assessment

Aim 1: Stocks of natural resources are safeguarded and enhanced

Urban ecosystems in Wales face pressures from climate change, invasive non-native species (INNS), pests, and pollution. INNS introduced for ornamental purposes can disrupt native biodiversity and ecosystem functions, while pests like ash dieback and oak processionary moth threaten urban trees. Air pollution trends are mixed, with reductions in SO_2 and NO_2 but rising ozone and $PM_{2.5}$ levels in densely populated areas. Light and noise pollution also damage urban wildlife and human health. Water and soil pollution have historically degraded urban ecosystems, though large improvements in water quality and soil remediation happened during the 20th Century . Climate change intensifies the pressures on the urban environment through increased flooding, heat stress, and sea level rise, particularly affecting coastal urban zones.

Progress includes mandatory Sustainable Drainage Systems (SuDS) for new developments since 2019, improving water management. Wales' 2024 Clean Air Act sets strict air quality targets and addresses urban noise. The 20 mph speed limit policy aims to reduce traffic emissions and noise. Key actions include controlling INNS, monitoring pests, improving air and water quality, remediating contaminated land, adapting urban green spaces to climate impacts, monitoring urban wildlife, safeguarding existing large trees, and managing urban green spaces for pollinators.

Aim 2: Ecosystems are Resilient to Expected and Unforeseen Change

Urban ecosystem resilience is challenged by limited diversity, low green infrastructure extent, and unknown connectivity. Tree species diversity is low, making urban forests vulnerable to pests and climate stress. Green space extent is constrained, with only 3,721 ha of functional green space and 1,432 ha of blue space. Tree canopy cover averages 17–18% and urban trees face aging and loss. Connectivity remains poorly understood, though hedgerows offer some habitat links. Flooding, pollution, and heat stress further degrade urban ecosystem condition.

Recent initiatives include statutory SuDS on new developments, the Local Places for Nature programme, and pollinator-friendly mowing regimes. These efforts enhance resilience by creating new habitats and improving ecosystem services. Recommended actions include increasing tree diversity and canopy cover, protecting and expanding green and blue spaces, and improving ecological connectivity through green corridors and stepping stones including SuDS.

Aim 3: Healthy Places for people, protected from environmental risk

Urban ecosystems support health through climate regulation, air filtration, noise attenuation, and flood mitigation. Cardiff's urban forest sequesters nearly 8,000 tonnes of carbon annually, while vegetation cools cities and intercepts pollutants. Urban trees and grasslands remove over 1.6 million kg of air pollutants yearly. Vegetation stabilizes soils, reducing landslip risks, and SuDS retain stormwater, lowering flood hazards. Noise mitigation benefits 12,000 homes, improving mental well-being.

Cultural services include recreation, with over 72 million visits to urban green spaces in 2021/22, though usage declined post-2019. Access varies, with 69% of urban households within 300m of functional greenspace. Deprivation correlates with environmental inequality. Less affluent areas have lower tree cover and poorer access. Actions include expanding green infrastructure, improving access, and using nature to foster community cohesion and health.

Aim 4: Contributing to a Regenerative Economy, Achieving Sustainable Levels of Production and Consumption

Urban ecosystems contribute to economic sustainability through climate regulation, flood control, and food production. Green infrastructure reduces business costs by mitigating heat stress and air conditioning needs, valued at £1.45 million annually in Cardiff. SuDS and vegetation manage water flow and purify pollutants. Allotments and gardens produced food worth £10.3 million in 2021, supporting local food security and reducing carbon footprints.

However, reduced land management and urban development threaten green space extent and quality. Garden sizes are shrinking, and densification pressures persist. Nature-based solutions (NbS) offer cost-effective alternatives to grey infrastructure, with added value and job creation potential. Progress includes mandatory SuDS on new developments, updated allotment guidance, and the Local Places for Nature programme. Future actions should integrate NbS into planning, promote urban agriculture, and enhance green infrastructure to support a regenerative economy.

Key changes since SoNaRR2020

Urban areas have been subject to more storms and flooding, but also more heatwaves and droughts as our climate has become more variable.

Investments have been made in making homes more energy efficient, and in building energy efficient homes, but these have been small compared to our total housing stock.

Since January 2019 most new developments in Wales must install Sustainable Drainage Systems. However, these cover a very small proportion of urban areas.

Local Places for Nature funding enabled sites totalling 648 ha to adopt biodiversity-friendly mowing. However, this is around 0.5% of our urban area (126745 ha).

Local government funding for parks and green space management has fallen significantly.

Light pollution has become worse. The picture is mixed for other kinds of pollution.

Some bird and butterfly species have become more common whilst others have declined. We do not collect enough data to understand changes in most urban biodiversity.

Urban Full Assessment of SMNR

Aim 1: Stocks of natural resources are safeguarded and enhanced

The natural resources, as defined in the Environment (Wales) Act 2016 Section 2, most relevant to Urban Ecosystems are Animals, plants and other organisms; Air; Water; Soil; Climatic features and processes.

Animals, plants and other organisms

Urban areas remain significant refuges for species such as bees and other pollinators. Urban areas support a high numbers of bee species because of the variety of plant species found in places like gardens, allotments and constructed wildflower meadows (Hanley, Awbi and Franco, 2014). Biodiversity Indicators show a mixed picture over both the long and short-term. See Urban Aim 2 Diversity for more information.

Urban tree cover has increased over the long term (1945 - 2018) (Doick, Buckland and Clarke, 2020). Over the shorter term (2013 – 2019) there has been a decrease in total number of trees (Dowding and Hodges, 2020).

Historically, **Invasive, Non-Native Species (INNS)** have affected urban animals, plants and other organisms (1500 to 2020). The future outlook is that this will continue. Most established non-native species in the UK have arrived for ornamental purposes such as garden planting (Roy *et al.*, 2020), meaning urban areas both suffer from, and are a major source of INNS. This is a concern as these species outcompete native urban flora and disrupt the balance of urban fauna, leading to reduced biodiversity and altered ecosystem functions and services. There can also be considerable costs from INNS, including in urban areas where they reduce amenity of land, requiring expensive eradication and control.

Historically, **pests and diseases** have affected urban animals, plants and other organisms (1970 to 2012). The future outlook is that this will continue. This is a concern as urban trees and other plants suffer from weakened health or mortality (e.g., from ash die-back, oak processionary moth, and bleeding canker horse chestnut). Climate change may exacerbate pressures from pests and diseases in urban ecosystems.

Air

Historically, **air pollution** has affected urban air quality but the trends in these effects are mixed geographically and across pollutants (1990-2018). The future outlook is for these mixed effects to continue. SO2 and NO2 emissions have declined substantially due to the reduced burning of coal since 1990 and reduced emissions from transport since 2005 (Mitchell et al., 2024). However, the Clean Air Plan for Wales (Welsh Government, 2020a) highlights higher NO2 concentrations remain correlated with the more populated urban areas.

There have been some upward trends in suburban and urban ozone (average increases of the order 5 – 9 µg m-3 over the 20-year period 2000-2019) (DEFRA, 2025). Concentrations of PM2.5 in most of Wales are low, although there are hotspots of high concentrations in industrial and densely populated urban areas. Traffic, non-exhaust road transport emissions, domestic and industrial emissions contribute to local peaks of particulate matter in urban areas. The contribution of domestic wood burning to PM2.5 concentrations makes a significant contribution along the north coast and in urban areas, including for the large urban populations in Swansea and Cardiff, (Welsh Government, 2020a). Urban air pollution is a key concern for human respiration and health, as well as plant and animal health. Urban air pollutants also deposit on soils and water bodies, altering chemical balances and reducing the quality of these natural resources.

Over recent history, light pollution effects on urban ecosystems have increased substantially (1992-2017). Of the 214 urban areas assessed, only 9% are in the top 3 (out of 10) visually tranquil categories when considering light pollution (Green, Manson and Chamberlain, 2022). For the future outlook, the trend is mixed, with some local planning authorities (LPAs) adopting policies to control light pollution from new developments, but this will have a relatively small effect because around 90% of the 2050 housing stock has already been built (Green et al., 2019). Exposure to excess artificial light, especially artificial light at night (ALAN) has been associated with serious ill-health in people (Cao, Xu and Yin, 2023) and can interfere with the reproductive and foraging behaviours of urban plants and animals, affecting ecosystem interactions (Bruce-White and Shardlow, 2011).

Historically, **noise pollution** has affected urban ecosystems (1890-2000). The 2021-22 National Survey for Wales (Welsh Government, 2022) identified that 28% of people living in urban areas report being regularly bothered by noise from outside their home (compared to 21% in rural areas). The future outlook is for a mixed trend in noise effects in urban areas. Electric vehicles and lower speed limits may reduce urban traffic noise; however, the *National Survey for Wales, 2017-18 - Housing: Satisfaction, energy and fire safety SB 78/2018* identifies noise from neighbours as a major noise source. Welsh Government's Noise and Soundscape Action Plan, quoting figures from the World Health Organisation (WHO), identifies noise as the second biggest environmental contributor to the burden of disease in Western Europe after air pollution, (Welsh Government, 2018). Persistent urban noise disrupts communication, breeding, and foraging behaviours in urban wildlife, leading to increased stress and altered species interactions (Kok *et al.*, 2023).

Water

Historically, **water pollution** has affected urban ecosystems, from wastewater (both treated and untreated from storm overflows or via properties that are 'misconnected' to surface water drains rather than sewers) and industry. 10% of waterbodies in Wales are not achieving good status under the Water Framework Directive Regulations 2017, due to the use of run-off from land used for urban and transport purposes. Another 17 % of waterbodies in Wales are not achieving good status due to the impacts of wastewater (NRW, 2025b). However, there is evidence that water quality in urban areas has generally improved up to the first decade of the 21st century (Pharaoh *et al.*, 2023). The future outlook is mixed. Since 2019 all new developments of 100 m² or more in size, are required to have sustainable drainage systems (SuDS) helping to mitigate the effect of pollution from surface water run-off (Welsh Government, 2019a). At the same time, there are concerns with respect to pollutants from transport infrastructure (Kamalakkannan *et al.*, 2004; Bradley, Chisholm and Moncreiff, 2024) and Per- and polyfluoroalkyl substances (used in fire-fighting and industry) that will be a more prevalent pressure on water quality in urban areas (Abunada, Alazaiza and Bashir, 2020). Pollutants in urban water bodies change pH, dissolved oxygen levels, and their water quality. Associated animals, plants and other organisms (e.g., fish and invertebrates) suffer from toxic exposures and habitat degradation, leading to reduced urban biodiversity.

Soil

Historically **soil pollution** (contaminated land) has particularly affected urban ecosystems as centres of industrialisation and high demands for services (e.g., gas works) and waste disposal (NRW, 2016a). The future outlook is for land pollution pressures on urban ecosystems to reduce, largely via the planning process that is estimated to address 93% of contaminated sites in Wales, (NRW, 2016a). However, Local Authorities estimated that 9,330 potential contaminated land sites had yet to undergo detailed inspection, and of these at least 414 sites were considered to be high priority (NRW, 2016a), this implies that more contaminated land will be discovered as this work continues. Ongoing land pollution via illegal disposal of waste (fly-tipping) also effects the suitability of land for various uses, although the number of fly-tipping incidents appears to have dropped from circa 50,000 to 40,000 over the last 10 years, (Welsh Government, 2024c). Land pollution in urban settings degrades soil structure and fertility, leaching into water bodies and compromising the quality of these natural resources. It is also harmful to urban microorganisms, plants, and animals, affecting growth, reproduction, and overall biodiversity within urban ecosystems. Emerging pollutants including PFAS may become a significant problem in urban areas as more sites are tested for their presence (Abunada, Alazaiza and Bashir, 2020).

Climatic features and processes

Historically, **changes in intensity and frequency of weather events** have affected urban ecosystems (1836-2023; 1961-2025). The future outlook is for this to continue and for these effects to increase. This is a concern as heavy rainfall leads to flooding and there are estimated to be274,000properties (mainly residential) at risk of flooding in Wales,(NRW, 2025a). Many of these will be in urban areas. Intense storms also damage infrastructure (including in coastal urban zones), increase soil erosion, degrade water quality, and stir up particulate matter in the air. Urban trees and vegetation may also be damaged and habitats for urban fauna are disrupted, affecting breeding and shelter.

Historically **changes in air temperatures** have affected urban ecosystems (1884 to 2023). 2023 was the hottest year in Wales since 1884 with South Wales, including the major urban areas showing the highest temperature anomaly over the 1991-2020 baseline. The future outlook is for this to continue and for these effects to increase. This is a concern as extreme heat causes stress on our bodies and can result in heat stroke, exhaustion, and in the worst case, death (NRW, 2024). Elevated urban temperatures accelerate soil moisture loss, warm urban water bodies, and alter urban atmospheric chemistry. Urban plants can experience heat stress and altered growth cycles; urban animals may need to change behaviour or shift distributions to cope with hotter microclimates. People will be affected by heat stress.

Historically **sea level rise** has affected urban ecosystems (1900-2022). The future outlook is for this to continue and for these effects to increase. This is a concern in coastal urban zones, as rising sea levels increase flood risk to people, properties, and infrastructure, with over 91,000 properties (mainly residential) at risk from flooding from the sea (NRW, 2025a). Many of these will be in coastal urban areas. Increased sea level also leads to saltwater intrusion, increased erosion of soils and inundation of coastal and estuarine habitats in urban areas.

Pressures from economic activity (see Aim 4 for more detail)

Pressures arising more directly from economic activity are also negatively affecting natural resources in urban ecosystems (see Aim 4 for more details). These pressures are (in alphabetical order): built development and infrastructure and reduced land use or management intensity.

Built development and infrastructure results in increased overall extent and proportion of impermeable areas and associated water management issues in urban ecosystems.

Reduced land use or management intensity (and associated expertise) is identified as a concern with respect to the management of urban green spaces and parks in urban ecosystems. This is particularly a concern for urban animals, plants and other organisms that rely on these more natural areas.

Progress to meeting Aim 1 (Stocks of natural resources are safeguarded and enhanced)

The key opportunities taken up since SoNaRR2020 comprise:

- Funding secured to support the Coed Caerdydd 10 year programme, which aims to increase canopy cover in Cardiff from 18.9% to 25% by 2030. Since November 2021, the project has planted around 80,000 new trees in 300 sites across Cardiff including 40 street verges (Cardiff Council *et al.*, no date). Newport City Council's Tree Cover Regeneration Strategy 2025 - 2035 has a target of achieving 25% urban canopy cover by 2032 (Newport City Council, 2022). This would be a 7% increase from the 18% coverage shown in NRW's 2016 Urban Tree Canopy Cover Assessment. The Vale of

Glamorgan Tree Strategy commits to increasing net urban tree canopy by 7.5% on council owned land (Vale of Glamorgan Council, 2024).

- Since 2019 all developments 100 m^2 or more in size in Wales are required to have Sustainable Drainage Systems (SuDS) for surface water management and associated water quality benefits from urban land-use. However, issues remain with diffuse sources (e.g. misconnections, CSOs, run-off, etc).
- In September 2023, Wales became the first UK nation to implement a default 20 mph speed limit on restricted (residential and busy pedestrian) roads. This policy, covering most urban streets, is primarily for road safety but also brings environmental benefits. Overall the policy is expected to improve urban air quality and reduce traffic noise by ~2 dB (King, 2018).
- The Environment (Air Quality and Soundscapes) (Wales) Act 2024 – essentially Wales' "Clean Air Act" – was passed in February 2024 (Senedd Cymru, 2024; Welsh Government, 2024a). This Act sets a framework for implementing the Clean Air Plan and stricter air quality targets (notably $PM_{2.5}$), enables creation of Clean Air Zones in the future, and tackles emissions from domestic burning and idling. It also uniquely addresses urban noise pollution (soundscapes) by requiring a national soundscape strategy (Welsh Government, 2023).

Opportunities for Action Aim 1

The possible actions identified with respect to achieving Aim 1 relate to Awareness raising, Community engagement, Integrated plans, strategies and delivery, INNS and other species management, Pollution management, Species conservation and enhancement, and Waste prevention (reduce, recycle, recover).

Action 1. Monitor and control INNS in urban areas that reduce land value and crowd out other native animals and plants

Action 2. Promote biodiversity by enhancing opportunities for wildlife in gardens and the grounds of public buildings (e.g. by encouraging pollinator-friendly plants in gardens and managing public land for pollinators)

Action 3. Monitor and manage risks to urban trees and vegetation from the spread of pests such as oak processionary moth or adapt urban tree stocks to more resistant varieties

Action 4. Monitor the change in selected mammal and invertebrate species in urban areas.

Action 5. Improve air quality in urban areas by implementing the commitments in The Clean Air Plan for Wales, Healthy Air, Healthy Wales.

Action 6. Reduce light pollution by mandating all public bodies to follow the recommendations of Good Practice Guidance: Planning for the Conservation and Enhancement of Dark Skies in Wales.

Action 7. Reduce noise pollution by mandating all public bodies to follow the recommendations of the Noise and Soundscape Plan for Wales 2023-2028 – our national strategy on soundscapes.

Action 8. Improve water quality in urban areas (e.g., by retrofitting SuDS to existing development, reducing combined sewer overflow (CSO), identifying and rectifying misconnections and increasing permeability of surfaces).

Action 9. Improve urban soil quality via the remediation of contaminated land and control of fly-tipping.

Action 10. Adapt urban woodlands, trees, plants and greenspaces to changing climatic processes, such as storm damage, heat and water stress, and protect existing large trees in urban areas.

Aim 2: Ecosystems are Resilient to Expected and Unforeseen Change

Urban areas develop, change and adapt in common with other ecosystems. However, they are dominated by human populations and built infrastructure. This makes assessing diversity, extent, condition and connectivity (DECC) challenging in a way that is meaningful for ecosystem resilience. Nonetheless, achieving resilient urban ecosystems will be crucial for the well-being of most people in Wales as the projected effects of climate change manifest in the years ahead.

Diversity

The overall assessment of urban diversity is 'unknown.' The diversity of tree species is low, making them vulnerable to pests and diseases (NRW, 2016b; Dowding and Hodges, 2020). **The historic trend in urban species diversity is mixed.** Whilst systematic monitoring of urban biodiversity has not happened, species commonly found in urban areas can be used as proxy measures (Hanley, Awbi and Franco, 2014; Marshall *et al.*, 2023). Hedgehogs declined throughout the UK including urban areas. (Wembridge, 2011; Wembridge *et al.*, 2022) House sparrows in Wales increased in abundance whilst swifts and starlings showed population declines (Heywood *et al.*, 2024). Large white, small white, wall brown and peacock butterflies showed significant declines, whilst red admirals showed a very significant increase (UKBMS, 2023). **The future outlook is for these mixed trends to continue.**

Extent

Total overall extent of urban ecosystems has increased from 1,419,620ha (1990) to 1,997,471 ha (2021), mainly from the conversion of the Enclosed Farmland (Office for National Statistics, 2023a).. With respect to Green Infrastructure, the assessment of **urban ecosystem extent is low**. The ONS identify that 3,721 ha of urban ecosystem extent in Wales is Functional Green Space, of which 2,698 ha is publicly accessible (2021). The non-publicly accessible functional green space comprises golf courses (222 ha), allotments and community growing spaces (258 ha), bowling greens (22 ha) and other sports facilities (520 ha). The publicly accessible functional green space comprises public parks and gardens (1,080 ha), playing fields (1,174 ha), cemeteries (239 ha) and religious grounds 492 ha. In their Urban Natural Capital Accounts, the ONS identify Blue Space makes up 1,432 ha of urban ecosystem extent in Wales, (Office for National Statistics, 2023a).

The historic trend in green infrastructure extent is mixed. Allotment sites have declined substantially from their maximum extent in the 20th Century (Dobson, Edmondson and Warren, 2020). At the same time playing field provision has increased following adoption of minimum extent standards. The abandonment of heavy industrial and mining sites has provided opportunities for natural vegetation to establish (a priority habitat labelled Open Mosaic Habitats on Previously Developed Land). **The future outlook for green infrastructure extent is mixed**. The need for additional homes continues to increase demand for land in urban areas. This may be offset by the proliferation of SuDS and associated amenity space.

Condition

The overall condition of green infrastructure in urban ecosystems is Low to Medium. The Welsh Government (Welsh Government, 2015) and the Future Generations Commissioner (Future Generations Commissioner for Wales, 2020) suggest **20%** canopy cover as an indicator of good urban ecosystem condition. In 2013, NRW estimated that the mean urban tree cover in Wales was 16.3%, although this varies substantially between cities and towns, (NRW, 2016b). Recent analysis of woodland extent in urban areas using Living Wales suggests a similar level of canopy cover in Wales urban areas of 17% and recent analysis by Sales et al suggests 18% (Sales *et al.*, 2023). Whilst canopy cover is not far below targets, there remain concerns with respect to the aging population structure of Wales' urban trees, with fewer new trees being added (NRW, 2016; NRW, 2020b). It is estimated that 110,000 urban trees were lost in Wales between 2013 and 2019 (Dowding and Hodges, 2020)). **The future outlook for urban green infrastructure is Low to Medium.** As with trees across Wales, urban trees face increasing threats from pests, diseases and climate change. With respect to green spaces, UK-wide data shows a decline in the perception of park quality (Priestley, 2021).

As highlighted in Aim 1, there are several indicators of low urban ecosystem condition. Flooding is affecting the condition of urban ecosystems in various ways, with these pressures projected to increase with climate change. Elevated levels of particulate matter, NO_2 and ozone remain a concern for urban air quality, as is noise and light pollution. Indicators of medium urban ecosystem condition relate to improved but not necessarily good water quality in urban rivers and increasing urban temperatures and heat stress (projected to increase with climate change). Urban soils suffer from contamination, but this is being reduced via the planning system.

Connectivity

The overall assessment of urban ecosystem (or green infrastructure) connectivity is 'unknown.' Whilst there are examples of establishing green corridors and removing barriers in urban rivers, this remains a general evidence gap. The ONS provide some insight on hedgerows in urban areas, which can provide habitat and corridors for wildlife. The length of urban hedgerows in Wales is estimated to be 5,900 km (Office for National Statistics, 2023a).

Progress to meeting Aim 2 (Ecosystems are Resilient to Expected and Unforeseen Change)

The key opportunities taken up since SoNaRR 2020 comprise:

- The statutory use of Sustainable Drainage Systems (SuDS) in new developments has helped manage urban water flow, reducing flood risks and pollution runoff.
- The Local Places for Nature programme, launched 2019, has created new pocket parks, pollinator-friendly grassland which includes road verges, community growing spaces, and community orchards across Welsh towns and cities (Johnson and Vousden, 2023). 831 sites across 648 hectares have adopted biodiversity-friendly mowing practices.
- Many local authorities (17 of 22) have adopted pollinator-friendly mowing regimes, creating new meadows on road verges and parks (Johnson and Vousden, 2023).

Opportunities for Action Aim 2

The possible actions identified with respect to achieving Aim 2 relate to Ecosystem creation, Ecosystem protection, Ecosystem restoration, Nature based Solutions, Research and Technology, and Species conservation and enhancement.

Action 11. Increase tree planting to increase diversity of urban tree species, adapt urban trees stocks to emerging threats from INNS, pests, diseases and climate change and increase urban canopy cover, especially street trees to reduce urban temperature and heat stress.

Action 12. Protect existing green and blue spaces in urban ecosystems to maintain urban ecosystem resilience and conserve suitable habitat for species.

Action 13. Increase extent of green and blue spaces to improve urban ecosystem resilience and create suitable habitat for urban species.

Action 14. Better assess and improve connectivity in urban areas (e.g., creating green corridors and key connections/stepping stones including SuDS)

Aim 3: Healthy Places for people, protected from environmental risk

Health protection

Urban ecosystems and green infrastructure contribute to human health protection through the supply of the following regulating services:

- **Global climate regulation services** contribute to reducing greenhouse gas concentrations and mitigating climate change impacts on people. Work published by Forest Research used the i-Tree Eco tool to estimate that Cardiff's urban forest sequesters 7,950 tonnes of carbon per year net (Hand *et al.*, 2018) and Newport's, 2,114 tonne per year (Buckland *et al.*, 2020). Other urban centres in Wales have also been assessed, see i-Tree Eco Projects - Forest Research. However, the ONS Natural Capital accounts show that changing land for urban use in Wales resulted in 308,000 tonnes CO_2 equivalent emissions in 2022 alone(Office for National Statistics, 2024)
- **Local climate regulation services** reduce heat stress on people. Projections suggest 14% of the housing stock in Wales will be at risk of overheating in 2050. Urban vegetation or green infrastructure, such as trees (especially street trees), green spaces, green walls and roofs, as well as blue spaces, can cool urban areas and mitigate this risk. The importance of this service is driven by the number of hot days where heat stresses are manifested (Office for National Statistics, 2023a), which are projected to increase in Welsh cities (Huang *et al.*, 2024). Modelling suggests that increasing vegetative cover by 10% in areas of Manchester with little existing vegetation can mitigate these risks by keeping surface temperatures at 1961–1990 baseline levels under climate change scenarios (Gill *et al.*, 2007).
- **Air filtration services** reduce concentrations of air pollutants and damage to people's health. The Office for National Statistics estimates 1.1 million kilograms of air pollutants were removed by **Urban Grassland vegetation** and 500,000 kilograms by **Urban trees** each year in Wales between 2007 and 2022 (Office for National Statistics, 2024). The supply of this service is available from the ONS by Local Authority Area. By 2050, enhanced green infrastructure could create sustainable, liveable neighbourhoods. By 2100, widespread adoption of nature-based solutions will ensure long-term sensory and health benefits
- **Soil and sediment retention services** reduce risk to people from landslide hazards. Settlements in former coal mining areas are particularly at risk of damage to life and property from coal tips (e.g., the South Wales Valleys, Swansea, Caerphilly and Neath Port Talbot). Surface vegetation coverage, or promoting it where coal tips have been re-profiled, is important in stabilising the surface and preventing sediment run off (Mitchell *et al.*, 2023). Open Mosaic Habitats on Previously Developed Land (OMHoPDL) are particularly important for the supply of this service.

- **Water flow regulation services** lower peak flows in wet periods reducing risk of flooding to households. Urban areas are particularly at risk from surface water flooding due to the presence of impermeable areas. Green infrastructure reduces peak water flows during storms, releasing the water slowly afterwards. SuDS, urban parks, green spaces and green walls have been shown to retain >50% of rainfall, delaying stormwater run-off. This can be further boosted by urban trees, which intercept and retain rainfall. For example, trees in Cardiff are estimated to intercept 356,000 m^3 of water a year (Hand *et al.*, 2018).
- **Noise attenuation services** reduce noise disturbance to people and associated impacts on mental health. The Office for National Statistics (2023) estimates that 12,000 homes in Wales benefit from noise mitigation from urban vegetation (Office for National Statistics, 2023a). Urban woodland is identified as potentially delivering noise mitigation benefits of 2.84 dBA reduction per meter (Fletcher *et al.*, 2022).

Health Improvement

Urban ecosystems and green infrastructure contribute to human health improvement through the supply of the following cultural ecosystem services:

- **Recreation-related services** provide opportunities for people to enjoy in-situ interactions with nature and associated physical and mental health benefits. This service is likely to be used in combination with the visual and sensory amenity service in urban settings. In 2021/2022, people in Wales made 72,057,886 visits to urban ecosystems for recreation (i.e., an urban green space such as a park, field or playground, grounds of a historic property, country park, allotment or community garden) (Owen, Rhydderch and Williams, 2025). Analysis of the People and Nature Survey (21/22) for Wales, estimates around 5 million of these visits were to allotments and community gardens.
- The Office for National Statistics estimates that visits to urban ecosystems for recreation decreased by approximately 52% between 2019 and 2022, with the associated number of people gaining related health benefits from these visits declining from 500,000 to 200,000 (Office for National Statistics, 2024).
- The ONS also estimates average distance to the nearest public park or garden from urban residential properties in Wales is 1,147m, well above the Great Britain average (881m) (Office for National Statistics, 2023a) However, the average distance to the nearest park or playing field was 469m (36% of urban households are within the 300m national accessible space standard) and nearest functional greenspace was 252m (69% of urban households are within 300m (Office for National Statistics, 2023b)

Cultural Well-being

Urban ecosystems contribute to people's cultural well-being through the supply of the following cultural services:

- **Spiritual, artistic and symbolic services** contribute to people's cultural and spiritual identity. The UK NEA (Chapter 10, pp388) highlighted good quality urban greenspace can foster better levels of community cohesion, promote social inclusion and enhance social ties and a sense of community. The UK NEA highlights the role of churchyards and cemeteries in spiritual and religious service provision. The ONS Urban Natural Capital Accounts identify that there are 444ha of religious grounds and cemeteries within Wales' Urban Ecosystems (Office for National Statistics, 2023b).
- **Education, scientific and research services** contribute to intellectual development and the advancement of knowledge and understanding for people from interactions with ecosystems. However, indicators for the scale of the use of this service are unavailable for urban ecosystems discretely.

Equitable access

The Welsh Index of Multiple Depravation (WIMD) identifies areas with the highest concentrations of several different types of deprivation (income, employment, health, education, access to services, housing, community safety and physical environment). These areas are Lower Layer Super Output Areas with average populations of 1,600. The index identifies that 22 out of the 26 (or 85%) most consistently and deeply deprived areas are classed as being in Urban (City and Town) areas, with the highest concentration associated with the cities of Newport (43.2%) and Cardiff (43.0%).

The environment domain of the WIMD is an aggregation of sub-indicators for Air Quality (40% weighting), Flood Risk (40%) and Green Space (20%). The WIMD highlights the more prevalent general deprivation in urban areas is correlated with environmental deprivation. There are pockets of high deprivation for the environment domain in and around the large cities in South East Wales and, to a lesser extent, the South Wales valleys (Welsh Government, 2019b). Green infrastructure that can boost the supply of water flow regulation, air filtration and recreation related ecosystem services may be particularly beneficial for people in these areas. However, it needs to be recognised that environmental deprivation is not a main component of the assessment of overall deprivation. In 2019 it contributed 5% to the WIMD, compared to 22% for income and 22% for employment (Welsh Government, 2019b). WIMD was updated in November 2025 , too late to incorporate into this assessment.

NRW's Tree cover in Wales' towns and cities assessment identified that 51% of more affluent wards have cover greater than 15% compared to 37% for less well-off wards in 2013 (Dowding and Hodges, 2020). In the 10 deprived wards of Cardiff's Butetown, Riverside and Grangetown 'Communities First' cluster area, all have less than 8% tree cover. This also suggests an inequitable distribution of Green Infrastructure in urban areas, although this data is over 10 years old. Generally, but not exclusively, coastal towns have very low cover (e.g., Rhyl and Porthcawl (6%), Holyhead (7%) and Port Talbot (8%)). However, this may be indicative of coastal areas not being suitable for trees.

Progress to meeting Aim 3 (Healthy Places for people, protected from environmental risk)

The key opportunities taken up since SoNaRR 2020 comprise:

- The Local Places for Nature programme, launched 2019, has created new pocket parks, pollinator-friendly grassland, community growing spaces, and community orchards across Welsh towns and cities (Johnson and Vousden, 2023). The programme largely targets areas with limited access to nature, including areas of deprivation.
- Welsh Government Transforming Towns programme for Covid-proof travel; The Active Travel Fund; The Safe Routes in Communities grant, specifically focused on creating safe walking and cycling routes to schools; The Road Safety Capital grant (Welsh Government, 2025a)
- The new default speed limit in built up areas resulted in around 100 fewer people killed or seriously injured on roads with 20mph and 30mph road speed limits in the 12 month period after the introduction of the 20mph default speed limit, compared to the same period a year before. The number of casualties on roads with 20 and 30mph road speed limits (combined) in 2024 between July and September was the lowest Q3 figures in Wales since records began (Welsh Government, 2025b).
- NRW has updated its supporting guidance for Local on Green Infrastructure Assessments in 2023 (NRW, 2023).
- Some councils had updated Green Infrastructure Assessments to guide local development planning, e.g. Neath Port Talbot, (Neath Port Talbot Council, 2024)
- The Clean Air Plan (2020) includes actions to actions to increase woodlands in urban (and rural) areas to contribute to the interception of air pollutants. The plan will promote guidance and best practice to Local Authorities and urban planners to better design urban tree planting and plant species which maximise benefits by reducing people's exposure to air pollution (Welsh Government, 2020a).

Opportunities for Action Aim 3

The possible actions identified with respect to achieving Aim 3 relate to Access to nature, Awareness raising, Community engagement, Nature based solutions, Payment for ecosystem services, Pollution Management, and Research and Technology.

Action 15. Protect people's health using green infrastructure (e.g. large street trees) to mitigate urban heat stress.

Action 16. Protect people's health using green infrastructure to improve air quality, intercept light pollution and screening mitigating noise disturbance.

Action 17. Protect people's heath by reducing local risks from landslip by increasing vegetative cover on unstable soils and spoil

Action 18. Protect people's health using sustainable drainage (SuDS) and other Green Infrastructure to intercept rainfall and delay storm water run-off to reduce flood risk

Action 19. Protect and Improve people's health by promoting sustainable travel to make it safer and easier to get around

Action 20. Improve people's health by increasing access to high quality green and blue spaces and their associated recreational opportunities and health benefits in line with current standards for access to greenspace and via social prescribing.

Action 21. Improve people's health by providing adequate garden space for homes likely to house children.

Action 22. Improve people's cultural well-being by using urban greenspace to foster better levels of community cohesion

Aim 4: Contributing to a Regenerative Economy, Achieving Sustainable Levels of Production and Consumption

Urban ecosystems contribute to economic well-being through the supply of the following regulating services:

- **Local climate regulation services** from green and blue space benefit urban businesses by mitigating productivity losses in highly physical jobs and reduce air conditioning costs. Experimental data used to inform the UK Urban natural capital accounts indicates the annual value of this to business was £1.3million in avoided lost productivity to the Cardiff city region, rising to £1.45million when avoided air conditioning costs are included (DEFRA, 2018).
- **Water flow regulation services** lower peak flows in wet periods, also reducing risk of flooding to businesses. As highlighted under Aim 3, SuDS, urban parks, green spaces, green walls and urban trees have been shown to retain substantial volumes of surface and rainwater helping to reduce flood risk.
- **Water purification services** supplied by green infrastructure can provide solutions for surface water management and filter out pollutants such as microplastics. These would be more cost effective than installing new plant-based treatment approaches.
- Urban ecosystems and green infrastructure contribute to economic well-being through the supply of the following provisioning services:
- **Crop provisioning services** can be supplied by gardens, allotments and other green spaces in urban areas. The ONS (Office for National Statistics, 2024) estimate that urban ecosystems supplied food worth £10.3 million in Wales in 2021. The substantial reduction in allotment extent suggests a reduction in food production from urban ecosystems in Wales.

  It is recognised that there are wider health improvement benefits associated with participating in growing food in systems such as allotments. These are counted using self-reported visits to allotments as an indicator in the overall use of the recreation-related urban ecosystem service in Aim 3.

Urban ecosystems and green infrastructure contribute to economic well-being through the supply of the following cultural services:

- **Visual and sensory amenity services** contribute to increased property prices and can improve the value of development. Experimental statistics from the ONS suggest this is in the order of 3% in Wales' Urban areas (Office for National Statistics, 2024). The Tree cover in Wales' towns and cities study highlights evidence that 'Customers are prepared to pay more for parking and goods (9-12% for some products) in landscaped shopping areas' (NRW, 2016b). This service is often likely to be used in combination with recreation-related services in urban areas.

Economic drivers and their pressures on urban ecosystems

The key direct economic drivers within Wales directly related to the degradation of urban ecosystems relate to '**Land and sea use and management change.' Direct exploitation** of urban ecosystem services by the economy is not currently considered to be a key issue for the state of urban ecosystems and their capacity to contribute to well-being in Wales. Climate change pressures are considered to be driven by global economic activity.

Land and sea use and management change

Recent years (2010 to 2021) have seen **reduced land management intensity** in urban green spaces, likely linked to reduced funding for management (Heritage Lottery Fund, 2016; Association for Public Service Experience, 2019; Priestley, 2021) The future outlook is that this will continue. This is a concern as urban green spaces require ongoing management to continue to supply multiple benefits to human well-being and urban nature.

Historically, **built development and infrastructure** has led to urban extensification (1990 – 2021), largely at the expense of Enclosed Farmland (Office for National Statistics, 2023a). Based on trends in English cities, it is likely densification has also reduced the extent of urban green space in urban areas since 2001 (Dallimer *et al.*, 2011). At the same time, garden size in new-build housing has also decreased (Thompson and Head, 2019). **The future outlook is for this to continue** in response to increasing housing demand. This is a concern as urban development is associated with loss of surface permeability and associated water management issues, reduction in the extent of other ecosystems and the services they supply and loss of functional green space and habitat in cities.

Contributions of urban ecosystems and green infrastructure to sustainable economic production and consumption

The need to transition to Nature based Solutions to urban development challenges is a mainstream economic development concern. The World Economic Forum has called for a transition to nature positive cities by 2030, highlighting that investments in Green Infrastructure (or NbS) can be 50% more cost-effective than “grey” alternatives, deliver 28% more added value and can create jobs (World Economic Forum, 2022). As highlighted in Aim 3, urban Green Infrastructure can help mitigate flood and heat stress risk and adapting to projected climate change effects.

‘Own production’ of fruit, vegetables and other crops in urban ecosystems (e.g., allotments) can reduce per capita environmental impact of cities and contribute to local food security (Edmondson *et al.*, 2020). It can also reduce reliance on imported fruit and vegetables, with relatively high carbon footprints. There are likely to be multiple co-benefits that can be realised from urban agriculture for wider ecosystem services and biodiversity.

Progress towards meeting Aim 4 (Contributing to a Regenerative Economy, Achieving Sustainable Levels of Production and Consumption)

The key opportunities taken up since SoNaRR 2020 comprise:

- Low carbon energy efficient houses: To learn how to decarbonise Welsh homes, Welsh Government launched the Optimised Refit Programme in 2020. The programme was for social housing and had a budget of £19.5m. (Welsh Government, 2020b). In 2024 the Welsh Government published their Heat Strategy for Wales to guide their approach to decarbonising heating and hot water for buildings as well as industrial heat (Welsh Government, 2024b)
- More than double the amount of certified renewable installations in Wales in 2023 than in 2022.The total number of Welsh homes and businesses with renewable energy was over 100,000. 2023 was also the first year that installations rose above 20,000 in a single year, according to the MCS database of certified installations (The MCS Foundation, 2024).
- The Welsh Government's NEST scheme delivered a home energy improvement package, such as a central heating system, a boiler, insulation, solar panel PV or an Air Source Heat Pump, to 4,364 households between 2022 and 2023 (Welsh Government, 2023e).This represents 0.3% of Welsh households.
- Since 2019 all development 100 m² or more in size in Wales are required to have Sustainable Drainage Systems (SuDS) for surface water management and associated water quality benefits from urban land-use. However, issues remain with diffuse sources (e.g. misconnections, CSOs, run-off, etc).
- In 2021 the Welsh Government updated guidance to support allotment and community growing (Welsh Government, 2021).
- The Local Places for Nature programme (launched 2019) has created new community growing spaces and community orchards across Welsh towns and cities (Johnson and Vousden, 2023).

Opportunities for Action Aim 4

The possible actions identified with respect to achieving Aim 4, relate to Access to Nature, Nature based Solutions, Pollution management, Research and Technology Sustainable agriculture, forestry and fisheries, Sustainable construction, and Sustainable transport.

Action 23. Integrate green and blue infrastructure into built development and secure environmental gains via the planning system.

Action 24. Transition from 'Grey' to Green Infrastructure / Nature based Solutions (e.g., SuDS, Trees, Green and Blue Spaces) to mitigate heat stress, flood risk and manage pollution as the default

Action 25. Encourage food production from urban ecosystems, especially allotments to improve sustainability of the food system

Action 26. Improve the energy efficiency of Welsh housing stock and decarbonise heating in that housing

Action 27. Enable charging of Electric Vehicles for homes with no off-street parking

Evidence Needs

The urban ecosystem needs systematic evidence on air quality, light pollution, biodiversity, and on pollutants in surface water runoff. The data that we have is from a few localities in some urban areas so systematic sampling across each urban area is needed to provide the evidence required to guide the management of the habitat in which most people live. We have systematic mapping of urban green spaces, but we need evidence about which are accessible, and which are managed to an appropriate standard. We need better and more up to date data on the extent of urban tree canopies. Most urban areas still require modelled evidence of the impacts of future heatwaves. We need to collect data on the impact of the changing local authority resources allocated to green infrastructure management, and we need to develop monitoring strategies for new and emerging pollutants such as "forever chemicals" (PFAS and PFOS).

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Woodland ecosystem

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Woodlands in Wales can be broadly categorised as native (generally broad-leaved) and non-native (generally coniferous). This assessment covers woodlands that meet the National Forest Inventory definition, which includes a minimum size of land covered (0.5 hectares). This definition will include farm woodlands above the size threshold, although these are not identified separately within the assessment. Small tree groups and Trees outside Woodland (ToW) are covered in other ecosystem assessments, including Enclosed Farmland ecosystem and the Urban ecosystem assessment.

This woodlands assessment is one of eight ecosystem and three natural resource assessments that inform the overall SoNaRR 2025 report. It builds on the findings of SoNaRR2020, drawing together updated evidence from subject experts and national datasets. Related assessments include [Enclosed farmland] and [Urban]. which consider trees outside of woodlands.

The assessment is structured around four interlinked aims that guide Wales' progress toward the sustainable management of natural resources (SMNR), helping to communicate the relationship between the environment, well-being, and the economy.

Key messages

1. Woodlands deliver a range of ecosystem services and benefits which are important for well-being. They are important for biodiversity, provide timber, help improve air quality and reduce flood risk, sequester carbon, enrich our culture and heritage, and provide opportunities for recreation, education and learning.
2. Action is needed to improve the resilience of existing woodlands to pressures such as climate change and pests and diseases, to make sure the benefits they provide continue in the future.
3. Timber, a sustainable and natural resource, makes a valuable contribution to the Welsh economy and more needs to be produced in Wales to deliver greater benefits.
4. Trees and woodlands have a vital role to play in tackling Wales' declared nature and climate emergencies; we need to protect and positively manage what we have and expand woodland cover.

Woodlands Summary SMNR Assessment

Aim 1: Stocks of natural resources are safeguarded and enhanced

Welsh woodlands contain a diverse stock of trees and associated flora and fauna, but pressures from climate change, pests, diseases, invasive species, and grazing are reducing their health and extent. Tree diseases such as Ash Dieback and Phytophthora ramorum have significantly impacted tree health, which in turn affects woodland biodiversity. Invasive non-native species (INNS), including Grey squirrels, non-native deer and Rhododendron ponticum, continue to damage woodland ecosystems. Grazing by deer and livestock also hinders regeneration of trees and ground flora, although in specific locations, managed grazing may support specialist woodland bird populations. Air pollution, particularly ammonia, is increasingly affecting ancient woodlands, despite reductions in sulphur and nitrogen emissions.

Efforts to safeguard and enhance woodland resources include the Celtic Rainforest project, woodland restoration grant schemes, and improved woodland management through amendments to the Agriculture (Wales) Act. Planning Policy Wales now mandates protection of trees and woodlands. Woodland creation schemes have increased tree stocks, and targeted actions are addressing INNS and herbivore pressures. However, reduced management in some woodlands remains a concern. Built development and infrastructure, particularly renewable energy, also pose risks to woodland extent and connectivity.

Aim 2: Ecosystems are Resilient to Expected and Unforeseen Change

Woodland resilience is assessed through diversity, extent, condition, and connectivity. Native woodlands show medium-high diversity. Generally, they are becoming more mature with increased shading, except where Ash dieback is creating canopy gaps which is increasing herbaceous plant cover. Non-native woodlands remain low in diversity, though restocking is improving species mix. Woodland extent has increased from 4.2% in 1905 to 15% of Wales in 2024, largely due to non-native plantations in post-war years, but recent broadleaf planting has helped. However, to some degree, losses from development and habitat restoration will offset gains. Native woodlands tend to be smaller and more fragmented, while larger, non-native blocks have better internal connectivity.

Condition is mixed, with disease and nitrogen deposition reducing ecosystem health, while targeted management and INNS removal improve it locally. Most stands are in intermediate condition. Connectivity is improving through woodland creation within Priority Ecological Networks (PENs), though historic fragmentation persists. Future resilience depends on continued but targeted planting, improved management including diversifying tree species, and addressing pressures from climate change, pests, and land use change. Welsh Government schemes and updated forestry standards are supporting progress.

Aim 3: Healthy Places for people, protected from environmental risk

Woodlands support human health and healthy places by regulating climate, filtering air, and managing water flows. In 2020, Welsh forests sequestered 1.2 million tonnes of CO_2, projected to rise to 1.6 million tonnes by 2050. All woodlands filter air pollutants, for example broadleaf woodlands filtered air pollutants which prevented nearly 1,000 life years lost in 2022. Woodlands also reduce flood and drought risks by regulating water flow and retaining soil moisture. These services are increasingly recognised in policy and planning, with new guidance promoting woodlands as a nature-based solution.

Woodlands also improve well-being through recreation, cultural identity, and education. In 2021/22, nearly 39 million visits were made to Welsh woodlands, with 280,000 people gaining health benefits. However, access is unequal with mobility issues and lack of transport limiting use for some groups. Initiatives like the National Forest for Wales aim to improve accessibility. Research and policy developments are enhancing understanding of woodland benefits and guiding future investment in nature-based solutions.

Aim 4: Contributing to a Regenerative Economy, Achieving Sustainable Levels of Production and Consumption

Woodlands contribute to Wales' economy through timber production, flood mitigation, pollution control, and recreation. Between 2014–2023, softwood removals averaged 1.26 million tonnes annually, though a 40% decline is forecast by 2046. Hardwood removals are increasing, but market uptake remains low. In 2022, wood provisioning services contributed £614 million in Gross Value Added, supporting over 10,000 jobs. Long-lived wood products offer carbon storage and circular economy benefits, especially in construction.

Sustainable management is supported by UK Forestry Standard and certification schemes. Around 48% of Welsh woodlands are certified, with more managed under grant conditions. Welsh Government's timber industrial strategy 'Making Wood Work for Wales' (2025) promotes high-value production aligned with biodiversity and climate goals. Sustainable finance options are being developed to advance nature-based solutions for flood and pollution management. Challenges remain from development pressures and reduced management, but policy and funding initiatives are helping to align woodland use with regenerative economic principles.

Key changes since SoNaRR2020

Overall, there have been few significant changes since SoNaRR2020 in terms of drivers and pressures, woodland resilience, ecosystem services and benefits and progress towards SMNR. This is to be expected given the long-life of woodlands, the time it takes for many drivers of change to generate a response, and the availability of evidence of the impact of these responses. An ongoing deterioration in tree health as a result of pests and diseases is one of the main concerns, as is climatic change with evidence of greater impacts such as windthrow due to extreme weather events. Nitrogen pollution impacting the woodland ecosystem is also an increasing concern. Positively, with Welsh Government's publication of a new timber industrial strategy in 2025 and the commencement of the Sustainable Farming Scheme in 2026 which will support improved woodland management and more woodland creation, there is potential for positive improvement towards delivery of SMNR.

Woodland Full assessment of SMNR

Aim 1: Stocks of natural resources are safeguarded and enhanced

Animals, plants and other organisms

There have been declines over the long term in some woodland flora (e.g., wood anemone) and woodland birds are the fastest declining bird group on the UK (British Trust for Ornithology, 2024) and reduction in Hazel coppice management is associated with declines in Dormouse populations. There have been increases in some bryophyte and epiphyte populations (possibly due to increased surveying). Recent surveys find an increase in shade tolerant species due to denser canopies (Smart et al., 2024).

Recent inventories of standing trees and timber are not available. Total tree stocks are a function of the extent of different woodland types and their condition. Indicators for these are considered in Aim 2 of the SMNR assessment in the context of ecosystem resilience.

Over the last 15 years, pests and diseases have had a significant negative effect on tree health in Welsh woodlands and, through that, a significant impact on the animals, other plants and organisms supported by them. This is expected to continue into the future, exacerbated by climate change and global trade. Pests and diseases cause a decline in tree health, which is a key determinant of the growth, composition and productivity of woodlands. The most significant diseases affecting Welsh woodlands are Phytophthora ramorum, a fungus primarily affecting Larch species in non-native woodlands, and Ash Dieback (Hymenoscyphus fraxineus) in broadleaf woodlands. Phytophthora pluvialis is an emerging pest likely to negatively affect coniferous woodlands. The significance of Oak processionary moth is increasing, associated with defoliation of oak trees. European spruce bark beetle (Ips typographus) is an emerging concern and can be a serious and destructive pest of the spruce tree genera/family. This includes commercially important species such as Norway and Sitka spruce.

Since the 1970s, animals, plants and other organisms in Welsh woodlands have in places been negatively affected by inappropriate types and levels of grazing and other feeding activity by large mammals. This includes herbivores such as wild deer, and domestic cattle and sheep, and omnivorous wild boar. This activity can have a significant effect on the ground flora of woodlands and on the regeneration of shrubs and trees (Mathews et al., 2020). This pressure is expected to continue in future, particularly due to increases in deer population and range.

Invasive non-native species (INNS) have negatively affected animals, plants and other organisms in Welsh woodland ecosystems since at least the late 19th century, and this is expected to continue in future, linked to climate change and global trade. INNS can negatively impact the condition and function of woodlands. The most significant INNS is the Grey squirrel, which damages trees (particularly young trees). Other INNS of significance include Rhododendron ponticum, American skunk cabbage, Himalayan balsam, Cherry laurel, Japanese knotweed and non-native Sika and Muntjac deer (see Large mammal herbivore activity). A heat map that shows the distribution of INNS that have the potential to impact on woodland ecosystems is available on the Wales Environmental Portal (NRW, 2024).

Air

Air pollution, particularly sulphur and nitrogen, can cause changes to woodland flora composition due to nutrient enrichment.

Sulphur deposition has reduced (Smart et al., 2024) and soil pH is increasing (i.e. becoming less acidic). This increasing pH, however, has a less mediating effect on the impacts of atmospheric nitrogen, so although nitrogen deposition has been declining, its impacts have not.

There is no data on longer-term past trends for ammonia (a form of nitrogen) in woodlands. However, over the last decade (2015-2022), air pollution, particularly from ammonia, has been a concern for bryophyte and lichen-rich ancient woodlands. Modelling indicates that in 2015-17 around 52,000ha, 53,2%, of ancient woodland were exposed to air concentrations of ammonia above critical thresholds for lichens and bryophytes. In 2020-2022, this is estimated to have increased substantially to over 62,000ha, 65.6%. Also of concern is that the area of ancient woodland now in exceedance of the critical level for vascular plants has increased from 10ha to 150 ha since the last reporting round. This increase is greater than any changes in ammonia emissions and is caused by the increased ability of ammonia to spread across a landscape following reductions in sulphur dioxide pollution over recent decades. The future outlook to 2030 is expected to continue deteriorating, with a mixed picture to 2040. The SoNaRR 2025 Ammonia case study provides more detail on this general air pollution pressure and the types of ancient woodlands affected.

Climatic features and processes

Over the last two decades, woodlands have been negatively affected by **changes in intensity and frequency of weather events**. This is expected to continue throughout the coming century. The range of effects include increased wind and storm damage, flooding, waterlogging and soil erosion, and increased risk of wildfire and drought. This may also increase the susceptibility of forests to insect pests or pathogen damage.

Over the last two decades, **changes in air temperature** have had both positive and negative effects on woodlands. This mixed picture is expected to continue to 2030 but in the longer term the negative effects on extent and functioning of woodland ecosystems are expected to outweigh the positive. Changes in mean air temperature (and seasonal rainfall patterns) will cause a range of effects in all regions of Wales in all seasons, including increased late season growth, increased risk of spring frost damage, increased tree growth, increased numbers of deer and grey squirrel, changes in tree species suitability, changes in epidemiology of tree diseases, and enhanced fragmentation of habitats.

Pressures from economic activity (see Aim 4 for more detail)

Pressures arising more directly from economic activity are also negatively affecting the stocks of natural resources in woodland ecosystems (see Aim 4 for more detail). These pressures are (in alphabetical order): built development and infrastructure, and reduced land use or management intensity.

Built development and infrastructure, including housing, roads and renewable energy provision, can result in the direct and permanent loss of ancient trees, woodland cover and habitat fragmentation, affecting not only the extent of woodland cover but also its condition, connectivity and adaptability.

Reduced land use management may affect Welsh woodlands. Around half of Welsh woodlands, including the Welsh Government Woodland Estate, are managed to the UK Woodland Assurance Standard (UKWAS), an independent certification standard for verifying sustainable woodland management, and the UK Forestry Standard (UKFS), the UK government's technical standard for sustainable forest management. Some additional areas of woodland will be managed in accordance with UKFS (but not UKWAS), as evidenced by the granting of felling licences and Welsh Government grant allocation which requires adherence to the UKFS. Remaining areas are hard to quantify but the absence of planned management is a concern and can impact on timber quality, forest animals, plants and other organisms and on ecosystem condition (e.g., reduced age-structure diversity, under-developed shrub and ground flora, a lack of regeneration and fewer opportunities for biodiversity). Illegal felling, and the restoration of open habitat can also result in a direct and permanent loss of woodland cover and biodiversity.

Progress to meeting Aim 1 (Stocks of natural resources are safeguarded and enhanced)

Specific actions have been carried out since SoNaRR2020 to help Wales towards achieving Aim1 in woodland ecosystems. These include:

- Amendments to the Agriculture (Wales) Act have allowed environmental conditions to be added to Felling Licences for the first time (Senedd Cymru, 2023), improving woodland management, protecting ancient/veteran trees and better protecting wildlife and the environment during felling operations.

- The Celtic Rainforest project has facilitated INNS and non-native conifer removal (as well as conservation grazing, and restoration of plantations on ancient woodland sites (PAWS)) (Eryri National Park, no date).
- A Red squirrel reinforcement programme has taken place in Clocaenog forest (The red squirrel trust, no date), and the Vincent Wildlife Trust has received grant funding to support Pine marten recovery (Vincent Wildlife Trust, 2025) .
- The Wales Wildfire Charter and the Healthy Hillsides project have supported measures to adapt woodland management to reduce risks associated with wildfire (NRW, 2022).
- The State of Wales' Rainforests Report (2024) has been published. For the first time, this "establishes an ecological baseline for rainforest condition in Wales, shining a spotlight on the multiple threats that the habitat faces and outlining the actions required to restore Wales' temperate rainforest and create a healthier, better connected and more resilient rainforest landscape" (Alliance for Wales' Rainforests, 2024).
- Welsh Government's Woodland Restoration Scheme has provided grant funding to support restocking following the removal of infected Larch (Welsh Government, 2024c).
- Research about, and increased awareness of, techniques for controlling the Grey squirrel population.
- Research to improve climate projections and evaluate risks to forest ecosystems and the services they provide. Increased learning about the effects of increased CO_2 will also help decision-making around planting woodland that is most likely to survive and thrive in the future (UK Centre for Ecology and Hydrology, no date).
- Planning Policy Wales Edition 12, published in 2024, provides greater emphasis on the protection to woodlands and individual trees such as ancient and veteran trees. It states that Planning Authorities now 'must' protect trees, woodlands and hedgerows and they should set minimum tree cover targets to guide the protection of canopy cover. These changes, and others in the policy, are expected to reduce the amount of woodland lost for the purposes of development (Welsh Government, 2024b).
- Written statement on improving the protections for ancient woodland which sets out a range of measures currently underway or being developed that will contribute to better protection of ancient woodland (Irranca-Davies MS, 2025).

Opportunities for Action Aim 1

The possible actions identified with respect to achieving Aim 1 relate to INNS and other species management; Pollution management; Species conservation and enhancement; Sustainable agriculture and forestry; Resource protection.

Action 25. Effective control of Grey squirrels and non-native deer, as well as other INNS such as Rhododendron ponticum, American skunk cabbage, Himalayan balsam, Cherry laurel, Japanese knotweed.

Action 26. Reduce large mammal herbivore activity damage to woodland plants

Action 27. Reduce the impact of tree pests and diseases such as Phytophthora ramorum and emerging threats such as Phytophthora pluvialis and the European spruce bark beetle, by diversifying tree species, improving monitoring, surveillance and implementing appropriate management interventions.

Action 28. Improve the condition of woodland flora and fauna by tackling the root cause of poor air quality linked to ammonia.

Action 29. Support woodland adaptation to reduce the impacts of changes in intensity and frequency of weather events, such as storm damage to trees, water logging affecting growth, wildfires and water stress leading to crown die back

Action 30. Support woodland adaption to address the impacts of changes in air temperature, such as increased lammas (late season) growth, increased risk of spring frost damage, increased tree growth due to longer, warmer growing seasons.

Aim 2: Ecosystems are Resilient to Expected and Unforeseen Change

Ecosystem resilience is assessed in SoNaRR by using four ecosystem attributes as proxies: diversity, extent, condition and connectivity. For the Woodlands ecosystem, resilience is assessed for native and non-native woodland as they have different characteristics.

Diversity

Historically there is a mixed picture trend for diversity in Welsh woodlands over both the long term (1971 to 2024) and the short term (2019 to 2024). Native woodlands have older and fewer stems than in the past, increasing opportunities for shade tolerant species. Ash dieback is causing a reduction in native tree diversity but an increase in canopy gaps leading to increased forb (herbaceous, flowering plants, not including grasses) cover (Smart *et al.*, 2024). Current native woodland diversity is medium-high with more than half of stands being favourable. Within non-native woodlands, diversity is Low-medium with 45% of stands remaining even aged, and forests dominated by a few species (Forestry Commission, 2020). Diversity of non-native woodlands has been low but stable over the short-term past (2019-2024) although there has been some improvement on the Welsh Government Woodland Estate (WGWE) due to increased diversity of conifer species in restocking (Forest Research, 2020, 2021, 2022b, 2023, 2024b). The future outlook (2024-2050) for overall woodland diversity is one of improvement, with likely increases in the diversity of restocked and newly planted species, increases in canopy variation due to ash die-back and increases in woodland management facilitated by new Welsh Government schemes.

Extent

Historically there is an improving trend for extent in woodlands over both the long term (1905 to 2024) and the short term (2019 to 2024) (Forest Research, 2024b). Woodland cover increased from 4.2% of Wales in 1905 to 15% in 2024. Most of this increase has been due to non-native plantations, particularly in the post second world war years. In the short term, extent has also improved due to new woodland creation, mostly of broadleaf species, although there has been some loss of conifer and broadleaf species in this period in conifer woodlands due to renewable energy infrastructure, built development and open habitat restoration. Ecosystem resilience is linked to extent of patches of ecosystem, as well as overall land coverage. Native woodlands had an overall land cover of 173 thousand hectares in 2024, with 51% of stands assessed favourably for size so this attribute has been assessed as medium for SoNaRR2025. Non-native woodlands extent has been assessed as high, covering 139 thousand hectares in 2024 (Forest Research, 2024b). In 2020 89% of non-native stands scored favourably for size (Forestry Commission, 2020). Future trends for extent are likely to be a mixed picture to 2050, depending on the competing pressures from climate change, land use change, pests and diseases, together with Welsh Government policies and strategies in this regard.

Condition

Historically there is a mixed picture trend for condition in woodlands over both the long term (variable) and the short term (2019 to 2024). There is little long-term evidence for the condition of conifer woodlands. In native woodlands, loss of condition has been associated with declines in some woodland flora and fauna (see Aim 1). More recent trends also reflect a mixed picture with disease and increased effects of Nitrogen deposition negatively effecting condition on the one hand and on the other, improved condition due to project funding for positive woodland management actions. Current overall woodland condition is assessed as medium, with 91% of native stands and 98% of non-native stands in intermediate ecological condition (Forestry Commission, 2020). This mixed picture is expected to continue. An increasing presence of deer and grey squirrel and their negative effects on woodlands is expected. In relation to native broadleaf woodland, the same is true of invasive non-native conifer especially into upland Sessile oak woods and Ash woods (NRW, 2026). The restoration of Plantations on ancient woodland sites (PAWS) is having both positive and negative effects, as is the impact of Ash die-back through changes in canopy cover and increased deadwood. Bringing more woodlands into planned management will be key in improving woodland condition. Several projects to remove INNS in woodlands have led to local improvements in condition.

Connectivity

Historically there is a mixed picture trend for connectivity in woodlands over both the long term (1905-2024) and the short term (2019 to 2024). Historic loss of woodland in Wales has reduced connectivity of native woodland, and current connectivity is assessed as medium. In contrast, non-native stands are large blocks with good internal connectivity and current connectivity is assessed as high. (Forestry Commission, 2020).

ERAMMP reported that increases in woodland and woody linear features between 2010 and 2021 have not increased woodland connectivity (Emmett *et al.*, 2025). Welsh Government woodland creation grant data (Welsh Government, 2024a) shows that new woodland planting in Wales between 2019 and 2024, has contributed 1257.06 ha to the woodland Priority Ecological Network (PEN), of which 620.5 ha is entirely within the PEN and the remaining areas have at least part of their planted area within the woodland PEN. Increasing woodland area within the woodland PEN will contribute to increased connectivity.

An improving trend is projected to 2050 if woodland creation rates continue to increase and are additionally targeted within networks to improve connectivity (e.g. creation to support Priority Ecological Networks (PENS).

Progress towards meeting Aim 2 (Ecosystems are Resilient to Expected and Unforeseen Change)

The key opportunities taken up since SoNaRR 2020 comprise:

- Some PAWS restoration but limited by resources and funding (Eryri National Park, no date).
- Improvements to woodland management through amendments to the Agriculture (Wales) Act, allowing environmental conditions to be added to Felling Licenses.
- Nature Networks BERF funding has improved woodland condition on a number of protected sites across Wales, mainly through INNS and invasive non-native conifer removal, but also re-instatement of grazing through provision of infrastructure.
- A number of Welsh Government and Woodland Trust initiatives supporting woodland creation have been set up or continued e.g.(Welsh Government, no date b; Woodland Trust, no date b).
- In the past five years (since April 2019), Welsh Government has offered 812 contracts to 673 customers for 4,323ha worth of woodland creation and restoration, worth over £18m. This has been via their Glastir Woodland Creation, Glastir Woodland Restoration, Small Grants – Woodland Creation, Woodland Creation Grant and Woodland Restoration Scheme schemes. In addition, Welsh Government has offered 50 contracts to 38 customers for £7.6m under The Woodland Investment Grant (TWIG) and 17 contracts to 16 customers for £92k under their Tiny Forests initiative (Welsh Government, 2024a)
- Welsh Government's Sustainable Farming Scheme has been published. It will support more tree retention, maintenance and planting on farms (Welsh Government, 2025b).
- A new version of UK Forestry Standard includes an updated requirement around the maximum percentage of single species, which will improve species diversity over time (Forestry Commission, 2023) .
- On the Welsh Government Woodland Estate, restocking figures show that species diversity is slowing changing (Forest Research, 2024c, tbl. New planting and Restocking).
- There has been some new woodland creation within PENs, improving extent and connectivity.

Opportunities for Action Aim 2

The possible actions identified with respect to achieving Resilient Woodland ecosystems relate to Ecosystem creation; Ecosystem protection; Ecosystem restoration; INNS and other species management; Nature based solutions; Pollution management; Species conservation and enhancement; Sustainable agriculture and forestry.

Action 1. Increase extent and connectivity of native woodland

Action 2. Improve condition of woodlands through controlling INNS, pests and diseases

Action 3. Improve condition of woodlands through reduction of large mammal herbivore activity damage to woodland plants

Action 4. Improve condition of woodlands by decreasing nitrogen deposition on the foliage of plants and organisms

Action 5. Improve diversity of non-native woodland

Action 6. Improve the condition of protected and designated woodland sites, including for example the removal of non-native species, and species that are not appropriate for the woodland habitat type in terms of future resilience.

Action 7. Improve connectivity through spatially targeted woodland creation (RENs and PENs)

Aim 3: Healthy Places for people, protected from environmental risk

Health protection

Woodlands in Wales contribute to the **protection of human health** through the supply of the following regulating services:

- **Global climate regulation service**: reducing greenhouse gases in the atmosphere leading to reduced climate change impacts on people. Woodlands act directly as reservoirs and sinks of carbon and indirectly as a sustainable source of wood-based products and bioenergy. The net annual rate of carbon dioxide accumulation by Wales forests was 1.2 million tonnes CO2 in 2020 and is predicted to rise to 1.6 million tonnes CO2 by 2050. The overall picture in Wales from 1990 to 2050 is relatively stable (Forest Research, 2024b).
- **Local climate regulation services**: mitigation of local temperatures leading to reduced heat stress on people, particularly in urban environments.
- **Air filtration services**: Woodlands reduce concentrations of pollutants, especially particulates, leading to less damage to people’s health. Broadleaf woodlands are particularly effective: in 2022, air filtration by Wales’ broadleaf woodland prevented

968 life years lost from exposure to particulates (Office for National Statistics, 2024b).

- **Water flow regulation services**: Woodlands lower peak flows in wet periods reducing risk of flooding, with associated risks to people's physical and mental health. Woodlands also increase the retention of rainwater by soil, delaying run-off so that base flows are maintained for a longer period, helping to mitigate against drought.

Health Improvement

Woodlands in Wales contribute to **human health improvement** through the supply of the following cultural ecosystem services:

- **Recreation-related and amenity services**: Woodlands support a range of recreational activities and local sensory benefits that are known to support physical and mental well-being and a connection to nature. In 2021/2022, people in Wales made 38,884,122 visits to woodland ecosystems for recreation (Owen, Rhydderch and Williams, 2025)). In Wales in 2022, 100,000 people gained health benefits from recreation in woodland ecosystems, compared to 200,000 in 2019 (Office for National Statistics, 2024a).

Cultural Well-being

Woodlands in Wales contribute to **people's cultural well-being** through the supply of the following cultural services:

- **Spiritual, artistic and symbolic services**: Woodlands and ancient trees are often a major component of landscape character, scenic quality and sense of place. They provide a source of inspiration for expression and cultural and spiritual identity including through art, folklore and language, historic features and practices.
- **Education, scientific and research services:** Woodlands are a place and subject of learning, intellectual development and advancement of knowledge.

Equitable access

Access to the benefits from woodland ecosystems is not distributed equitably across society in Wales. Proximity of people to woodland ecosystems is a key factor governing equitable access to benefits such as cleaner air and flood prevention as well as benefits from recreation and amenity. Health and mobility are also important factors, for example of the respondents to the Public Opinion of Forestry Survey who had not visited woodland in the last twelve months, 21% cited mobility reasons and 18% stated they do not have access to a car (Forest Research *et al.*, 2023). A half of those who reported having a long-term physical or mental health condition reported that it affected their use of woodlands, forests or other green space.

Progress towards meeting Aim 3 (Healthy Places for people, protected from environmental risk)

The key opportunities taken up since SoNaRR 2020 comprise:

- Promotion and communication of how woodlands can provide nature based solutions for climate change mitigation, flood and drought risk mitigation and air pollution mitigation. The UK Forestry Standard (2024) explains the multipurpose benefits of woodlands (Forestry Commission, 2023), and new UKFS Practice Guides on managing woodlands to reduce flood risk (Nisbet, 2022) and creating and managing riparian woodland (Forest Research, 2024a) have been published.
- Ongoing research on how, when and where floods and droughts occur will enable improved predictions, robust assessment of impacts and implementation of appropriate mitigation (Birmingham Institute of Forest Research (BIFoR), no date).
- The relative tranquillity associated with the abundance, perception or experience of seeing woodland is now identified in the LANDMAP Tranquillity and Place theme one indicator 'seeing woodland' (NRW and Land Use Consultants, 2025) .
- The National Forest for Wales programme is making progress towards providing a stretch of interconnected woodland the length and breadth of Wales, making it accessible to everyone (The National Lottery Heritage Fund, 2024; Welsh Government, no date a).
- Woodland Trust's Ancient Tree Inventory continues to expand, with more ancient and veteran trees recorded each year, providing a record of these living monuments contributing to our heritage (note that not all ancient and veteran trees are within woodland) (Woodland Trust, no date a).

Opportunities for Action Aim 3

The possible actions identified with respect to achieving Aim 3 relate to Access to nature; Nature based solutions; Payment for ecosystem services; Research and technology.

Action 8. Protect people around the world from the adverse effects of climate change by investing in woodlands to boost the supply of climate change regulation services.

Action 9. Protect the health of people in Wales by investing in woodlands to boost the supply of flood mitigation ecosystem services to manage risks related to flooding, including in the context of climate change.

Action 10. Protect the health of people in Wales by investing in woodlands to boost the supply of local climate regulation services to manage risks related to extreme heat, including in the context of climate change and in urban areas.

Action 11. Protect the health of people in Wales by investing in woodlands to boost the supply of air pollution filtration services.

Action 12. Improve the physical and mental health of people in Wales by providing opportunities for recreation in woodlands and access to associated recreation-related services.

Action 13. Increase possibilities for people in Wales to enjoy the experiential, spiritual and cultural identity benefits that woodlands can provide.

Action 14. Increase possibilities for people to build their knowledge and skills by using the educational services woodland ecosystems can provide.

Action 15. Increase equitable distribution of benefits to physical and mental health provided by woodlands.

Aim 4: Contributing to a Regenerative Economy, Achieving Sustainable Levels of Production and Consumption

Woodland ecosystems contribute to economic well-being through the supply of the following **regulating services:**

- **Local climate regulatory services** for livestock on farms. In their preliminary evidence synthesis, Jordon et al (2020) indicate that there is an emerging evidence base to demonstrate that temperate agroforestry can deliver economic benefits compared with pasture without trees, whilst also delivering co-benefits for nature.
- **Water purification services**: Woodlands help to trap and retain nutrients and sediment in runoff and are therefore effective at helping to tackle diffuse pollution (nitrogen, phosphorus and sediment) (Beauchamp *et al.*, 2020). This can lead to reduced water treatment and pollution management costs for the water sector, whilst also delivering co-benefits for nature.
- **Water flow regulation services**: A comprehensive review of the effectiveness of natural processes in reducing flood risk (DEFRA *et al.*, 2025) concluded that catchment woodland can help to mitigate against flood risk, reducing associated damage costs to businesses, agricultural land, infrastructure and other property. Transitioning from hard infrastructure solutions to mitigate flood risk, to investing in these natural flood management solutions will also delivering co-benefits for nature.
- **Nursery population and habitat maintenance services:** Large- and small-scale forest nurseries are essential for the supply saplings for woodland and forestry planting. A breakdown of sapling supply for Wales is not available. However, a Tree Supply Report for Great Britain (Forestry Commission, 2024) estimated that the production of forest nurseries was 160.1M saplings for the year 2023/24, up from 151.8M in 2022/23. In 2023/24, the number of tree species produced by nurseries was 129, a fall from 134 in 2022/23. It should be noted that the report excludes data from smaller scale nurseries which often produce local broadleaf species.

Woodland ecosystems contribute to economic well-being through the supply of the following provisioning services:

- **Wood provisioning:** Softwood removals in Wales (combined public and private) between 2014 and 2023 ranged from a low of 1,021,000 green tonnes in 2019 to a high of 1,460,000 green tonnes in 2014, with an average of 1,266,000 green tonnes over the ten-year period (Forest Research, 2024c). In 2022, softwoods represented 99% of timber stocks removed from woodlands in Wales (Office for National Statistics, 2024). The current 25 year forecast of softwood availability (Forest Research, 2022a) highlights a 40% reduction from 2022-2046.

Hardwood removals in Wales (combined public and private) between 2014 to 2023 ranged from a low of 24,000 green tonnes in 2014 to a high of 39,000 green tonnes in 2019, with an average of 33,000 green tonnes. Overall, there is significant increase over the period, due to increased contributions from the private sector (Forest Research, 2024c). The current 50 year forecast of hardwood availability (Forestry Commission and Brewer, 2014) shows a steady increase between 2013-46.

The Office for National Statistics highlight that the supply of wood provisioning services in terms of (overbark standing) total timber (excluding wood fuel) increased from 908,000 m3 in 2019 to 1.1 million m^3 in 2022 (Office for National Statistics, 2024b). The supply of (overbark standing) total wood fuel has increased a little from 253,000 m^3 2019 to 267,000 m3 in 2022. (Office for National Statistics, 2023a). They estimate the value of this service at between £40 and £50 million per year between 2019 and 2023 (based on stumpage prices) (Office for National Statistics, 2024b).

Wood provisioning services contributed £614 million Gross Value Added to the Welsh economy in 2022 (Giannelli, 2025; Welsh Government, 2025a). This was made up of direct forestry and logging activities (£74 million), which occurred in Wales. The remainder comprised manufacture of wood products (£272 million) and manufacture of paper (£268 million). GVA has increased across all three sectors since 1998, with the greatest increase seen in forestry and logging. Collectively, the sector employed over 10,000 people in 2023 (Giannelli, 2025; Welsh Government, 2025a).

- **Genetic material provisioning:** Forest Genetic Resources (FGR) are critical for multiple purposes including timber production, seed sourcing and the long-term conservation and adaptability of species to environmental challenges such as climate change and pests and diseases.

Woodland ecosystems contribute to economic well-being through the supply of the following **cultural ecosystem services:**

- **Recreation-related services:** In 2021/2022, people in Wales made 38,884,122 visits to woodland ecosystems for recreation (NRW and Natural England, 2024; Owen, Rhydderch and Williams, 2025). These visits support employment in tourism and outdoor leisure related activities.

Economic drivers and their pressures on woodlands

The key direct economic drivers within Wales that are directly related to the degradation of woodland ecosystems relate to ‘Land and sea use change’. Direct exploitation as a driver of pressures on woodlands is not considered to be a key issue in Wales currently (i.e., the use of woodland ecosystem services is considered broadly sustainable). Climate change pressures are considered to be driven by global economic activity, and the specific economic drivers of pollution pressures are assessed via the relevant natural resource assessments.

Land and sea use and management change

There is currently no or insufficient data or evidence for Wales that reliably captures woodland loss (numerically or spatially) linked to **built development and infrastructure**. However, it is known that built development and infrastructure, including housing, roads and renewable energy provision, can result in the direct and permanent loss of woodland cover and habitat fragmentation, affecting not only the extent of woodland cover but also its condition, connectivity and adaptability. The future outlook is a mixed picture to 2030 and beyond to the end of the century. As Wales transitions to a low carbon economy, onshore wind farms are likely to pose a greater threat to woodland ecosystems unless mitigated by compensatory planting elsewhere; and bult development and infrastructure outlined in the Welsh Government’s National Plan 2040 will likely impact on woodlands (Welsh Government, 2021).

An example of changes in woodland cover linked to renewable energy infrastructure

Effect of renewable energy sector on the Welsh Government Woodland Estate. Since the start of the renewable energy programme on the WGWE in 2007, encompassing small scale hydropower schemes and wind turbines at Brechfa, Pen Y Cymoedd and Clocaenog, a total of 804 ha of trees have been felled. Of this, 211 ha has been restocked as normal; 390 ha has been set aside for HMP (Habitat Management Plan) or operational reasons; and 202 ha has energy infrastructure on it and therefore cannot be restocked but will be offset by compensatory planting elsewhere. As Wales transitions to a low carbon economy, onshore wind farms in particular are likely to pose a greater threat to woodland ecosystems as the turbines and associated infrastructure typically result in some permanent loss of woodland cover, although it is hoped that most of this will be mitigated by compensatory planting elsewhere. Details of preferred spatial areas for built development and infrastructure are detailed in Future Wales: The National Plan 2040 and some of this will likely impact on woodlands.

Reduced land management intensity can affect condition of woodlands and capacity to supply ecosystem services. However, since 2004 we see an improving trend in the amount of woodland in planned management through the UK Woodland Assurance Scheme (UKWAS) which also ensures adherence to the UK Forestry Standard (UKFS), increasing over both the longer and shorter term (2004-2025 and 2020-2025). Currently at least 48% of Welsh woodland is managed through the UKWAS, a large majority of which is the Welsh Government Woodland Estate. However, this figure is an underestimate as many more woodlands in Wales will be managed to the UKFS as evidenced by the granting of felling licences and the award of Welsh Government grant funding but there are currently no collated data sets to quantify these elements. The future outlook in the short and longer term is likely to be an improving trend, although this will depend heavily on future support mechanisms (including within the Sustainable Farming Scheme). Absence of planned management in remaining woodlands is a concern as these woodlands are likely to deliver fewer ecosystem services and to have reduced condition. Illegal felling, and the restoration of open habitat can also result in a direct and permanent loss of woodland cover. These issues are highlighted in Aim 1: Stocks of natural resources are safeguarded and enhanced.

Contributions of Woodlands to sustainable economic production and consumption

The UK Forestry Standard (UKFS) defines the government requirements for sustainable forest management in the UK. It provides a basis for regulation and monitoring, including national and international reporting. At least 48% of all forests in Wales are managed to this standard as they are certified through the UK Woodland Assurance Standard (UKWAS) (Forest Research, 2024c, tbl. Certified woodland area, UK).

The UKWAS standard is used as the basis for the two accredited forest certification schemes operating in the UK: the Forest Stewardship Council® (FSC®) and the Programme for the Endorsement of Forest Certification (PEFC). Certification to one or both schemes assures the buyers and users of wood, and wood products, that they come from sustainably managed woodlands. The FSC® and PEFC certification for sustainable forest management means that our forests supply responsibly produced wood (NRW, 2023). The management of certified woodland is done in such a way as to maintain biodiversity and natural ecological processes, as well as being socially and economically beneficial. This highlights a substantial portion of Wales' woodlands are managed to promote restoration and regeneration.

Timber supply from woodlands is a key provisioning service for the foundational economy in Wales. Recognising the potential for the forestry sector to support growth, the Welsh Government has committed to sustain high value production and processing, whilst supporting biodiversity, biosecurity and carbon sequestration through the timber industrial strategy Making Wood Work for Wales (Welsh Government, 2025a). Long-lived wood products from the timber industry have the potential to store and lock up carbon in the economy and reduce waste compared to other short-lived products. Scaling up production of these types of products as substitutes for other materials or shorter-lived products will contribute to a more circular economy. The ONS estimate that harvested wood products in Wales captured 183,500 tCO2e in 2021 (Office for National Statistics, 2023b). A key potential area for increased use of long-lived wood products is the construction sector. Evidence suggests that substituting to home grown timber can help reduce construction times for housing, as well as reliance on other materials and imports with higher environmental footprints (Welsh Government and Shirra, 2025).

It is well recognised that restoration and regeneration of woodland ecosystems can deliver multiple benefits for well-being (NRW, 2021). As such, they are recognised as Nature based Solutions (NbS) to many of the development challenges we face. This includes mitigating heat stress, purifying water and managing flood risks. In Wales, maps are available that identify potential areas for woodland planting that support water flow regulation: [Natural Resources Wales / Maps for Natural Flood Management](). Woodlands can also deliver effective solutions to tackling diffuse pollution (nitrogen, phosphorus and sediment) (Beauchamp *et al.*, 2020). These are examples of how woodland investment can support transitioning away from investment in 'grey' built infrastructure solutions to NbS that deliver co-benefits for nature and people.

Progress towards meeting Aim 4

The key opportunities taken up since SoNaRR 2020 comprise:

- Amendments to the Agriculture (Wales) Act have allowed environmental conditions to be added to Felling Licences for the first time, improving woodland management and providing better protection for wildlife and the environment during felling operations (Senedd Cymru, 2023).
- Woodlands are being newly planted.
- Welsh Government has published Making Wood Work for Wales, a timber industrial strategy (Welsh Government, 2025a).

Opportunities for Action Aim 4

The possible actions identified with respect to achieving Aim 4, A regenerative economy, relate to Nature based solutions; Payment for ecosystem services; Sustainable agriculture and forestry; Increased resource use efficiency; Pollution Management; Sustainable construction; Sustainable Transport; Renewable energy; Waste prevention.

Action 16. Increase amount of woodland under planned management.

Action 17. Mitigate pressures from built development and pursue compensatory planting to ensure there is no net loss of woodlands.

Action 18. Increase use of sustainably produced timber and high value long-lived wood products.

Action 19. Encourage investment in woodlands for Nature based Solutions to mitigate heat stress, purify water and reduce flood risk and other development challenges.

Evidence Needs

We have identified evidence needs linked to improving understanding of how to accelerate woodland adaptation to improve resilience, for example to climate change and pests and diseases. There is a call for better data on the distribution and impact of non-quarantine pests and diseases, as well as the genetic diversity of tree species. Evidence is also needed on the effectiveness of natural colonisation, the net change in woodland cover, and the condition of ‘ancient woodlands including Plantations on ancient woodland sites.

The impact of nutrient enrichment and adjacent land use on woodland ground flora, and the role of tree species diversity in woodland productivity, are further priorities. There is a need to quantify the ecosystem trade-offs and synergies associated with woodland expansion, particularly in relation to land use change and climate adaptation. Reliable methods, including earth observation and ground-based measures, are required to measure woodland cover and condition more comprehensively, assess trends and monitor the effectiveness of restoration. These evidence needs are critical for informing sustainable management, policy, and operational decisions for Wales’ woodlands.

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Natural resource SMNR assessments

In SoNaRR 2025 we use four interlinked aims as a framework to assess Wales' progress towards SMNR. These aims focus on stocks of natural resources, ecosystem resilience, healthy places for people and a regenerative economy

The SMNR assessments for the three main natural resources use the evidence set out in the SoNaRR evidence portal. The evidence in the portal describes the pressures, state, trends of state, benefits and dis-benefits provided by the resource in Wales. Where suitable evidence is not available, we have made that clear. A confidence assessment is provided for each description within the SoNaRR evidence portal.

Air

Evidence leads: Gary Evans and Matthew Bevington

Air as a resource refers to the quality of the air around us in Wales and the emissions, we produce including pollutants and radioactive substances.

This air assessment is one of three natural resource and eight ecosystem assessments that inform the overall SoNaRR2025 report. It builds on the findings of SoNaRR2020, drawing together updated evidence from subject experts, national datasets, collaborative projects and an ammonia specific case study.

The assessment is structured around four interlinked aims that guide Wales' progress toward the sustainable management of natural resources (SMNR), helping to communicate the relationship between the environment, well-being, and the economy.

Key messages

- Clean air and places free from noise and light pollution are essential for public health, biodiversity, and economic prosperity in Wales, with air pollution estimated to cause 1,000-1,400 premature deaths annually and cost the country £1 billion per year in lost workdays and healthcare expenses.
- Despite improvements since the industrial era, parts of Wales still have some of the worst air quality in Britain, with major pollution sources including transport, agriculture, industry, and domestic burning.
- The Welsh Government has demonstrated a strong commitment to improving Wales' air resource through the Clean Air Plan for Wales and the introduction of the Environment (Air Quality and Soundscapes) (Wales) Act 2024
- Addressing air and noise pollution in Wales requires a multi-sector, collaborative approach that integrates nature-based solutions, sustainable transport, and emissions control across various industries.
- Improving Wales' air will benefit public health and ecosystem resilience, as well as promoting sustainable economic growth through cleaner technologies and practices.

Air Summary SMNR Assessment

Aim 1: Stocks of natural resources are safeguarded and enhanced

Air quality in Wales has shown mixed progress. Emissions of key pollutants such as sulphur dioxide (SO_2), nitrogen oxides (NO_x), particulate matter (PM10 and PM2.5), and lead (Pb) have declined significantly since 2005, largely due to shifts in energy production and transport technologies. For example, SO_2 emissions from power stations fell by 99%

due to the transition from coal to cleaner energy sources. However, ammonia (NH_3) emissions have increased, driven by agricultural intensification, including greater use of urea-based fertilisers and livestock housing. The Environment (Air Quality and Soundscapes) (Wales) Act 2024 introduces the requirement to set a new national target for PM2.5 and for at least one other pollutant, aiming to further reduce emissions.

Efforts to enhance air quality include legislative actions, urban planning, and technological improvements. Initiatives such as Clean Air Zones, active travel promotion, and improved energy efficiency in housing are expected to reduce emissions. Localised air pollution however remains a concern, particularly in urban and industrial areas.

Tranquillity mapping indicates that 69% of the country is in the top three national tranquillity categories for the sound environment where natural sounds are more prominent than noise when considering solely road and rail.

Aim 2: Ecosystems are Resilient to Expected and Unforeseen Change

Air pollution poses significant risks to ecosystem resilience. NOX and NH3 contribute to nitrogen deposition, leading to eutrophication, soil acidification, and water pollution. In 2021, 99.1% of sensitive habitats areas in Wales exceeded their critical load for eutrophication, and 70.6% exceeded acidity thresholds. Although the magnitude of exceedance has declined over time, all Special Areas of Conservation (SACs) and Special Protection Areas (SPAs) still exceed nutrient nitrogen critical loads for at least one feature.

Progress includes reductions in SO_2 emissions, which are expected to relieve acidification pressures by 2050. The Control of Agricultural Pollution Regulations (2021) aim to reduce ammonia emissions and nutrient losses. Coordinated efforts to manage nitrogen pollution are essential for restoring ecosystem health. Actions such as sustainable agriculture and pollution management are being implemented to mitigate air-related impacts on biodiversity and habitat quality.

Aim 3: Healthy Places for people, protected from environmental risk

Air pollution significantly affects human health, contributing to respiratory and cardiovascular diseases. In Wales, between 1,000 and 1,400 deaths annually are attributed to poor air quality. Pollutants like NO_2, SO_2, PM2.5, and ozone (O3) are particularly harmful. Noise pollution also impacts well-being, with 27% of urban residents reporting regular disturbance. Cleaner air and quieter environments improve physical and mental health, reduce healthcare costs, and enhance quality of life.

Environmental inequalities persist, with deprived communities more exposed to poor air quality and limited green space. In 2019, Newport and Cardiff had the highest concentrations of areas in the most deprived physical environment category. The 2024 Act and urban planning initiatives aim to address these disparities through integrated approaches, including nature-based solutions and active travel infrastructure, fostering healthier, more equitable living conditions.

Aim 4: Contributing to a Regenerative Economy, Achieving Sustainable Levels of Production and Consumption

Air quality is closely linked to economic activity. Agricultural intensification has driven increases in ammonia emissions, while industrial and transport sectors have seen reductions. Poor air quality affects productivity, with estimated losses of £1 billion annually in Wales. Ground-level ozone, formed from NO_2, damages crops, ecosystems, and materials, adding socio-economic costs.

Efforts to transition to a regenerative economy include reducing emissions through cleaner transport, sustainable agriculture, and improved infrastructure. The Environment (Air Quality and Soundscapes) (Wales) Act 2024 sets targets for PM2.5 and potentially other pollutants such as NO2 and NH3, supporting long-term sustainability. Research into pollution management and resource efficiency is vital for aligning economic growth with environmental protection, ensuring air quality contributes positively to Wales' future prosperity.

Key changes since SoNaRR2020

Since SoNaRR 2020, Wales has seen notable progress in air quality. Concentrations of nitrogen dioxide have declined in many urban areas, leading to the revocation of several AQMAs. However, ammonia and ozone levels remain problematic, especially for sensitive habitats.

A major legislative shift came with the Environment (Air Quality and Soundscapes) (Wales) Act 2024, which empowers Welsh Ministers to set pollutant-specific targets (e.g. $PM_{2.5}$, NO_2, ammonia) and includes requirements such as active travel promotion to reduce emissions. In regard to industrial sources of air pollution the closure of the blast furnaces at Port Talbot is expected to reduce emissions, especially of PM_{10} and PAHs, measurable improvements are likely to become clearer in 2025–2026 as monitoring continues.

While emissions have broadly dropped, air pollution still poses risks to health and ecosystems. Integrated action across sectors is now key to meeting health and biodiversity goals.

Air Full assessment of SMNR

Aim 1: Stocks of natural resources are safeguarded and enhanced

Assessment of safeguarding air

The key pressures on air in Wales are associated with the following drivers of change:

- Pollution
- Land and sea use and management change

Pollution

Historically there is a mixed picture for **air pollution** affecting the quality of air in Wales. The future outlook is for this to continue, with some pollutants decreasing in concern and others increasing.

Most pollutant **emissions** to air were lower in 2022 than they were in 2005. Emissions of Sulphur dioxide (SO_2) have reduced the most, with more modest declines of Nitric oxide (NO) and Nitrogen dioxide (NO_2), Lead (Pb), Volatile organic compounds (VOCs) and Particulate matter (PM_{10} and $PM_{2.5}$). Ammonia (NH_3) emissions have increased. (Mitchell *et al.*, 2024).

Emissions of SO_2 fell by 78% between 2005 and 2022. Emissions of SO_2 from Power stations fell by 99% during this time due to the change from using coal to natural gas, nuclear and renewable sources.

Emissions of Nitrous oxides (NO_X) fell by 61% between 2005 and 2022, mainly due to changes in transport sources, particularly in road transport. In 2021, NO_X emissions from power stations were 87% lower than in 2013. Encouraging the use of the cleanest modes of transport for freight and passengers, active travel and the creation of urban green space, are likely to be key in reducing NO_X emissions in the future.

Emissions of PM_{10} fell by 33% between 2005 and 2022. Recent trends have been influenced by all sectors. In recent years, emissions from residential, commercial and public sector combustion have increased somewhat, and this is primarily due to increasing wood fuel use in the residential sector (DEFRA, 2023).

Emissions of $PM_{2.5}$ fell by 40% between 2005 and 2022, mainly due to the change in the fuel mix used in electricity generation away from coal and towards natural gas, and reductions in emissions from the transport sector due to the turnover of the vehicle fleet, with the continued penetration of vehicles that comply with more stringent exhaust emissions standards over time. However, declines in emissions have been offset by increases in emissions from the residential sector, and in particular, the combustion of wood. The Environment (Air Quality and Soundscapes) Act 2024 introduces new national targets for $PM_{2.5}$ (to be established within 3 years of the act). A target will be set for an additional pollutant within 6 years, the pollutants being considered include NH_3, NO_X and others.

Metals emissions are reducing gradually for example Nickel (Ni) and Lead (Pb). Emissions of Pb fell by 0.7% between 2005 and 2022 due to reductions within industrial processes. Tata Port Talbot, a significant contributor in Wales to total UK emissions of Benzo[a]pyrene (BaP), has stopped operating the heavy end of the site which produced BaP. This should result in a significant improvement of concentrations in 2025. Emissions of BaP fell between 2005 and 2022, mainly due to decreases from industry and waste sectors (Mitchell *et al.*, 2024)

Emissions of NH_3 rose between 2005 and 2022 (Mitchell *et al.*, 2024) due to increased use of urea-based fertiliser application; increases in housed cattle numbers and subsequent manure spreading on soils; and increases in digestate and other organic fertilisers which are applied to soils. (Misselbrook *et al.*, 2023) (See SoNaRR 2025 Ammonia case study). NH_3 emissions are expected to increase if measures to control agricultural emissions are not carried out.

Noise pollution is a significant issue in urban areas (NRW, 2021b). There is limited evidence to describe trends in noise pollution. In 2021 25% of people report being regularly bothered by noise coming from outside their home, a similar proportion to 2017-18. People living in urban areas are more likely to be bothered by noise (28%) than those in rural areas (21%). (Welsh Government, 2021)

The Environment (Air Quality and Soundscapes) (Wales) Act 2024 aims to improve air quality and reduce pollution impacts on human health, biodiversity, and the environment.

By 2030, noise reduction measures under the Clean Air Plan and urban green space development will improve living conditions in urban areas. By 2050, advancements in transport technology and infrastructure design could make noise pollution negligible. By 2100, quieter environments will be the norm across Wales.

There is little evidence to describe the impacts of **odour** in Wales. Examples of potentially odorous activities are sewage works, intensive animal rearing, processing of animal remains, solid waste management (for example composting) and some industrial processes.

46% of Wales was associated with negligible levels of night-time **light pollution** in 2009 (NRW, 2021a)

There are indications that the amount of light emitted around the edge of major built up areas is increasing, data also suggests the amount of light within the built-up areas is decreasing (Green, Manson and Chamberlain, 2021)

Pressures from economic activity (see Aim 4 for more detail)

Pressures arising more directly from economic activity are also negatively affecting air in Wales (See Aim 4 for more detail). These comprise:

- **Built development and infrastructure.** Pressures associated with the expansion of urban areas and transport are identified as economic activities affecting the quality of air.
- Agriculture is identified as a sub sector of the economy in rural areas. **Agricultural intensification** creates pressures which affect the quality of air. High levels of methane and NH_3 are emitted from manure spreading and livestock housing.

Assessment of enhancing air resources

The current state of air quality in Wales is mixed. While some areas have air quality among the best in the UK, persistent problems remain, especially in urban and industrial zones

Local areas of elevated concentrations of particulate matter and NOX continue to be problematic. Ground level ozone concentration is rising. (Welsh Government, 2024).

81% of Wales and 10% of Wales Urban areas are in the top 3, out of 10, most visually tranquil categories where the perception of nature and natural landscapes is greater than that of human influence and light pollution. (Green, Manson and Chamberlain, 2022; NRW and Land Use Consultants, 2025).

86% of Wales is in the top 5(out of 10) combined sound environment categories where natural sounds are expected to be more prominent than noise. 69% of Wales is in the top three tranquillity categories for the sound environment where natural sounds are more prominent than noise when considering solely road and rail (Gibbs and Sims, 2024).

Progress to meeting Aim 1 (Stocks of natural resources are safeguarded and enhanced)

The key opportunities taken up since SoNaRR2020 comprise:

- The Welsh Government has demonstrated a strong commitment to improving air quality through initiatives like the Clean Air Plan for Wales (Welsh Government, 2020) and the recent introduction of the Environment (Air Quality and Soundscapes) (Wales) Act 2024, which aims to create a comprehensive legislative framework for air quality management.
- UK Government published **the Air Quality Commons Framework February 2022** (UK Government, 2022a). This policy paper explains how the UK Government and the Devolved Administrations propose to work together to develop air quality policy, following the UK's exit from the European Union (HM Government, 2022)

- Welsh Government published A Low Carbon Wales (2019a) which aims to reduce ammonia emissions through improving efficiency of livestock production, improving crop and nutrient management, and improving on farm fuel and energy efficiency
- Innovative projects are being implemented, for example involving the installation of ammonia sensors to monitor emission levels and by producing Site Nitrogen Action Plans (NRW, 2023)
- Welsh Government's Transforming Towns programme and funding for active travel will reduce vehicle emissions (Welsh Government, 2023b)

Opportunities for Action Aim 1

The possible actions identified with respect to achieving Aim 1 and safeguarding and enhancing air as a natural resource relate to Awareness raising, Increase resource use efficiency, Pollution management, Research, Sustainable agriculture, forestry and fisheries, Sustainable manufacturing, and Waste prevention (reduce, recycle, recover)

Action 1. A coordinated effort is required to address nitrogen pollution, which affects both air and water quality.

Action 2. Encourage cleaner options to reduce Emissions of B[a]P from wood combustion in homes.

Action 3. Reduce light and noise pollution in urban areas.

Action 4. Improve transport technology and infrastructure design to address noise pollution.

Action 5. Improve air quality in urban areas via the creation of clean air zones

Aim 2: Ecosystems are Resilient to Expected and Unforeseen Change

The quality of Air impacts on ecosystem resilience in the following ways:

Nitric oxide and Nitrogen dioxide (NOx)

NOX emissions contribute significantly to nitrogen deposition in all ecosystems, especially in upland Wales where the impacts from industrial and transport emissions are often very distant from pollution sources. Nitrogen deposition causes eutrophication of surface waters

Ammonia (NH_3)

NH_3 concentrations in air can directly harm sensitive plants. NH_3 also contributes significantly to nitrogen deposition in all ecosystems. Nitrogen deposition from NH_3 also contributes to soil acidification and water pollution, further stressing ecosystems.

Remaining virtually unchanged over the long-term, the area of N-sensitive habitats with critical load exceedance in Wales reduced by 0.8% between 2003 and 2021. The Average Accumulated Exceedance for all Welsh habitats combined for nutrient nitrogen has declined by 23%, from 14.2 KgN/ha/yr in 2003 to 10.9 KgN/ha/yr year in 2021.

In 2021 99.1% of sensitive habitats in Wales exceeded their critical load for eutrophication (JNCC, 2024). 45.2% of land area in Wales exceeded the 1µg/m3 critical level of NH3 concentration which has been set to protect bryophytes and lichens (See case study)

The percentage of the area of nitrogen sensitive habitats in the UK where ammonia concentrations exceed critical levels of 1 µg/m3 has decreased from 24.2% (2019-2021) to 21.2% (2020-2022) (Rowe et al., 2024)

Sulphur dioxide (SO_2)

SO2 inhibits plant growth, and damages sensitive ecosystems and waterways. Causes Acidification of surface waters.

Improving over the long-term, the area of sensitive habitats in Wales exceeding acidity critical loads decreased from 83.8% in 2003 to 70.6% in 2021. The magnitude of exceedance (AAE or Excess Acidity) fell by almost 55%, from 0.82 keq/ha/yr in 2003 to 0.37 keq/ha/yr in 2021. (Rowe et al., 2024)

In 2021 70.6% of sensitive habitats in Wales exceeded their critical load for acidity (JNCC, 2024).

Progress to meeting Aim 2 (Ecosystems are Resilient to Expected and Unforeseen Change)

The key opportunities taken up since SoNaRR 2020 comprise:

- SO2 emissions have reduced. Acidification of surface waters is expected to disappear as a pressure by 2050.
- The Welsh Government introduced the Control of Agricultural Pollution Regulations in Wales to tackle pollution from agriculture and protect water quality across the country. These regulations came into force on 1 April 2021. The Regulations have been designed to reduce losses of nitrogen by targeting key agricultural practices that are the main sources of these pollutants and as a result also contribute to reduce air emissions of ammonia.

Opportunities for Action Aim 2

The possible actions identified with respect to achieving Aim 2 in relation to air relate to Pollution management and Sustainable agriculture, forestry and fisheries.

Action 6. A coordinated effort is required to address nitrogen pollution, which affects both air and water quality.

Aim 3: Healthy Places for people, protected from environmental risk

The quality of Air impacts on human health in the following ways:

- NO_2 and SO_2 have direct impacts on human health, causing respiratory and cardiovascular effects.
- NO_2 reacts with other pollutants in the presence of sunlight to form ozone. Ozone (O_3) is an irritant to the airways of the lungs, throat and eyes.
- Small particles less than 2.5 micrometres ($PM_{2.5}$) in diameter pose the greatest problems because they can get deep into the lungs and bloodstream leading to respiratory problems.
- The impact of pollution goes beyond physical health and can impact human well-being and mental health

Long-term exposure to poor air quality in the UK is estimated to contribute to between 28,000 and 43,000 deaths annually. In Wales, it is estimated that between 1,000 and 1,400 deaths per year are attributable to air pollution. (Welsh Government, 2025a).

Cleaner air results in fewer respiratory and cardiovascular diseases, reducing premature deaths and improving quality of life. Households benefit from lower healthcare costs and fewer sick days.

By 2030, advancements in air quality monitoring and emission reductions under the Environment (Air Quality and Soundscapes) Act 2024 are expected to significantly improve public health. By 2050, sustained improvements could reduce health burdens, particularly for vulnerable groups. By 2100, air pollution-related health impacts may be minimal.

Improved air quality enhances sensory experiences, such as enjoying outdoor activities. Cleaner, greener neighbourhoods foster a sense of community and well-being.

By 2030, urban planning improvements will provide residents with greater access to clean, aesthetic environments. By 2050, enhanced green infrastructure could create sustainable, liveable neighbourhoods. By 2100, widespread adoption of nature-based solutions will ensure long-term sensory and health benefits.

At least one million years of healthy life are lost annually in Europe because of noise pollution (World Health Organization, 2011). Noise pollution is more likely to affect those living in urban areas, who are also more likely to be affected by other environmental, social and spatial inequalities.

In 2021, 25% of people were regularly bothered by noise coming from outside their home, a similar proportion to 2017-18. People living in urban areas are more likely to be bothered by noise (28%) than those in rural areas (21%) (Welsh Government, 2021). For more detail see the SoNaRR 2025 Urban assessment.

Quieter environments improve mental health, reduce stress, and enhance the quality of life for residents and visitors. Tranquillity promotes better sleep and overall well-being.

By 2030, noise reduction measures under the Clean Air Plan and urban green space development will improve living conditions in urban areas. By 2050, advancements in transport technology and infrastructure design could make noise pollution negligible. By 2100, quieter environments will be the norm across Wales.

Equitable access to Healthy Places for people, protected from environmental risk

The quality of air disproportionately impacts households in deprived communities. The physical environment domain within the Welsh Index of Multiple Deprivation (WIMD) includes an Air Quality Indicator. The newly published WIMD 2025 includes a noise pollution indicator (Welsh Government, 2025b).

In 2019, The local authority with the highest concentration of areas in the most deprived (physical environment) 10% in Wales was Newport (43.2%, or 41 areas) closely followed by Cardiff (43.0%, or 92 areas). This is primarily attributable to the impact of the air quality and green space sub-domains. The local authorities with the lowest proportion of areas in the most deprived (physical environment) 10% in Wales were Blaenau Gwent, Conwy, Isle of Anglesey, Pembrokeshire and Wrexham who had none of their areas in the most deprived 10%. Only 2.3% of the areas in Isle of Anglesey were in the most deprived 50% in Wales. (Welsh Government, 2019c).

The 2021/22 National survey reported that People were more likely to be bothered by noise if they lived in materially deprived households or in deprived areas. 38% of people in the most deprived 20% areas of Wales were bothered by noise compared with 19% of the least deprived 20% areas of Wales (Welsh Government, 2023a).

Progress to meeting Aim 3 (Healthy Places for people, protected from environmental risk)

The key opportunities taken up since SoNaRR 2020:

- The Welsh Government has published The Environment (Air Quality and Soundscapes) (Wales) Act 2024, which aims to create a comprehensive legislative framework for air quality management.
- There is an increased focus on integrating air quality improvements with other environmental and health initiatives, such as active travel promotion and nature-based solutions.

- Improving energy efficiency reduces emissions to air. In 2020 we said "Wales has some of the oldest and least thermally efficient housing stock in Europe (Green et al.,2018). The percentage of dwellings that were estimated to have an “adequate energy performance” has increased to 47% in 2017-18, compared to 11% in 2008 (Welsh Government, 2019b).
- The COVID-19 pandemic has influenced air quality management strategies, as lifestyle changes during lockdowns led to reduced car journeys and increased appreciation for local environments and active travel.

Opportunities for Action Aim 3

The possible actions identified with respect to achieving Aim 3 relate to Nature Based Solutions and Pollution management.

Action 7. Protect people’s health by improving air quality, reducing light pollution and noise disturbance, particularly in areas of deprivation

Aim 4: Contributing to a Regenerative Economy, Achieving Sustainable Levels of Production and Consumption

The quality of Air impacts economic well-being in the following ways:

- NO_2 reacts with other pollutants in the presence of sunlight to form ozone. Concentrations of Ground level ozone are increasing. Ozone can harm agricultural crops, forests and habitats and also many synthetic materials such as plastic, rubber and metal, with socio-economic impacts as a result.
- Air pollution reduces productivity from lost workdays. Collectively these are estimated at £1 billion per year in Wales (Grey *et al.*, 2018, p. 4).

Economic drivers and their pressures on air

The key direct economic drivers within Wales directly related to the degradation of air relate to **Land and sea use and management change**. Climate change pressures are considered to be driven by global economic activity.

Agricultural intensification affects the quality of Welsh air. Emissions of NH3 increased by 2% between 2005 and 2022 (Mitchell *et al.*, 2024), due to increases in activity from several sources; urea-based fertiliser application, increases in housed cattle numbers and subsequent manure spreading on soils, and increases in digestate and other organic fertilisers which are applied to soils. (Misselbrook *et al.*, 2023) (See SoNaRR 2025 Ammonia case study). Ammonia emissions are expected to increase if measures to control agricultural emissions are not carried out. The Environment (Air Quality and Soundscapes) Act 2024 introduces new national targets for Ammonia within 6yrs along with other pollutants.

Historically **built development and infrastructure** has affected the quality of Welsh air, most notably due to emissions arising from vehicles, industry and construction.

The reduction in NOx emissions from energy industries more recently corresponds to the reduction in coal use at Aberthaw power station since 2013, but in particular between 2017 and 2019. NOx emissions from power stations fell by 87% between 2013 and 2022 (Mitchell *et al.*, 2024).Urban expansion adds to GHG emissions, although overall emissions of GHG from changing land-use to urban (settlements) reduced by 6,000 tonnes CO2 equivalent between 2019 and 2021 (Office for National Statistics, 2023) (SoNaRR 2025 Urban assessment).

There are approximately 35,100 km total road length in Wales, an increase of 0.3% on the previous financial year (2020-21). Total road lengths in Wales change relatively little from year to year. Some of the annual increase is due to an improvement in the quality of the data rather than an actual increase. (Welsh Government, 2022). [SoNaRR 2025 land use and management change chapter]

Progress towards meeting Aim 4 (Contributing to a Regenerative Economy, Achieving Sustainable Levels of Production and Consumption)

The key opportunities taken up since SoNaRR 2020 comprise:

- **The Environment (Air Quality and Soundscapes) (Wales) Act 2024** provides a framework for setting national air quality targets; to amend existing legislation relating to the national air quality strategy; local air quality management; smoke control; clean air zones/low emission zones and vehicle idling; to place a duty on Welsh Ministers to promote awareness of air pollution; and to place a duty on Welsh Ministers to publish a national soundscape strategy (Senedd Cymru, 2024).
- Welsh Government published A Low Carbon Wales (2019a) which aims to reduce ammonia emissions through improving efficiency of livestock production, improving crop and nutrient management, and improving on farm fuel and energy efficiency.
- Innovative projects are being implemented, for example involving the installation of ammonia sensors to monitor emission levels and by producing Site Nitrogen Action Plans (NRW, 2023).

Opportunities for Action Aim 4

The possible actions identified with respect to achieving Aim 4relate to Increased resource use efficiency, Pollution management, Sustainable agriculture, forestry and fisheries, Sustainable construction, Sustainable manufacturing, and Sustainable transport.

Action 8. A coordinated effort is required to address nitrogen pollution, which affects both air and water quality

Action 9. Research and development into the management of anthropogenic pollutants at their source

Evidence Needs

Several priority areas for air quality evidence have been identified:

Wider monitoring to support modelling: While existing monitoring and modelling meet statutory reporting requirements, expanding pollutant monitoring - such as ammonia – would strengthen the evidence base and support national modelling.

Health impacts: Additional research on the effects of emerging air pollutants of concern such as ultrafine particulates, PFAS and microplastics may help the understanding of potential impact and the development of effective mitigation strategies.

Odour impacts: Evidence of odour impacts in Wales and understanding the national and local scale issues and what are the main issues and from what sectors.

Noise impacts: Greater understanding of soundscapes and how effective soundscapes can enhance human health and ecosystems.

Emissions reduction: Research into the effectiveness of strategies that incorporate emission reductions would help validate those approaches and inform future policy decisions.

Ecosystem impacts: Up to date site habitat monitoring data would help improve understanding of how air pollution affects biodiversity and designated sensitive features. Additional evidence on the impact of air pollution on crop yields would also support more informed decision-making.

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Soil

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Formed by the weathering of rocks and minerals and the accumulation of organic materials, which often takes hundreds to thousands of years. Soil formation is a continuous process although rates of loss can be much greater than formation and therefore should be treated as a non-renewable resource. Soils are the foundation of land, ecosystems and habitats.

This Soil assessment is one of three natural resource and eight ecosystem assessments that inform the overall SoNaRR2025 report. It builds on the findings of SoNaRR2020, drawing together updated evidence from subject experts and national datasets such as the *ERAMMP Report-105: Wales National Trends and Glastir Evaluation and ONS Natural Capital Accounts*. This assessment is closely linked to the Enclosed Farmland, Mountain moorland and heath and Woodland's ecosystem assessments, and the evidence we have set out in the Climate Change and Land and sea use and management change evidence.

The assessment is structured around four interlinked aims that guide Wales' progress toward the sustainable management of natural resources (SMNR), helping to communicate the relationship between the environment, well-being, and the economy.

Key messages

1. Healthy soils are key to supporting our terrestrial ecosystems and providing a diverse range of ecosystem services that benefit our communities.
2. The state of soils across Wales are generally stable, with some initial indications of topsoil carbon loss in arable soils, and high phosphorus levels and localised compaction in improved soils.
3. Climate change and unsuitable management practices are the key concerns for future trends of soils. Soils in a degraded state are less resilient to climate change.
4. We must use and manage soils in ways that maintain and enhance soil organic matter; protect soil from erosion; maintain and improve soil structure; protect and foster soil biodiversity; and balance soil nutrient cycles.
5. Timely, accessible, and meaningful data sharing is essential for sustainable soil management. Collecting detailed, long-term data on Welsh soils is crucial for tracking trends, targeting interventions, and assessing policy effectiveness.

Summary of assessment against the SMNR aims

Aim 1: Stocks of natural resources are safeguarded and enhanced

Soils in Wales face multiple pressures that threaten their long-term health and productivity. Climate change is a major driver, with wetter winters, warmer summers, and more frequent storms increasing erosion and compaction risks. These changes are geographically variable but affect soil workability periods throughout the year, reducing resilience and impacting agriculture, forestry, and ecosystem services. Pollution also poses some challenges. While nitrogen and sulphur deposition have declined, nutrient enrichment and other pollution remain a concern, affecting soil quality, and contributing to ecological harm.

Efforts to enhance soil resources include monitoring erosion and compaction, which are localised in improved grasslands. Topsoil carbon levels are stable overall, but losses are evident in arable and horticultural areas. Excess phosphorus is increasing, with more sites exceeding leaching thresholds, posing risks to water quality. Policy responses include the Agricultural Soil Policy Statement (2025) and the upcoming Sustainable Farming Scheme (2026), which aim to improve soil health through more sustainable land management and reduced pesticide use. These initiatives support integrated strategies to protect and enhance soil as a finite natural resource.

Aim 2: Ecosystems are Resilient to Expected and Unforeseen Change

Soils underpin ecosystem resilience by supporting biodiversity through the provision of ecosystem services such as regulating carbon, nutrient, and water cycles. Healthy soils reduce downstream impacts on freshwater and marine ecosystems by limiting sedimentation and nutrient runoff. However, degradation through erosion, compaction, and nutrient imbalance threatens ecosystem stability. Contaminated land also disrupts ecosystem functions, with pollutants migrating into water systems and affecting coastal and freshwater habitats.

Progress includes the Sustainable Farming Scheme (2026), which promotes soil health and habitat connectivity, and the Agricultural Soil Policy Statement (2025), which prioritises soil function and data sharing. The National Peatland Action Programme has restored over 3,600 hectares; addressing hydrology and erosion issues, and completed restoration actions over a further 8,000ha to improve habitat and protect the peat resource. Actions to maintain soil structure, adopt holistic land management, and sustainable farming practices are key to enhancing resilience. These efforts aim to mitigate climate-driven pressures and support long-term ecosystem health across Wales.

Aim 3: Healthy Places for people, protected from environmental risk

Soils contribute to healthy environments by storing carbon, filtering water, and supporting food production. Welsh soils hold an estimated 410 million tonnes of carbon, but poor management can lead to emissions, particularly from degraded peatlands. Contaminated land poses direct risks to human health through exposure to toxic substances. Over 9,000 sites in Wales require inspection, with at least 414 considered high priority. Remediation is costly and often reliant on redevelopment through planning systems.

Peatlands in good condition help store carbon, regulate flood risks by reducing rapid flushes of water, and have a reduced fire risk ensuring resilience for the provision of clean drinking water. Restoration efforts under the National Peatland Action Programme have improved hydrology and reduced fire and flood risks. Regulatory measures such as the Water Resources (Control of Agricultural Pollution) (Wales) Regulations 2021 and the updated UK Forestry Standard (2024) aim to reduce nutrient pollution and protect soil downstream. Continued collaboration, improved data on contamination, and integrated planning are essential to safeguard public health and environmental quality.

Aim 4: Contributing to a Regenerative Economy, Achieving Sustainable Levels of Production and Consumption

Soils are central to Wales' economy, supporting agriculture, forestry, and water supply. In 2024, agriculture employed 12,200 people and contributed £1.1 billion to the economy. However, soil degradation from compaction, erosion, and nutrient imbalance reduces productivity and resilience. Arable land, though limited in extent, faces particular risks from crops like maize and oilseed rape, which are more likely to degrade soil structure. Built development and infrastructure also threaten soils through sealing, loss of high-grade land, and loss of peat, contributing to loss of valuable soil resource.

Restoration of peatlands and improved planning guidance offer opportunities to protect soil resources. The Agricultural Soil Policy Statement (2025) and Sustainable Farming Scheme (2026) promote sustainable practices and environmental benefits. While past schemes like Glastir had few positive outcomes for soils, new approaches aim to better integrate soil health into economic planning. Protecting soils from development, adapting to climate pressures, and restoring degraded areas are vital for a regenerative economy that balances production with long-term sustainability.

Key changes since SoNaRR2020

Welsh soils remain broadly stable across measures and ecosystems but show some initial indication of topsoil carbon decline for arable land and broadleaf woodland, and an increase in arable soil bulk density. Soil acidity shows trends of reversing previous recovery, with pH declining in semi-natural habitats and bogs. Phosphorus enrichment has worsened on improved land. Soil biodiversity remains poorly understood; no new national data exists, though mesofauna decline has been linked to intensive land use, chemicals, and extreme weather. Pressures have intensified: climate change is driving heavier rainfall and droughts, increasing erosion and compaction risks, and sea-level rise could remove up to 3% of Best and Most Versatile land by 2100. Crops with a higher risk for soil erosion have expanded in area, and pollution concerns remain including microplastics and PFAS alongside legacy nutrients.

Soils Full Assessment of SMNR

Aim 1: Stocks of natural resources are safeguarded and enhanced

The key pressures on soil in Wales from which soils need to be safeguarded are associated with the following drivers of change:

- Climate change
- Pollution
- Land and sea us change (from economic activity)

Climate Change

Climate change has already resulted in, and is predicted to have, an increasingly significant impact on land use and soil in Wales. Agricultural crops, animal and plant health and tree suitability, tree species distribution and productivity levels will be impacted (NRW, 2021a). The UK Metrological Office Climate Change Projections (2018) predicts wetter winters, warmer summers, increased incidence of storms, extreme weather and rising sea levels.

Predicted **changes in intensity and frequency of weather events,** including wet weather and flood events, will increase erosion and reduce workability of soils. This will affect agricultural food and feed production; the time livestock can be out on land; and forestry (increased soil wetness causes sapling failure). NFU Cymru has reported on the impacts of prolonged wet periods on farming activities due to reduced workability of soils and soils at above field capacity for extended periods. More intense rainfall increases the challenge of preventing soil erosion and run-off. It creates greater instability on slopes leading to more widespread and frequent landslides (NRW, 2021a).

Predicted Changes in air temperature and associated changes in rainfall distribution and intensity can alter soil chemistry and biology. Prolonged heat and drought could lead to crop yield impacts. Increases in groundwater temperature have been shown to alter soil dynamics, biology and chemistry (Egidio, Luca and Lasagna, 2024). All of these factors can contribute to impacts on soil capability, productivity and mobilisation of contaminants. Areas with peat and peaty soils (including organo-mineral soils) represent an important store of soil carbon which may still be accumulating where hydrological conditions are favourable. Drainage and erosion lead to the loss of this carbon; other factors such as burning, nutrient enrichment, and disturbance to peat soils due to development pressure, also pose a risk. These areas are vulnerable to climate change (notably reduced summer rainfall), but restoration can greatly enhance their resilience.

Predicted **Sea level rise** caused by climate change, along with a higher incidence of storms, increases the risk of erosion, flooding and flooding of coastal communities (Met Office, 2018). Of the reported 296,897 ha of Best and most versatile (BMV) agricultural land in Wales, the loss for 0.5m, 1.5m and 5m sea level rise scenarios is 0.13, 0.39 and 3.03% respectively by 2100 (Welsh Government, 2022c).

Pollution

Regions in Wales that receive higher rainfall tend to accumulate greater nutrient loads from atmospheric deposition (Tomlinson *et al.*, 2021)**. Air pollution** effects on Soil in Wales decreased between 1990 and 2017. Nitrogen deposition across the UK decreased from 465 to 278 kt N per year between 1990 and 2017 largely due to a decrease in emissions from industry, traffic, and agriculture (Tomlinson *et al.*, 2021). For agricultural land only, between 1990 and 2023, across the UK, atmospheric N deposition fell from 172 to 124 kt N per year (DEFRA, 2024). This has been accompanied by substantial reductions in SO_2 emissions (National Atmospheric Emissions Inventory, 2024). Some of the areas with the highest N deposition in later years are remote upland areas (Tomlinson *et al.*, 2021). This remains a concern as it can lead to nutrient enrichment and acidification of soils, influencing plant health and ecosystem dynamics (including carbon sequestration processes). Recent new Strategies, policies and interventions to reduce air pollution will have a knock-on effect for reducing deposition to land and soil in the future.

Land pollution affects soil in Wales by disrupting soil condition and introducing harmful substances, leading to usually negative ecological consequences. In Wales, the most common soil contaminants are benzo(a)pyrene, lead, and arsenic (NRW, 2016). Other sources include physical contaminants from fly tipping and microplastics. Reported fly tipping events have held steady since c. 2010, although there was a spike in agricultural fly tipping in 2019-20 and 2020-21 which may be due to COVID-19 pandemic (Welsh Government, 2023b, 2024a). Microplastics are commonly found in fertilizers and agricultural films (Cusworth et al., 2024). Other chemical pollutants include insecticides which negatively affect soil biodiversity. One example includes Sheep Dip, which contains the insecticide Diazinon. There are 997 groundwater activity permits in Wales for the disposal of waste sheep dip to land (NRW internal briefing paper).

Where soils contain higher than necessary nutrients, this can also be considered pollution, and there is a further risk to surface and groundwater quality especially in sensitive river catchments. Phosphorus has accumulated in soils due to historic overuse of fertilisers and manures, particularly in improved grassland and arable systems (Emmett *et al.*, 2025). Although soil phosphorous levels have declined over time and now remain stable across the UK, they often still exceed agronomic needs. Limited sub-national data makes it challenging to fully assess the scale and impact of this issue in Wales (Cordell *et al.*, 2022). The future outlook of **Land pollution** is mixed, with some pollutants decreasing in concern and others increasing. Climate change may result in increased mobilisation of contaminants from soils potentially affecting aquatic as well as terrestrial ecosystems.

Water pollution can affect soils by introducing substances (heavy metals, chemicals, excess nutrients, particles etc.) that interfere and disrupt natural soil processes, nutrient balances, pH, biodiversity and soil structure. Floodwaters are of particular concern as they contain chemical contaminants, biological contaminants, and sediment and debris. The lasting impacts of floodwater pollution can vary depending on the pollutant, some may bioaccumulate over time (NRW, no date). No evidence on water pollution affecting the quality of soils in Wales has been identified. However, flooding has seen an increase over time and increased mobilisation of contamination due to climate change will be exacerbated by increased surface water run-off associated with predicted increases in **changes in intensity and frequency of weather events**.

Land and Sea Use Change (from economic activity, see Aim 4 for more detail)

Pressures arising more directly from economic activity are also negatively affecting soils in Wales (See Aim 4 for more detail). These comprise:

- **Agricultural intensification**. Most soils in Wales are considered at low risk of degradation under current agricultural management, which is mainly permanent grassland. The primary threat to grassland soil is compaction from heavy machinery and poorly managed grazing livestock. For soils managed for arable cropping, the main threats are compaction, erosion, and loss of soil organic matter due to agricultural practices. (ADAS, 2019)
- **Built development and infrastructure** pressures associated with urban expansion, renewable energy and other infrastructure are affecting soils by changing land use. Land use change is one of the primary threats to soils through soil sealing, soil degradation, and loss of soils as a resource through waste disposal and pollution/contamination.
- **Afforestation in the past** has affected peatland soils in Wales, causing changes in soil chemistry, structure, nutrient cycling, microbial activity and carbon storage. This can increase risk of soil erosion and carbon emissions from peatlands and organo-mineral soils. Historical pressures are being addressed via peatland restoration and changes to forestry standards. No new woodland creation is permitted on deep peat (>50cm depth) and new woodland creation proposals should be well-designed to minimise soil impacts and ensure these pressures do not manifest in other places. Restocking continues the pressures on peat and will need to be well-planned to manage trade-offs
- **Drainage** of land so that soils can be exploited for various uses has impacted soil quality, particularly peat land soils. Some of the effects of this historic pressure are being addressed via peatland restoration.

Summary of the State of Soils

The evidence presented here provides a summary assessment of the state of soils in Wales. Key sources are provided; all additional data is presented in the SoNaRR 2025 evidence portal. Where no new data has been identified, data reported in SoNaRR2020 has been used. It is also recognised that there are evidence and data gaps for soils in Wales.

Most soils in Wales are considered at low risk of degradation through erosion and compaction, as the majority of Wales is under agricultural management for permanent grassland (ADAS, 2019). Recent national monitoring also found low levels of erosion and disturbance features, with only 4% of the surveyed area affected (Emmett *et al.*, 2025). Further information on likely soil erosion rates in Wales is provided in SoNaRR2020: Theme Land use and soils. ERAMMP national monitoring collected samples from across the survey area and found an increase in bulk density across the majority of habitats (7 out of 10 with data) between 2013-16 to 2021-23, however this is an initial indication with only two time points, a small sample size, and did not consider soil type (Emmett *et al.*, 2025).

There is a high proportion of carbon rich soils in Wales. Topsoil carbon is stable across Wales (2013 – 2023) (Emmett *et al.*, 2025). National Well-being Indicator 13 estimates from ERAMMP were 80.40g C/kg for 2021 to 2023 (Welsh Government, 2022b). However, there are gains and losses in different ecosystems, with areas used for Arable & and Horticulture Broadleaved, Mixed &Yew Woodland showing a loss of 8% and 13% in topsoil carbon concentrations respectively between 2013-16 and 2021-23 (Emmett *et al.*, 2025). This is a concern as Soil organic carbon (SOC) is used as a proxy indicator of overall soil quality associated with soil nutrient cycling, soil aggregate stability and soil structure, with direct implications for water infiltration, vulnerability to erosion and ultimately the productivity of vegetation, and in agricultural contexts, yields (Sims *et al.*, 2017).

Limited evidence exists on trends in soil biodiversity in Wales but changes are most likely related to land use change, loss of organic matter, extreme weather events, and land management and intensity (Welsh Government, 2022c). The most recent assessment of Welsh soil biodiversity (2013-2016) reported a decline in total topsoil mesofauna (invertebrates between 0.1 and 2 mm in size) abundance to similar levels to those in 1998 numbers across all land uses (George *et al.*, 2017). More information is provided in SoNaRR2020: Theme Land use and soils.

There has been an increase in excessive phosphorous levels in some soils. Farming Connect also reported from their 2023/24 samples that 28.3% of soil samples were above the optimum P-index (2) for grasslands, where 23.8% of soil samples were categorised within soil-index 3 (26-45 mg/ L dry soil) and 4.5% of soil samples were categorised as having a soil P-index equal to or greater than 4 (≥46 mg/ L dry soil) (Farming Connect, 2025). Soil exceeding leaching risk thresholds for phosphorus (>60mg P kg^{-1}) were seen in Arable and Horticulture soils, increasing from 4% of sites in 2013-16 to 16 % of sites in 2021-23. Soil exceeding the same leaching thresholds in Improved Grassland increased from 5% of sites in 2013-16 to 17% of sites in 2021-23 (Emmett *et al.*, 2025).

Progress to meeting Aim 1

The key opportunities taken up since SoNaRR2020 comprise:

- Welsh Government’s **Sustainable Farming Scheme** (SFS) has progressed and will start in 2026. It aims to support farmers in delivering sustainable land management, which includes the objective to maintain and enhance the resilience of ecosystems and the benefits they provide. The scheme is whole farm, with soil health at its foundation in the universal code and universal actions. For farmers who want to build on this, optional and collaborative actions will potentially support improved soil health and minimise the use of pesticides.
- Welsh Government’s National Peatland Action Programme (NPAP) which commenced in 2020 has progressed >3,600ha of peatland in Wales across the Welsh Government Woodland Estate and through 20 external partners. As part of the project an all-Wales strategic Partnership groups have been set up to address important sectoral issues such as strategy, evidence, monitoring and practitioner best practice.
- **Welsh Government’s Agricultural Soil Policy Statement** (ASPS) published in April 2025 sets out the vision for protection and sustainable management of soils and acknowledges the crucial functions and services soils provide (Welsh Government, 2025)
- The **British Society of Soil Science** issued industry guidance on Benefitting from Soil Management in Development and Construction (British Society of Soil Science, 2022)
- There is work ongoing to develop biodegradable alternatives to agricultural plastics as part of the Agri plastics Global Challenges Research Fund project. (Cusworth *et al.*, 2024)
- Welsh Government published A Low Carbon Wales (2019) which aims to reduce ammonia emissions through improving efficiency of livestock production, improving crop and nutrient management, and improving on farm fuel and energy efficiency

Opportunities for Action Aim 1

Every decision must recognize soil as a precious, finite resource—its value embedded at the heart of planning and action. The possible actions identified with respect to achieving Aim 1 and safeguarding and enhancing natural resources in Soils relate to Pollution management; Sustainable agriculture and forestry; Resource protection; Increase resource use efficiency; Waste prevention; Integrated plans, strategies and delivery and place-based approaches.

Action 1. Monitor and control pollution of soil, particularly from pesticides and fertilizers

Action 2. Adapt agricultural practices to take account of pressures from the changing climate, particularly to protect soils on arable land

Action 3. Plan for the future risk to soils from flooding and erosion

Action 4. Ensure effective identification and monitoring of contaminated land, while proactively addressing sources of known and emerging contaminants and pollutants across sectors and supply chains to support more sustainable soil management.

Aim 2: Ecosystems are Resilient to Expected and Unforeseen Change

Soil impacts on ecosystem resilience in the following ways:

- Soils play a pivotal role in major global biogeochemical cycles (carbon, nutrient, and water), while hosting the largest diversity of organisms on land (NRW, 2021a). As such, soil is a vital resource that sustains life and provides crucial ecosystem services to Wales (Welsh Government, 2022c). The condition and resilience of all terrestrial land-based ecosystems are directly dependent on the quality of soils
- Healthy soils reduce downstream impacts on waterbodies within Freshwater and marine ecosystems. Loss of soil through degradation and erosion is a concern for all ecosystems. A large volume of soil is lost through erosion each year leading to sedimentation of water courses as well as nutrient flushes.
- The effects of Climate change will increase mobilisation of nutrients and contaminated soils.
- Compaction, loss of carbon, and unbalanced nutrient levels are a concern for all managed ecosystems, particularly Enclosed Farmland. s. (Emmett *et al.*, 2025)
- Contaminated land has particularly affected urban ecosystems as centres of industrialisation and high demands for services (e.g., gas works) and waste disposal (NRW, 2016).
- Contaminated land can cause significant harm to ecosystems. Pollutants enter into controlled waters by migrating or leaching into groundwaters or surface waters (Welsh Government, 2013). This is a concern for freshwater ecosystems and the coastal margin and marine ecosystems they discharge to.

Progress to meeting Aim 2

The key opportunities taken up since SoNaRR 2020 comprise:

- Welsh Government's Sustainable Farming Scheme (SFS), which starts in 2026, aims to support farmers in the sustainable production of food whilst addressing both the climate and nature emergencies. It addresses the Sustainable Land Management objective in the Agriculture (Wales) Act 2023 to maintain and enhance ecosystem resilience. The scheme integrates relevant measures such as actions aimed at minimising the use of pesticides through Integrated Pest Management, improving habitat coverage and connectivity across farmland and improving Soil Health.

- Welsh Government published the Agricultural Soil Policy Statement (Welsh Government, 2025), which sets out the vision for protection and sustainable management of soils in Wales and includes three objectives:
    - Increase information on Welsh soils
    - Encourage sharing of information on soils
    - Protect, maintain and enhance soil functions & services
- The National Peatland Action Programme (NRW, 2020a) identified ultra modified peatlands as a priority action theme listing the following national actions:
- Assess the scale suitability and potential sites for restoration
    - Establish collaborative dialogue with private land managers
    - Establish field-scale trials (feasibility & viability) for wet agriculture and paludiculture techniques.
- The National Peatland Action Programme 2020-2025 (NRW, 2020a) has delivered:
    - Hydrological management over a footprint of 2110 ha
    - Erosion control over a footprint of 715 ha
    - Vegetation management over a footprint of 435 ha
    - Grazing management over a footprint of 638 ha
    - Tree removal over a footprint of 770ha

Opportunities for Action Aim 2

Every decision must recognize soil as a precious, finite resource—its value embedded at the heart of planning and action. The possible actions identified with respect to achieving Aim 2 and achieving resilient ecosystems mitigating the impact of soil natural resources on their condition and opportunities relate to Ecosystem protection; Ecosystem restoration; Nature based solutions; Sustainable agriculture and forestry.

Action 5. Maintain and improve soil structure and protect soils from erosion

Action 6. Adopt more sustainable and/or holistic land management practices

Action 7. Financial incentives to support farmers in maintaining low input arable systems

Action 8. Improve climate resilience within the farming environment

Aim 3: Healthy Places for people, protected from environmental risk

Soil impacts on the protection of human health in the following ways:

- Soils are a significant store of carbon sustainable management can increase soil carbon storage and mitigate climate change impacts on people. Welsh soils are estimated to contain 410 million tonnes of carbon (UKNEA, 2011; NRW, 2016). However, unsustainable management of soils can lead to this carbon be emitted, rather than sequestered and stored. The ONS estimate that emissions from peatlands were approximately 280,000 CO_2 teq in 2022 (Office for National Statistics, 2024).

- Contaminated land can cause significant harm to human health as people can be exposed to toxic and carcinogenic contaminants via a range of potential exposure pathways (e.g., direct contact, ingestion or inhalation) (Welsh Government, 2013). 9,330 potential contaminated land sites are yet to undergo detailed inspection, and of these at least 414 sites are considered to be high priority. There are also anticipated to be many more sites affected by contamination that will need to be remediated via the planning systems (NRW, 2016). As well as human health risks, remediating these sites also has economic implications due to higher development and assessment costs.
- Healthy soils produce healthy food and fibre for people and support nature.
- Soils store and filter water, potentially helping to reduce flood and drought risks (NRW, 2021a). (Office for National Statistics, 2019)Peatlands in good condition help store carbon, regulate flood risks by reducing rapid flushes of water, and have a reduced fire risk ensuring resilience for the provision of clean drinking water. Restoration efforts under the National Peatland Action Programme have improved hydrology and reduced fire and flood risks.

Progress to meeting Aim 3

- The key opportunities taken up since SoNaRR 2020 comprise:
- The National Peatland Action Programme 2020-2025 (NRW, 2020a) has delivered Hydrological management over a footprint of 2110 ha. As a nature-based solution some key benefits identified through NPAP's restoration objectives were tackling the Climate and Nature emergencies as well as mitigating against flood and fire risks.
- The Water Resources (Control of Agricultural Pollution) (Wales) Regulations 2021 came into effect in April 2021; this is regulatory measures to help address agricultural pollution specifically regarding nutrients lost to controlled waters. The regulations have requirements for: storing silage; risk mapping and nutrient management planning; holding nitrogen limit of 170kg N, and closed spreading periods (Welsh Government, 2023a).
- Version 5 of the UK Forestry Standard was adopted October 2024. It includes soil management measures which should reduce negative impacts on soils and from soils downstream (Forestry Commission, 2023).
- Local Authorities have continued to progress their contaminated land inspection strategies (and NRW has provided support/comments where requested). However, without central funding progress via Part 2A EPA 1990 (the contaminated land regime) has been funded by local authority internal budgets and the number of sites investigated has been low. Outside of the planning and contaminated land regimes, sites have also been assessed/remediated via voluntary action. NRW provided input where requested via our discretionary planning advice service to developers.

- Historic **soil pollution** (contaminated land) is largely being addressed via the planning process. It is estimated the construction sector can address 93% of contaminated sites in Wales, (NRW, 2016). However, there still remains a substantial number of high priority sites in Wales requiring detailed inspection and potential remediation. This could be achieved via redevelopment where appropriate.

Opportunities for Action Aim 3

Every decision must recognize soil as a precious, finite resource—its value embedded at the heart of planning and action. The possible actions identified with respect to achieving Aim 3 – Healthy places for people, protected from environmental risk relate to Nature based solutions; Research and technology; Integrated plans, strategies and delivery; Pollution management; Place based approaches.

Action 9. Adapt land management practices to take account of pressures from the changing climate, particularly to protect soils and increase carbon sequestration.

Action 10. Collaborate with stakeholders on Enclosed Farmland plans and programmes.

Action 11. Improve information on contaminated soils

Action 12. Mitigate risks to people and nature from contaminated soils

Aim 4: Contributing to a Regenerative Economy, Achieving Sustainable Levels of Production and Consumption

Soil impacts economic well-being in the following ways:

- Soil is a key natural resource for food and fibre production, providing nutrients, water, and physical and biological support for plants, which is critical to agricultural productivity (NRW, 2021a). Land used for agricultural production generally comprises of Enclosed farmland, Semi-natural grassland, Coastal margins and Mountain, moor and heath ecosystems. Fibre production is mainly associated with the Woodlands ecosystem.
- In 2024, Wales land supported stocking of 8.7 million sheep and lambs in Wales (similar to the 2023 but the lowest level since 2011). In 2024 there were 1.09 million cattle and calves in Wales, a small fall from 1.12 million in 2023. Overall, 53,000 hectares of cereals were grown in Wales in 2024 – up 4% from 2023 but lower than the 2022 figure which was a peak figure in recent years (this accounts for less than 3% of all agricultural land in Wales). The number of people employed on farms on 1 June 2024 was 12,200 (Welsh Government, 2024c). Agriculture (and hunting) are estimated to have contributed approximately £1.1 billion to the Welsh economy in 2022 (Welsh Government, 2022a).

- Soil in poor condition has a direct impact on the productivity of the land where the poor-condition soil is located, resulting in reduced crop, forage and fibre yields, reduced establishment and success or increased vulnerability during extreme weather events. Soil loss and erosion also impacts on land productivity over time, stripping valuable topsoil off the land containing organic material and nutrients, this also has knock on effects for biodiversity more widely. Climate change poses threats of more extreme weather increasing short term intense weather events, including rainfall which may exacerbate soil erosion.
- Soil stores and filters water, providing a source for water supply and contributing to flood prevention (NRW, 2021a). Peat, in particular, is dominant in the higher grounds and is identified as intercepting a significant proportion of the UK's water supply. The ONS (2019) experimental peatland accounts identify that peatlands supply over a quarter of the UK's drinking water (Office for National Statistics, 2019). Water from functioning peatlands is naturally high quality, increasing the value of its water for economic uses such as drinking or agricultural water supply (Office for National Statistics, 2019).

Economic drivers and their pressures on soils

The key direct economic drivers within Wales that contribute to the degradation of soils relate to **Land and sea use and management change** and **Direct exploitation**. Climate change pressures are considered to be driven by global economic activity.

Land and sea use and management change

The effects of **agricultural intensification** on soils can be immediate (e.g. soil structural damage from trafficking in too wet soil conditions) or can take longer to appear (e.g. continuous overapplication of nutrients, changes in agricultural management).

Over the long term (1970 – 2020) there has been a shift towards livestock farming, resulting in a 75% decline in cultivated land (1930s–1990s) and increased improved grassland. By 2021, arable and horticultural land covered only 4% of Wales, a 24% decrease since 2010 (Emmett *et al.*, 2025).

Land managed under permanent grassland is considered at a lower risk to degradation. The primary threat to grassland soil is compaction from heavy machinery and poorly managed grazing livestock.

The main threats to soil managed for arable cropping, are compaction, erosion, and loss of soil organic matter due to agricultural practices (ADAS, 2019). There has been a recent increase in maize and oil seed rape (OSR) grown on agricultural land. Both crops can degrade soil structure with shallow roots. Their lack of ground cover can increase the risk of soil erosion from wind and rain. (Jaafar and Walling, 2010; Vogel, Deumlich and Kaupenjohann, 2016; Smith and Boardman, 2025)

Historically (1990 – 2023) phosphate levels remain high in intensively managed grasslands due to the impact of site-specific pathways and management intensity on phosphate distribution. National assessments of soil phosphorus concentration is similar across all land uses and has shown historical declines, although now stable on improved land. However, only 9% of soil samples collected from over 200,000 across the UK were at recommended target levels for both potassium and phosphorus, demonstrating how common under and over application of nutrients is (Welsh Government, 2022c)**.**

The Sustainable Farming Scheme (SFS) may have a positive impact on reducing the effects of agricultural intensification on Welsh soils as farmers will be paid for providing environmental benefit (Welsh Government, 2024b).

Historically **built development and infrastructure** has been associated with a loss of enclosed farmland ecosystem extent (see farmland ecosystem DPSIR) and agricultural land more generally., particularly due to urban expansion. This development on soil can lead to irreversible changes, sealing the surface, affecting structure and causing soil waste. Urban Expansion leads to the loss of high-grade soils and was a main source of Greenhouse Gas emissions in the Land Use, Land Use Change and Forestry sector in 2018 (21%). The development of large scale renewable energy infrastructure is also associated with soil sealing and damage to soil structure. Increased protection in Planning Policy Wales Section 6 and the publication of the guidance note for developments on peat (NRW, 2025) will provide additional clarity and protection for the soil and carbon resource in Wales.

Historically **afforestation** has affected soils in Wales (1988 - 2020). An estimated 18,092ha of woodlands and forests are thought to remain of those historically established on peat soils (NRW, 2020b), changing the soil chemistry, structure, nutrient cycling, microbial activity and carbon storage. National Peatland Action Plan restoration figures show a total restoration area of over 3,000 hectares, including previously afforested peatland. (Forestry Commission, 2023; NRW, 2024)

Direct exploitation

Historically water abstraction and demand has changed soils by adding drainage to create more suitable conditions for agriculture and forestry, or simply by accessing water contained within the soil for growth. The demand for drainage in winter months and water in summer months will be exacerbated by climate change.

The spatial variation of the water storage capacity of soils varies across Wales. Areas with <125mm water storage capacity are generally located in coastal areas in mid and south Wales, and in the Bannau Brycheiniog National Park area. These areas are also where larger populations and arable agriculture is located, which may increase pressures on water during drier months, or have an increased flood risk during wet weather events.

Historically drainage of soils for different land uses has affected soil quality in Wales (1900 to 2020). Post World War II saw a major agricultural expansion and during 1971-1980 10% of farmland in the UK was drained, and there has not been significant drainage instillation since. It is estimated that 80% of peatlands is in a “damaged and deteriorating state” due to drainage of soils for various uses (NRW, 2020a). More recently, the National Peatland Action Plan has restored 3,600 hectares of peat soils (2020 to 2025). The future outlook is for these improving trends to continue as the action plan aims to restore 1800 hectares of peatland per year by 2031. Addressing peatland drainage is one of six priority themes for the plan. There is currently no extraction of peat in Wales for horticultural purposes (NRW, 2021b).

Contributions of soils to sustainable economic production and consumption

Sustainable management of soils across all ecosystems will help maintain and enhance soils. When undertaken during more productive activities, such as forestry and agriculture operations, this can contribute to more sustainable production in both sectors. (NRW, 2016)

Soils contribute to sustainable fibre production (see SoNaRR 2025 Woodland assessment).

Progress towards meeting Aim 4

The key opportunities taken up since SoNaRR 2020 comprise:

- While past schemes like Glastir had few positive outcomes for soils, new approaches aim to better integrate soil health into economic planning. Woodland Management (primarily through reduced stocking density) led to improvements in topsoil carbon concentration and bulk density within Semi-Improved Grassland. Where Glastir had a significant effect on soil health indicators this was not reflected in the national trend, likely due to low rates of uptake. (Emmett *et al.*, 2025)
- The Agricultural Soil Policy Statement (published April 2025) raises awareness of soils in the policy landscape and sets out the vision for the sustainable use and management of agricultural soils for future generations (Welsh Government, 2025).

Opportunities for Action Aim 4

Every decision must recognize soil as a precious, finite resource—its value embedded at the heart of planning and action. The possible actions identified with respect to achieving Aim 4, A regenerative economy, relate to Nature based solutions; Payment for ecosystem services; Sustainable agriculture and forestry; Pollution Management; Sustainable construction; Renewable energy.

Action 13. Adapt agricultural practices to take account of pressures from the changing climate, particularly to protect soils on arable land

Action 14. Plan for the future risk to soils from flooding and erosion

Action 15. Protect vulnerable soil from built development

Action 16. Continue to restore peatland from past exploitation

Evidence Needs

Evidence gaps remain in understanding Welsh soils at local, regional and national scales. Comprehensive baseline data across land uses and soil types is required. Particularly emphasis on stability, erosion, compaction rates, carbon stocks and sequestration potential and their variability under extreme weather. Soil biodiversity is poorly understood, with limited national data and uncertainty around the impacts of pesticides and veterinary medicines. Evidence on the extent of soil loss through sealing and land take from development, and the interaction of climate change and land use, as well as long-term effects of forestry and afforestation on organo-mineral soils and greenhouse gas balances are insufficient. These gaps limit our ability inform resilient land management.

Further evidence is also needed to improved understanding of nutrient dynamics, especially phosphorus and micronutrients in a Welsh context. Research is required on existing and emerging threats to soil. These threats include the fate, transport and ecological risks of pollutants, as well as contaminated floodwaters and pathways. Predictive modelling of soil responses to combined pressures like drought and flooding, and socio-economic links between soil condition, productivity, and water quality, are also required.

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Water

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Water is essential to the environment and people. It creates and sustains the ecosystems upon which all life depends, while also providing water for us to drink, run industries, grow food and generate power.

This water assessment is one of three natural resource and eight ecosystem assessments that inform the overall SoNaRR2025 report. It draws together up to date evidence from national datasets, such as those compiled for Water Framework Directive Regulations, data from Flood Risk Assessment Wales, as well as other published data analysis for Wales. This assessment is closely linked to the freshwater and marine assessments.

This assessment is structured around four interlinked aims that guide Wales' progress toward the sustainable management of natural resources (SMNR), helping to communicate the relationship between the environment, well-being, and the economy.

Key messages

1. 40% of our water bodies achieve good Water Framework Directive Regulations Status. Significant pressures include physical modifications; pollution from wastewater, towns, cities and transport, agriculture and abandoned mines; and changes to the natural flow and levels of water.
2. The industrial past, including discharges from abandoned mines, has resulted in an ongoing ecological impact from persistent chemicals and metals. Emerging threats from novel pesticides, consumer goods and pharmaceuticals also present a risk to ecosystems and people.
3. Zones covering 70% of Wales' population could be in water deficit by 2050, unless leakage control and water efficiency measures are implemented. People using private water supplies will become increasingly vulnerable during prolonged dry periods due to climate change.
4. Risk of flooding is likely to increase due to climate change and population growth, with almost 353,000 properties predicted to be at risk of flooding by 2120. We need to improve delivery of adaptation, mitigation and resilience measures, and to develop catchment-wide water management using nature-based solutions.
5. Sea levels are expected to rise in Wales by up to 1 metre by 2100, alongside more frequent and severe storms and wave action. This will increase the risk of coastal

flooding, coastal erosion and damage to coastal infrastructure, as well as land loss and saltwater intrusion onto agricultural land.

Summary of assessment against the SMNR aims

Aim 1: Stocks of natural resources are safeguarded and enhanced

Water in Wales face pressures from climate change, pollution, land use changes. Climate projections indicate reduced summer rainfall and increased winter rainfall, leading to more frequent prolonged dry periods and droughts and flooding, respectively. These changes can affect water availability and quality, with warmer temperatures increasing the risk of algal blooms and pollutant toxicity. Only 40% of water bodies achieved good or high status in 2024, with rural pollution, urban areas, and wastewater being major contributors to poor water quality. Chemicals including combustion by-products, pesticides, insecticides, persistent chemicals, and microplastics are present in the waters of Wales. Heavy metals continue to impact water bodies, with legacy metal mine discharges affecting around 700 km of rivers. Groundwater quantity is stable, but quality remains moderate.

Efforts to enhance water quality include statutory Drainage and Wastewater Management Plans, the Wales Metal Mines Programme, and Sustainable Drainage Systems (SuDS) for new developments. Investment through water company National Environment Programmes supports nutrient reduction, storm overflow mitigation, and wastewater treatment upgrades. Current regulation strives to prevent pressures from licensed water abstraction. Water efficiency initiatives, such as the UK labelling scheme for water appliances and behavioural campaigns, aim to reduce demand.

Aim 2: Ecosystems are Resilient to Expected and Unforeseen Change

Freshwater, marine and groundwater dependent terrestrial ecosystems are dependent on sufficient water and vulnerable to changes in water quantity and quality. Sea level rise will result in coastal areas becoming increasingly vulnerable to flooding and increased risks of groundwater saline intrusion, these will impact on humans, infrastructure and wildlife habitats. Pollution from nutrients, metals, and emerging contaminants like microplastics and antimicrobial resistant genes further degrade ecosystem health. Physical modifications, such as essential impoundments for drinking water, hydropower and flood protection, disrupt natural flow regimes and habitat connectivity.

To build resilience, actions include restoring ecosystem connectivity, protecting groundwater-dependent ecosystems, and managing pollution. Nature-based solutions such as hedge and tree planting and other attenuation measures are promoted to mitigate downstream flooding and provide benefits to biodiversity supported by sustainable drainage systems (SuDS). Programmes like the Wales Metal Mines initiative and statutory wastewater plans contribute to ecosystem protection. Investment in peatland restoration supports resilience to climate change through carbon sequestration, whilst reduction in water supply leakage reduces water loss and therefore pressure on water supply stocks These initiatives aim to reduce pressures and enhance the capacity of ecosystems to adapt to changing conditions.

Aim 3: Healthy Places for people, protected from environmental risk

Water plays a vital role in public health through supply for drinking, maintenance of hygiene standards and agriculture. Most abstractions are for public supply, in addition to this there are around 56,000 small private supplies which do not require a licence and are vulnerable to prolonged dry weather periods. Water also supports recreation and wellbeing. In 2023, 45% of surveyed adults had visited inland waters, with swimming being the most popular activity. Although 98% of bathing waters meet regulatory standards, concerns about water quality deter participation.

Flooding poses significant risks, with 275,000 properties currently at risk, projected to rise to 353,000 by 2120. Flooding impacts physical safety and mental health, especially in deprived communities less able to afford protection measures. Programmes like the Natural Flood Management Accelerator and flood alleviation schemes integrate environmental enhancements to benefit communities. Awareness campaigns and statutory planning frameworks aim to safeguard water supplies and promote equitable access and resilience.

Aim 4: Contributing to a Regenerative Economy, Achieving Sustainable Levels of Production and Consumption

Water underpins economic activity across sectors, with 11.9 million megalitres licensed for abstraction in 2024. Agriculture and urban development continue to exert pressure on water quality. Three Water Resource Zones are currently projected to face supply deficits by 2050; this shortfall will be addressed through both leakage and demand reduction. Efforts to reduce water usage include behavioural campaigns and efficiency targets.

The economic impacts from flooding can be substantial, including damage to vehicles, buildings, and infrastructure. Flood risk mitigation activities, including nature based solutions help reduce these economic losses. Nature based solutions offer cost effective ways for sustainably managing water across catchments. They improve water quality alongside reducing flood risk and water treatments costs. These actions aim to align water management with circular economy principles and climate goals.

Key changes since SoNaRR2020

In SoNaRR 2020, evidence relating to water was not all one place. SoNaRR 2025 brings the Water evidence and assessment together.

Although Wales has experienced numerous storms, devastating floods and drought conditions impacting the communities and ecosystems of Wales the data has not shown significant changes in this period. Programmes such as those related to metal mines and SAC Rivers, and the Teifi Demonstrator Project aim to improve the quality of Wales' waters.

Due to become law in 2026, the UK Government and devolved nations have agreed to implement mandatory water labelling on all water using appliances. The Independent Water Commission made recommendations in relation to the strategic direction for water legislation, regulation and planning, including plans to reduce demand by increased water metering. The Welsh Government has provided funding to increase the delivery of natural flood management, supporting the wider activities undertaken by flood risk management authorities to reduce risk of flooding to communities of Wales and enhance nature.

Water Full assessment of SMNR

Aim 1: Stocks of natural resources are safeguarded and enhanced

Assessment of safeguarding water

The evidence describing the key pressures on water in Wales is associated with climate change; direct exploitation; land and sea use and management change; and pollution. The effects of climate change and pollution are used to assess the stocks of natural resources in Aim 1. Direct exploitation and land and sea use and management change also affect stocks of natural resources, but the pressures are more directly related to Wales' economic activity and are considered in detail in the assessment of Aim 4.

Climate change

Historically, **changes in intensity and frequency of weather events** has impacted on water quality and availability (1960 to 2022). The future outlook is that this will continue. In Wales, summer rainfall is projected to decrease by 15% by the 2050s (18%-26% from 2080). Winter rainfall is projected to increase by 5% by the 2050s (7% to 13% by the 2080s) (Climate Change Committee, 2021). Groundwater levels are also becoming more variable (British Geological Survey, 2012), characterised by similar patterns of increased recharge in winter and decreased recharge in summer (Hughes *et al.*, 2021).

The most recent decade has had around 20% more days of exceptional rainfall compared to the 1961-1990 averaging period. This can cause widespread flooding and contamination of water from runoff, re-mobilisation of legacy pollutants and increased stormwater discharges (Climate Change Committee, 2021; Sheahan, 2021; Nijhawan and Howard, 2022; Bolan *et al.*, 2024). 2020 saw an exceptionally wet winter leading to the most severe and widespread flooding incidents seen in Wales since 1979 .

During low flows there may be less dilution of pollutants, for example there could be less dilution of sewage effluent in watercourses. (Climate Change Committee, 2021; Sheahan, 2021). The most recent notable droughts being in 2022 and 2025 (NRW, 2025h).

Warmer water temperatures could increase the risk of algal blooms, this may clog filters at water treatment works and as well as causing unfavourable tastes and odours in drinking water treatment (Perkins *et al.*, 2019).

There is likely to be an increase in frequency of prolonged dry periods increasing vulnerability of private water abstractors and reducing resilience of the aquatic environment.

Pollution

Historically there is a mixed picture for **water pollution** affecting water in Wales. The future outlook is for this to continue. Under the Water Framework Directive Regulations (WFDR) (2017) water bodies are classified according to quality and quantity elements. Only 40% of water bodies (including rivers, lakes, canals, coastal waters, estuaries and ground waters) in Wales achieved the target of good or high status in the 2024 interim assessment. Of those that did not achieve good status, pollution from rural areas was the main reason for 21% waterbodies in Wales not achieving good status under the WFD Regulations. A further 10% of waterbodies in Wales are not achieving good status under the WFD Regulations, due to the run-off from land used for urban and transport purposes. Another 17 % of waterbodies in Wales are not achieving good status due to the impacts of wastewater (NRW, 2025b).

The Nutrient Review (2024a) highlights that phosphate pressures are more widespread than nitrate pressures, and provides no evidence to suggest reduction in nutrient pressures where they are currently observed by 2031 (NRW and ARUP, 2023). Source apportionment modelling identifies rural land use (including agriculture and forestry) (7 out of 10 catchments) and wastewater treatment (3 out of 10) the main sources of phosphorus pollution in SAC river catchments, data derived from (Dŵr Cymru Welsh Water, 2023b) .

Despite long-term restrictions in the production and use of PBDEs, a class of fire retardants, and PCBs, a group of persistent organic pollutants, the majority (99%) of time series data from the Irish Sea and Celtic Regions show no downward trend between 2014 and 2019, highlighting the persistent nature of these pollutants (Marine Scotland, 2022). Microplastics are widespread in the Welsh environment (Windsor *et al.*, 2019). Chemicals that may have an increasing impact on water include pyrene (a PAH), bisphenol A (a plasticiser) and insecticides commonly used in flea treatments. The long-term outlook for antimicrobial resistance is unclear: as reductions in veterinary use of antibiotics may be offset by increased use for human health.

Heavy metal emissions from industrial and domestic sources have reduced considerably after their peak in the 1970s and 1980s. However, historic metal mine discharges still affect 700km rivers in Wales, with 41 river water bodies, 2 lakes and 5 transitional waters failing to meet Environmental Quality Standards for metals (notably zinc, cadmium and lead) (NRW, 2025e).

UV disinfection at wastewater treatments help to reduce bacterial levels, especially at bathing waters. The percentage of bathing waters classified as excellent has increased from 65% in 2004 to 70% in 2025 (Welsh Government, 2025a). However, diffuse water pollution from land management and spills from storm overflows remain a challenge at some bathing waters. There are concerns increased precipitation associated with climate change may result in increased bacterial levels in waters

Pressures from economic activity (see Aim 4 for more detail)

Pressures arising more directly from economic activity are also negatively affecting Wales' water resource (see Aim 4 for more details). These pressures are (in alphabetical order): agricultural intensification, built development and infrastructure, and water abstraction.

> Agriculture is a sub sector of the economy in rural areas. **Agricultural intensification** pressures are identified as economic activities affecting the quality of water.
>
> **Built development and infrastructure** pressures associated with construction in urban areas, transport and wastewater treatment are identified as economic activities affecting the quality of water.
>
> **Water abstraction** by the water sector to meet increasing demand is identified as a future concern for supply from 3 Water Resource Zones in Wales unless demand is reduced. Reduction of water demand will be managed through reduction in leakage and an increase in water efficiency measures across all sectors

Assessment of enhancing water

The overall status of river water is assessed as medium, reflecting 42.7% of river waterbodies achieved good WFD regulations (WFDR) status in 2024 (NRW, 2025i). Monitoring of Special Areas of Conservation in rivers has identified widespread breaches associated with elevated levels of phosphorous with 50% waterbodies passing targets (NRW, 2025a). The long-term trend for orthophosphate is improving, with reductions of 81% observed between 1990 (0.15 mg/l)) and 2023 (0.03 mg/l) (Lowe and Gislam, 2024). The Enhanced Future Flows and Groundwater (eFLaG) project estimates that river flows in Wales will further reduce by between 10% and 40% in the near future (2020 – 2049) (Hannaford *et al.*, 2022). Threats to water quantity and supply are associated with reduced water availability in summer months, with 3 out of 27 Water Resource Zones in Wales anticipated to go into deficit by 2050 (Dŵr Cymru Welsh Water, 2024).

Lakes and reservoirs are assessed as low WFDR status, with 0.9% of these waterbodies achieving high status and 23.7% of waterbodies achieving good status in 2024 (NRW, 2025i). Canals are assessed as medium status, 62.5% of these waterbodies achieved good status in 2024(NRW, 2025i). Coastal waters are assessed as medium status, 4.3% of coastal waterbodies achieved high status and 26.1% of coastal waterbodies achieved good status in 2024 (NRW, 2025i). Transitional waters are assessed as low status, 15.6% of these waterbodies achieved good status in 2024 (NRW, 2025i).

The quantity of groundwater is not considered to be an overall concern, with 100% of groundwater bodies achieving good quantitative status in 2024. However, groundwater levels are becoming more variable, suggesting there is a changing resilience in resource. Overall groundwater is medium, reflecting approximately 55% of groundwater bodies in Wales are of good WFDR status in 2024 (NRW, 2025i).

Metals are the most common substances detected in groundwater above drinking water standards, with chlorinated volatile organic compounds, nitrate, sodium and pesticides are also identified above drinking water quality standards (NRW, 2024c).

Progress to meeting Aim 1 (Stocks of natural resources are safeguarded and enhanced)

The key opportunities taken up since SoNaRR2020 comprise:

- Water efficiency labelling scheme to be put in place by 2026 (DEFRA, 2022). Water efficiency labelling of water using appliances is one of the objectives of the UK Water Efficiency Strategy to 2030 (Waterwise, 2022).
- The Ofwat Water Efficiency Fund, launched in 2025, has set aside £100m over 5 years. £75m to promote England and Wales wide behavioural change campaigns to reduce water use and £25m for research into technology to manage water more efficiently (Ofwat, 2025) .
- There are plans underway to introduce mandatory water efficiency labelling of goods and appliances (DEFRA, 2023).
- Water companies in Wales offer water meters for existing customers, they are fitted to new and redeveloped properties. Dŵr Cymru offers customers water audits for domestic customers, free repairs for leaky loos and free water efficiency products. Hafren Dyfrdwy offer subsidised rainwater butts and advice on how to reduce water use in the home.
- Introduction of the Water Resource (Control of Agricultural Pollution) (Wales) Regulations in 2021.
- Dŵr Cymru's business plan (2020 – 2025) included £218M investigate target investment to reduce the impacts of high spilling CSOs, UK Chemicals Investigation Programme third phase (UKCIP3), and further investment at wastewater treatment works to meet Urban Waste Water Treatment (England and Wales) Regulations 1994 requirements. Ofwat have approved £1.7bn expenditure for the National Environment Programme (NEP) in Wales and includes £192m reducing nutrient pollution, £1.1billion towards reducing harm from storm overflows, £88m on expanding wastewater treatment works and £14m on restoring peatlands, as well as a 23% reduction in leakage (Ofwat, 2024).
- There is significant ongoing policy work by NRW in conjunction with Welsh Government and the other UK Administrations to reduce levels of chemicals released to the water environment. This includes increased monitoring along with restrictions in use and disposal methods.

- Drainage and Wastewater Management Plans (DWMPs) became statutory requirements in 2024. These plans represent long-term, strategic frameworks developed by water companies to address the complex challenges surrounding drainage, flooding, and wastewater management.
- River Basin Management Plans and associated programmes of measures were updated, and published in 2021 (Environment Agency, 2022; NRW, 2022a, 2022b)
- The **SAC Rivers Project** focusses on planning advice and guidance, water quality targets, regulation, compliance assessments and improvements and materials to land (NRW, 2023a). **Opportunity Catchments** focus on addressing Water Framework Directive Regulations objectives in freshwater and marine water bodies along with wider SMNR and well-being outcomes. NRW is taking an integrated approach via our **River Restoration Programme** to bring together a range of protective and proactive work on rivers including water quality interventions. The **Teifi Demonstrator project** will involve partners, land and water management sectors and others, to showcase collaborative approaches to water quality improvements and building riverine habitat resilience through sustainable land and water management (NRW, 2023c).
- The Wales Metal Mines programme has been in place since 2020, funded by Welsh Government. Over 50 sites have been subject to investigation; and design of remedial measures to reduce the pollution arising from them is ongoing. The Wales Metal Mines Programme is working to make significant reduction in discharges of metals from abandoned metal mines over the next two decades (NRW, 2025e).
- The Catchment Systems Thinking Cooperative – CaSTCo aims to include communities in the collection and sharing of data to improve understanding and develop the management of rivers and their catchments. One of the trial catchments is the River Usk (CaSTCo, no date).
- The Independent Water Commission review of the water sector in England and Wales published its findings in July 2025. The report provided recommendations in relation to strategic direction for the water industry, water company planning, legislative framework and targets, regulator and regulatory reform. This may result in changes to water environment planning, monitoring and reporting in the future (Independent Water Commission, 2025).

Opportunities for Action Aim 1

The possible actions identified with respect to achieving Aim 1 relate to Awareness raising, Increase resource use efficiency, Pollution management, Sustainable agriculture, forestry and fisheries, Sustainable manufacturing and Waste prevention.

Action 1. Adapt water distribution and associated demand levels to better mitigate variation in high and low flows associated with predicted climate change impacts.

Action 2. Protect water from nutrient pollution from rural areas, urban areas, transport and wastewater treatment.

Action 3. Protect water resources from metals and chemical pollution.

Aim 2: Ecosystems are Resilient to Expected and Unforeseen Change

The condition of all surface and groundwater dependent ecosystems are directly dependent on the quality and quantity of water. Groundwater-dependent terrestrial ecosystems (GWDTE) occur in Freshwater; Mountains Moorlands and Heath (peat bog, wet heath, wet grassland); Coastal (dune slacks); Woodland (some wet woodlands) and Enclosed Farmland ecosystems. Increased variability in groundwater level from climate change pressure will result in lower baseflow to rivers, lakes and wetlands during dry periods. The increased risk of saline intrusion via groundwater could lead to significant damage to sensitive habitats within GWDTE's. Pollution of water resources in terms of elevated nutrients, metals, chemicals, emerging contaminants of concern, microplastics and anti-microbial resistance genes can directly impact on freshwater and marine ecosystem condition where it occurs.

In Wales, 115 water bodies are designated as artificial or heavily modified to reflect their substantial physical modification for the purpose of providing drinking water supply and water regulation (NRW, 2025i). Impoundments to secure drinking water supplies impact on freshwater ecosystems by limiting water flows, create barriers to species movement and restrict the transfer of sediments, nutrients and other materials. There are 65 water bodies which are designated as heavily modified to reflect the substantial modification required for flood protection (NRW, 2025i), essential structures that protect property prevent the inundation of adjacent riparian and floodplain areas. This has impacts on species and habitats which depend on the inundation provided by this lateral connectivity.

Progress to meeting Aim 2

Safeguarding natural resources is essential for supporting resilient ecosystems. All progress towards meeting Aim 1 is considered relevant to supporting Aim 2 progress.

Opportunities for Action Aim 2

The possible actions identified with respect to achieving Aim 2 relate to Ecosystem restoration, Nature Based Solutions, Pollution management, and Sustainable agriculture, forestry and fisheries.

Action 4. Protect Groundwater Dependent Ecosystems from drying out.

Action 5. Protect Groundwater Dependent Ecosystems from contaminated groundwater.

Action 6. Protect Freshwater and Marine Ecosystems from water pollution.

Action 7. Restore Freshwater Ecosystems and their connectivity by removing or mitigating barriers, modifications and associated infrastructure for water supply and regulation.

Action 8. Work with Natural Processes to improve ecosystem resilience for agricultural ecosystems where there is a flooding issue.

Action 9. Work with Natural Processes to improve ecosystem resilience for urban ecosystems where there is a flooding issue.

Aim 3: Healthy Places for people, protected from environmental risk

Water impacts on the protection of human health

Water we use

In Wales 1,500,000 Ml per year is licenced for abstraction for water supply by NRW to meet domestic and business needs for drinking, cooking, hygiene, industrial, manufacturing and agricultural use. Of this, 96% is for Public Water Supply by water companies and water undertakers, the remaining 4% is private water abstraction (NRW, 2025g). Drinking water must be wholesome, meaning that it is free from harmful chemicals and bacteria with a pleasant taste (Dŵr Cymru Welsh Water, no date)

Modelling for the 'Reducing Uncertainty in Private Water Supply Demands in Wales report 2021' suggests there may be an additional 42,000 private water supplies which are unlicensed because they are below the 20m3/day threshold and are not registered with the drinking water inspectorate. These small abstractions are likely to be particularly vulnerable to prolonged dry periods (Welsh Government, 2021). Water companies in Wales have pledged to support these non-customers during these periods (Dŵr Cymru Welsh Water, 2024; Hafren Dyfrdwy, 2024).

Flooding

There are approximately 275,000 properties at flood risk in Wales. The numbers of properties at risk in Wales may increase to 353,000 by 2120 due to climate change. This is an increase of approximately 78,000 (28%) properties (NRW, 2025c). Flooding poses a risk to life and can have a severe impact on the short and long term mental health of those affected, as well as impacting on the cohesiveness of their immediate and wider communities as they work to recover.

Whilst flooding presents acute risks to people and their properties, Public Health Wales also identify that flooding is also related to increased mental health risks (Public Health Wales, 2024). The impact of flooding on mental well-being can persist well after the physical flooding event has passed. This impact on mental well-being may also extend to those in areas at risk of flooding.

Water impacts on the improvement of human health

Recreation

Outdoor swimmers in Wales reported that they swam for their mental health, fun or exercise (McAllister, 2023; Palma and Marks, 2023). In 2023 Welsh Government undertook a representative sample of 1000 adults in Wales (McAllister, 2023), 45 per cent of respondents to the survey had visited inland waters in the last few years for recreation, with swimming being the most popular activity. 98% of Wales' 112 bathing waters (109 coastal and 3 Inland waters) met the sufficient standard of the bathing waters regulations in 2025 (Welsh Government, 2025a). In a Welsh Government survey, 84 % cited water quality as a factor that put them off from open water swimming (Palma and Marks, 2023).

Equitable access to water resources

People living in properties with private water supplies are likely to be more at risk of reduced water availability. The majority (94%) of registered private water supplies in Wales are dependent on groundwater, which are likely to become increasingly vulnerable due to prolonged dry periods due to climate change. These are mostly located in rural parts of Wales such as Mid, West and North Wales. (Farr et al., 2022)

Flooding disproportionately impacts households in deprived communities (Welsh Government, 2019). - Risk of flooding is one of the 'Physical Environment' domain indicators. Lower income households are less likely to be able to afford insurance and flood protection adaptations.

Progress to meeting Aim 3 (Healthy Places for people, protected from environmental risk)

The key opportunities taken up since SoNaRR 2020 comprise:

- Welsh Government funding for flood and coastal erosion risk management has enabled the delivery of a number of major schemes including alleviation works at Crindau (Newport), East Rhyl, Central Rhyl, Prestatyn, Llyn Tegid, and Ammanford. Enhancements, such as habitat creation, tree planting, community seating and interpretation areas have been incorporated within scheme designs to deliver environmental benefits and enhance the health and wellbeing of local communities (NRW, 2023b, 2025d).
- The Welsh Government NFM Accelerator programme has provided funding to flood risk management authorities (NRW, lead local flood authorities), to progress delivery of nature-based solutions to reduce the risk of flooding to properties and enhance the natural environment (Welsh Government, 2023) .
- All development since 2019 and 100 m² or more in size in Wales are required to have Sustainable Drainage Systems (SuDS) for surface water management and associated water quality benefits on water from urban land-use. Funding has

been granted to feasibility studies to retrofit SuDS in 5 projects across Wales. (NRW, 2025f)

- Welsh Government have pledged to work with water companies to deliver strategies for social tariffs and water saving measures to reduce energy costs.
- Dŵr Cymru's business plan (2020 – 2025) included £218M investigate target investment to reduce the impacts of high spilling CSOs, UK Chemicals Investigation Programme third phase (UKCIP3), and further investment at wastewater treatment works to meet Urban Waste Water Treatment (England and Wales) Regulations 1994 requirements. Ofwat have approved £1.7bn expenditure for the National Environment Programme (NEP) in Wales and includes £192m reducing nutrient pollution, £1.1billion towards reducing harm from storm overflows, £88m on expanding wastewater treatment works and £14m on restoring peatlands, as well as a 23% reduction in leakage (Ofwat, 2024).
- There is significant ongoing policy work by NRW in conjunction with Welsh Government and the other UK Administrations to reduce levels of chemicals released to the water environment. This includes increased monitoring along with restrictions in use and disposal methods.
- Drainage and Wastewater Management Plans (DWMPs) became statutory requirements in 2024. These plans represent long-term, strategic frameworks developed by water companies to address the complex challenges surrounding drainage, flooding, and wastewater management.
- Potential hotspots of private water supplies have been identified (Welsh Government, 2021).

Opportunities for Action Aim 3

The possible actions identified with respect to achieving Aim 3 relate to Nature Based Solutions, Pollution management and Awareness raising.

Action 10. Protect public and private water supplies to protect people’s health.

Action 11. Protect water for recreation opportunities.

Action 12. Seek and take opportunities through flood risk management work for enhancement to the health and wellbeing of communities.

Aim 4: Contributing to a Regenerative Economy, Achieving Sustainable Levels of Production and Consumption

Water impacts on economic well-being

- In 2024, the total volume of licensed abstractions of water for consumptive and non-consumptive uses across all sectors of the economy was 11,890,217Ml. This included 428,617Ml abstracted for industry 127,939Ml for amenity and 118,671Ml for agriculture (NRW, 2025g). Licensed amounts are not always used to their full capacity. There is the potential to take back a perpetually unused licensed amount and re-license to another applicant.
- The greatest volume of licensed abstractions is associated with the energy sector, comprising 9,629,231Ml in 2024 (approximately 81% of total licensed abstraction in Wales). This includes non-consumptive abstractions for hydropower generation (NRW, 2025g). In 2023 the estimated hydropower generation in Wales was 332 GWh across 380 projects. 95% of this hydropower generation is from North and Mid Wales, where mountains and hills support hydropower resources (Welsh Government, 2025b).
- Abstraction of water resources for consumptive use by the water sector represents around 16% of the total volume of licensed abstractions (NRW, 2025g). The total economic impact of Dŵr Cymru's activities in Wales is estimated to exceed £1 billion per year (including water supply and sewage treatment) and supports around 3,000 full time jobs (Dŵr Cymru Welsh Water, 2023c)
- The economic impacts of a flood can be substantial, including damage to vehicles, buildings, infrastructure and flood assets themselves (Welsh Government, 2020)
- The estimated damage from Storm Dennis to household property in 2000 alone in Wales was £81 million. This is very much an underestimate of total damage as it excludes costs to businesses, other non-residential properties and infrastructure (NRW, 2020).
- Modelled data from Flood Risk Assessment Wales indicates that around 170 km of rail and 2600 km of road infrastructures is at risk of flooding from rivers, 160 km rail and 1600 km road from sea. This is predicted to increase to approximately 220 km of rail and 3,200 km of roads at risk of flooding from rivers, 310 km rail and 2,500 km road from sea in 2120 under predicted climate change (NRW, 2024b).
- In addition, Wales has over 40,000Ha of agricultural land that is at risk of flooding from the sea, which is expected to increase to 46,000Ha in 2100 under predicted climate change scenarios (NRW, 2024b).

Economic drivers and their pressures on water

The key direct economic drivers within Wales related to the degradation of water are **Land and sea use and management change** and **Direct exploitation**. Climate change pressures are considered to be driven by global economic activity.

Land and sea use and management change

Historically, **agricultural intensification** has shown a mixed trend in Wales (1946 – 2024), this impacts on water quality. The future outlook is also mixed (to 2050). As Aim 1 highlighted, 21% of waterbodies not achieving good status remain impacted by rural land uses, predominantly agriculture (NRW, 2025b). Intensive agriculture, and associated poor practice, can result in sediment, nutrients, organic matter, ammonia, litter, pesticides, pharmaceuticals, bacteria, viruses and antimicrobial resistance affecting surface water and groundwater. Soil compaction, which may be caused by increased agricultural activity, can reduce the infiltration of water across the land, resulting in increased run-off of water which may cause localised flooding and increased risk of pollution. As highlighted in Aim 1, source apportionment modelling identifies agricultural intensification (7 out of 10) the main sources of phosphorus pollution in SAC river catchments (Dŵr Cymru Welsh Water, 2023b).

Historically, the effects of **built development and infrastructure** on water show a mixed – improving trend in Wales (1970 – 2020). The future outlook is also mixed (to 2050). Housing, transportation and other urban land-uses are identified reasons for not achieving good status in 10% of water bodies, pollution from waste water impacted on 17% water bodies (NRW, 2025b). As highlighted in Aim 1, source apportionment modelling identifies wastewater treatment (3 out of 10) the main sources of phosphorus pollution in SAC river catchments (Dŵr Cymru Welsh Water, 2023b).

Direct exploitation

Water abstraction and demand have decreased in Wales (1995 to 2020). The future outlook is mixed, due to projected decreases in summer rainfall reducing supply (to 2050). Over the last 25 years, Dŵr Cymru report a reduction from 1000 megalitres per day (Ml/d) to 850 Ml/d. This is due to a reduction in both industry demand and a reduction in leakage from distribution systems. However, there remain concerns to meeting this demand dure to spatial and temporal variations in the availability of water resources in Wales. Of the 27 Water Resource Zones in Wales, 3 of these are anticipated to go into deficit by 2050 (SEWCUS and Tywi Gower associated with the urban south and Lleyn/Harlech/Barmouth in the northwest) (Dŵr Cymru Welsh Water, 2024). In these zones direct exploitation of water by the economy (including public supply) will be an acute concern. Decreases in demand will be mitigated by leakage reduction and more **efficient use** of water.

Contributions of water to sustainable economic production and consumption

Electricity generated from hydropower and pumped hydropower facilities plays an important role in Wales in decarbonising the energy sector. 4% of all Wales renewable energy generation in 2023 was from hydropower (Welsh Government, 2025b). The freshwater ecosystem therefore plays a small but important role in supporting the transition to a circular economy and achieving net-zero emissions in Wales. However, the hydropower sector is associated with the highest land use intensity of energy generation (see Annex 6: Aim 4 Energy evidence)

The Welsh Government has set a target for renewable electricity generation to be equivalent to 100% of annual electricity consumption by 2035. In 2023, renewable electricity generation in Wales was equivalent to 53% of its electricity consumption, including losses (Welsh Government, 2025b).

Future pressures on water resources are projected to increase with the drive for decarbonisation. Low carbon energy production and carbon capture and storage are processes which require large quantities of water either for cooling (Blue hydrogen, nuclear hubs) or, in the case of Green Hydrogen production, as feedstock (Aecom, 2025).

Safeguarding and enhancing clean water resources will reduce chemical and energy costs associated with water treatment. Green solutions can contribute to these cost savings whilst also serving to build back the stocks of nature in catchments (Dŵr Cymru Welsh Water, 2023a).

Progress towards meeting Aim 4 (Contributing to a Regenerative Economy, Achieving Sustainable Levels of Production and Consumption)

The key opportunities taken up since SoNaRR 2020 comprise:

- 112 abstractions (above 20m3/d) for previously exempt purposes were licensed by the statutory 31st December 2022 deadline.
- Increase in water availability for emerging low carbon energy production sector through revocation of unused licenses and license trading.
- Introduction of the Water Resource (Control of Agricultural Pollution) (Wales) Regulations in 2021.
- Dŵr Cymru's business plan (2020 – 2025) included £218M investigate target investment to reduce the impacts of high spilling CSOs, UK Chemicals Investigation Programme third phase (UKCIP3), and further investment at wastewater treatment works to meet Urban Waste Water Treatment (England and Wales) Regulations 1994 requirements. Ofwat have approved £1.7bn expenditure for the National Environment Programme (NEP) in Wales and includes £192m reducing nutrient pollution, £1.1billion towards reducing harm

from storm overflows, £88m on expanding wastewater treatment works and £14m on restoring peatlands, as well as a 23% reduction in leakage (Ofwat, 2024).

- Drainage and Wastewater Management Plans (DWMPs) became statutory requirements in 2024. These plans represent long-term, strategic frameworks developed by water companies to address the complex challenges surrounding drainage, flooding, and wastewater management.
- The Ofwat Water Efficiency Fund, launched in 2025, has set aside £100m over 5 years. £75m to promote England and Wales wide behavioural change campaigns to reduce water use and £25m for research into technology to manage water more efficiently.
- There are plans underway to introduce mandatory water efficiency labelling of goods and appliances.
- Water companies in Wales offer water meters for existing customers, they are fitted to new and redeveloped properties. Dŵr Cymru offers customers water audits for domestic customers, free repairs for leaky loos and free water efficiency products. Hafren Dyfrdwy offer subsidised rainwater butts and advice on how to reduce water use in the home.

Opportunities for Action Aim 4

The possible actions identified with respect to achieving Aim 4 for Water relate to Increase resource use efficiency, Nature Based Solutions, Pollution management, Renewable energy and LCEP, Research and Technology, Sustainable agriculture, forestry and fisheries, Sustainable construction, Sustainable manufacturing, and Sustainable transport.

Action 13. Use water resources to decarbonise the energy sector via Low carbon Energy Programme (LCEP) and Carbon Capture and Storage (CCS) where appropriate.

Action 14. Reduce the water intensity of the economy.

Action 15. Encourage Offline storage, rainwater harvesting and grey water recycling.

Action 16. Reduce pollution of water.

Action 17. Reduce the risk of flooding to people and communities to reduce the economic costs of flooding.

Action 18. Research and development into the management of anthropogenic pollutants at their source.

Evidence Needs

Evidence needs related to water as a resource in Wales highlight the urgent requirement to understand and manage water availability, quality, and flood risk in the face of climate change, land use change, and increasing demand. Key areas include assessing the impact of exempt and previously unregulated abstractions on local water resources. An understanding is required on how climate change could impact water temperatures, microbial and chemical pollution and reductions in summer flow on private water supplies.

There is a need to monitor the effects of agricultural intensification and built development on water quality and quantity. It is necessary to improve water efficiency across sectors, through updated guidance, behavioural change, and technologies like rainwater harvesting. Evidence is also needed to track development within floodplains and to understand the impacts of flooding and coastal erosion on agricultural land and rural businesses. Natural flood management and sustainable drainage systems are being explored for their potential to mitigate flood risk while enhancing ecosystem resilience and water retention in the landscape. Understanding the hydrological impact of these interventions across larger catchments is needed to support and increase delivery. To be confirmed

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Biodiversity assessment

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A Welsh biodiversity assessment is necessary to ensure that the strategies, programmes and policies in Wales are fit for purpose, are implemented and are able to achieve the results expected of them.

Summary

It is a critical time for conservation efforts in Wales. One million of Earth's estimated 8 million species of animals and plants are threatened with extinction (IPBES, 2019) and 75% of the Earth's land surface has been significantly altered by human actions (United Nations Environment Programme, 2024). In response to the unprecedented decline in global biodiversity, the Kunming-Montreal Global Biodiversity Framework was established with the ambitious goal of halting and reversing biodiversity loss by 2030. This framework aims to prevent further extinction crises, ecosystem collapse, and the degradation of ecosystem services.

The State of Nature Report 2023 (Smith *et al.*, 2023) highlights that Wales is one of the most nature depleted countries in the world. Evidence from the last 50 years shows that on land and in freshwater significant and ongoing changes in the way we use and manage our land combined with the effects of climate change, are having the biggest impacts on our wildlife (Smith *et al.*, 2023). In Wales, all ecosystems are to some extent impacted by human activity or land use, with 90% farmed (Welsh Government, 2024c).

Whilst there is evidence of recovery for some species, for example certain bat species (Smith *et al.*, 2023) and bittern *Botaurus stellaris* (NRW, 2024a), urgent action is required, and transformative changes are essential in how society interacts with nature to achieve the Global Biodiversity Framework 2050 nature-positive goal that nature will thrive (O'Brien *et al.*, 2025).

This biodiversity assessment makes use of the best available evidence building on the State of Nature Report, in addition to drawing on a range of recent reports on the current state of biodiversity in Wales, and the on-going conservation responses working towards a nature positive future. It highlights that while some action is being taken and can contribute to halting the decline in biodiversity, such as reintroducing species and protecting vulnerable populations, there remains a need for significantly more comprehensive and coordinated efforts. It also highlights that failure to act and the alternative to halting biodiversity decline, could result in the loss of ecosystem services that are essential for human wellbeing.

Introduction

SoNaRR 2020 demonstrated that biodiversity is fundamental to providing economic, social, environmental and cultural well-being. Our economies are embedded within nature, not external to it. Investing in ecosystems as assets gives an annual rate of return far greater than most conventional economic assets (Johnson *et al.*, 2023)**.** Despite this the loss of biodiversity is accelerating globally and at unprecedented rates in human history – around 1 million animal and plant species across the globe are now threatened with extinction, many within decades, at a rate of loss unparalleled for 65 million years (NRW, 2020a).

The Intergovernmental Panel for Biodiversity and Ecosystem Services (IPBES) Global Assessment Report on Biodiversity and Ecosystem Services (IPBES, 2019) identified that indirect and direct drivers of change (Table 1) have accelerated during the last 50 years. Indirect drivers refer to values and behaviours that lead to the to the activity that are the direct drivers. Direct drivers are the activities that take place on land, in freshwater and marine ecosystems, that result in biodiversity loss. However, the Global Assessment Report also identifies that nature can be conserved, restored and used sustainably while simultaneously meeting other societal goals through urgent and concerted efforts fostering growth and change.

Indirect Drivers	Direct Drivers
• Demographic and sociocultural	• Land/ sea use change
• Economic and technological	• Direct exploitation
• Institutional and governance	• Climate change
• Conflicts and epidemics	• Pollution
	• Invasive species

Table 1 Indirect and direct drivers of biodiversity loss (adapted from Figure SPM9, Brondizio et al., 2019)

Acknowledging this decline, the then Minister for Climate Change declared a nature emergency in June 2021 (Senedd Cymru, 2021) in what was described as a landmark moment. The Senedd was one of the first in the world to declare such an emergency, recognising the significant loss of biodiversity caused by humans and set out its expectations for action to restore it.

Towards a Nature Positive Future

The Biodiversity Assessment 2025 reflects on new evidence that has emerged since SoNaRR 2020; in particular the 2023 State of Nature (SoN) Wales Report which reveals the devastating scale of nature loss across Wales and provides a detailed picture of how nature is faring and what is needed to fix it (Smith et al., 2023). It also introduces three of

Natural Resources Wales' recent evidence reports, Species in Peril (Bosanquet et al., 2025), The Sites of Special Scientific Interest: a Review of the Current Series in Wales (Edwards C and York H, 2025) and the First Habitats Regulations 9A Report for Wales 2025 (NRW, 2026).

This assessment explores the current state of biodiversity decline, the factors contributing to the trend and the potential to reverse the decline of nature through dedicated conservation action in Wales. Further, this assessment considers how policy and legislative levers are being used to inform delivery of the Welsh commitment to the Kunming-Montreal Global Biodiversity Framework (GBF) in reversing the current decline in biodiversity as a critical step to thriving nature by 2050 (Brotherton et al., 2021).

Ultimately this biodiversity assessment aims to inform a collaborative approach to nature recovery supporting the development of statutory drivers such as the Natural Resources Policy, Nature Recovery Action Plan and Area Statements, whilst also empowering non-statutory action through, for example, local nature partnerships, local action groups, environment forums and landscape partnerships.

State and Trends

As highlighted by the Senedd declaration in 2021, Wales is in a state of 'nature emergency', with rapid and significant declines observed across many species and habitats. The SoN Report highlights the critical status of species diversity in Wales. It reveals that almost 1 in 5 (18%) of species in Wales are at risk of extinction, and that 95 species have already gone extinct in Wales (Smith *et al.*, 2023).

Species

Generally, Wales has failed to halt the decline of many threatened species. Between 2002 and 2008, fewer than half of the species of principal importance on the Environment (Wales) Act 2016 Section 7 list were considered to be stable or increasing (Smith *et al.*, 2023). The Section 7 list of species and habitats of principal importance in Wales includes 557 species. However, the list has been under review, and the current proposal would increase the number of species listed to over 1,250, covering terrestrial, freshwater and marine environments.

The most recent assessment of bird conservation in Wales reviewed all 220 species that regularly occur across the country. Alarmingly, 60 species are now on the Red List, indicating the highest level of conservation concern. A further 91 species are on the Amber List, while just 69 species, less than a third, remain on the Green List, which reflects relatively stable populations (Johnstone, I.G *et al.*, 2024).

Wales supports 70% of the UK's breeding seabirds, yet many colonies have experienced significant declines. The impact of Highly Pathogenic Avian Influenza (HPAI) has been severe, with some species, such as the black-headed gull *Chroicocephalus ridibundus*, declining by up to 77%(Tremlett, Morley and Wilson, 2024). According to the IUCN GB Red List, 108 bird species are now considered at risk of extinction in Great Britain (Stanbury *et al.*, 2021)

On Grassholm Special Protection Area (SPA), Wales' largest gannet *Morus bassanus* colony saw a 52% decline in 2022/23 due to the HPAI outbreak. This serves as a powerful example of the vulnerability of species to extinction, revealing how quickly populations can decline from disease, potentially undoing years of recovery for some seabirds (Johnstone, I.G *et al.*, 2024).

A recent Natural Resources Wales evidence report (Bosanquet et al., 2025) presents data on terrestrial and freshwater species most at risk of extinction in Wales, emphasising the urgent need for action. This report provides the first assessment of the most vulnerable as identified as being species found on five or fewer sites in Wales, termed Species in Peril. Based on decades of validated species data, the report reveals that there are 2,955 Species in Peril in Wales, including 309 fungi, 321 lichens, 107 mosses & liverworts, seven stoneworts, 155 vascular plants, 2,017 invertebrates, five freshwater fish & lampreys, one amphibian, six mammals and 27 bird populations (breeding, wintering or passage). Of particular concern is that 1,262 species are known from just a single site and that Wales has the only populations in the UK for 56 species.

The report also highlights the critical role of protected sites in safeguarding these species and the necessity of prioritising essential management actions for their conservation. Despite the significant number of species at risk, only a minority of those listed under Section 7 currently receive any kind of active conservation management (Bosanquet et al., 2025).

There is currently no scheme to assess species abundances or overall biodiversity in protected areas (Bailey et al., 2022) and there is generally a data shortfall for priority species (Burns et al., 2016). Improving data collection and reporting is crucial for effective conservation planning and ensuring the protection of priority species.

Habitats Regulations 9A Reporting

Regulation 9A of the Conservation of Habitats and Species Regulations 2017 (as amended) requires reporting on the current state of habitats and species protected in Wales due to their international importance. Changes in the reporting requirements due to the devolution of environmental responsibilities post EU exit mean that this will be the first time a Wales-level report is produced. This shift allows Wales to independently manage and report on its conservation efforts, ensuring that local priorities and specific ecological needs are addressed and communicated more effectively.

It also offers a comprehensive and evidence-based account of the condition of habitats and species protected under the Habitats and Birds Directives (NRW, 2026).

The report (NRW, 2026) findings are unequivocal: biodiversity in Wales is in decline, and the scale of the challenge demands a coordinated and strategic response.

Compiled by Natural Resources Wales, the report assesses 61 Annex I habitats, 53 non-bird species, 12 marine species and 350 bird populations, comprising 279 species or subspecies. It reveals that only two habitats are currently in Favourable condition, while 48 are classified as Unfavourable–bad (U2), and nine as Unfavourable–inadequate (U1). The status of two habitats could not be determined due to insufficient data. Among non-bird species, 14 are in Favourable condition, 18 in Unfavourable–inadequate condition, and 16 in Unfavourable–bad condition, with five species assessed as unknown. For marine species, four are in Favourable condition, two are Unfavourable–inadequate, one is Unfavourable–bad, and five could not be assessed due to data limitations.

The report identifies 84 pressures acting on habitats, 87 pressures acting on non-bird species and 73 pressures acting on bird populations in Wales. These pressures are predominantly anthropogenic and have been grouped into thematic categories to aid interpretation:

- Agricultural practices: Affecting 68 bird populations, 44 non-bird species, and 52 habitats.
- Pollution : Primarily nutrient enrichment and nitrogen deposition, impacting 55 habitats.
- Climate change: Influencing 54 habitats, 26 non-bird species and 124 bird populations.
- Invasive non-native species: Affecting 44 habitats, 17 non-bird species, and 46 bird populations.
- Urbanisation and infrastructure development: Impacting 46 habitats, 21 non-bird species and 46 bird populations.

The Report is not an isolated exercise. It serves to provide data and information as part of Wales' broader environmental governance framework, aligning with the Nature Recovery Action Plan (NRAP), and statutory duties under the Well-being of Future Generations (Wales) Act 2015 and the Environment (Wales) Act 2016. It also supports Wales' commitments under the GBF and the 30by30 target to protect and effectively manage 30% of land and sea for nature by 2030.

The evidence presented in the report is robust and compelling. It calls for:

- Accelerated implementation of conservation measures.
- Integration of biodiversity objectives into agricultural, marine, and infrastructure policy.
- Expansion of monitoring capacity, particularly in upland and marine habitats.
- Strategic investment through public funding and green finance mechanisms.
- Cross-sector collaboration to ensure coherent and effective delivery.

In conclusion, the Habitats Regulations 9A report represents a critical juncture for biodiversity policy in Wales. It provides the scientific foundation for informed decision-making and highlights the urgency of action. Wales possesses the legislative tools, institutional capacity, and ecological expertise to reverse biodiversity decline. What is now required is sustained commitment, strategic investment, and a shared vision for a resilient and nature-rich future.

Protected sites: vital refuges for biodiversity

Protected sites in Wales are vital to safeguard biodiversity of land, freshwater and sea. These protected sites cover many of the most valuable areas for biodiversity in the UK with associated legal mechanisms for vital refuges of habitats and species (Bosanquet et al., 2025) (JNCC, 2024) Emerging evidence from the Species in Peril report shows a total of 2222 (75%) species occur on at least one of the SSSIs in Wales, including 1402 (47%) found only on SSSIs, demonstrating just how critical SSSI protection is for our rarest Welsh species Further, Species in Peril confirms that 1047 species (35%) occur on National Nature Reserves (NNRs), with 353 species (12%) restricted to those NNRs (Bosanquet et al., 2025) .

The protected areas in Wales include (Edwards C and York H, 2025):

- 21 Special Protection Areas (SPAs) for internationally important populations of birds.
- 95 Special Areas of Conservation (SACs) for other threatened species and natural habitats.
- 10 Ramsar's for wetlands of global importance.
- 1,083 Sites of Special Scientific Interest (SSSI)
- 76 National Nature Reserves (NNRs).

Established in 1949, the SSSI series in Wales now includes 1,083 sites covering more than 267,500 hectares, around 12% of Wales' land and intertidal area (Edwards C and York H, 2025) . These sites protect a diverse range of habitats including woodlands, grasslands, wetlands, rivers, and coastal regions while safeguarding specific species of plants, fungi, and animals alongside a network of geological and geomorphological sites that represent Wales' geoheritage.

The SoN Report indicates that there is compelling evidence that protected sites are richer in nature (Burns et al., 2023), however even when an area is designated, harmful activities that are detrimental to the environment often persist (Bailey et al., 2022) with these pressures occurring both on and off site. For example, studies have shown that protected sites have not prevented some forms of intensive land management that are damaging nature in the Uk's upland ecosystems (Douglas DJ et al., 2015) (Bailey et al., 2022).

In addition, (Bailey et al., 2022) suggests that the UK's statutory protected sites are generally small, key species and/or habitats are often in unfavourable condition, poorly connected and often clustered in areas of relatively low economic and agricultural development. Many of these traits are not conducive to forming resilient ecological networks.

The Sites of Special Scientific Interest: a Review of the Current Series in Wales report (Edwards C and York H, 2025) confirms that evidence from specialist survey and evaluation reports indicate that more areas of land within Wales support habitats, species and Earth science features of special interest that have not yet been notified. The opportunities for new notifications and to review and where appropriate renotify existing sites that can be made bigger to reduce edge effects and increase structural connectivity should be taken forward. In assessing the cases for new protected sites and to renotify existing sites sufficient and effective resources to ensure all sites are under effective management and on a pathway to good condition by 2030 is needed.

Maintain and enhance ecological resilience

Semi-natural habitats are generally regarded as having relatively high ecosystem resilience compared to anthropogenic land-uses. For example, semi-natural habitat extent is used by Wales' Wellbeing Indicator 43 to describe 'Healthy Ecosystems' (Welsh Government, 2025c, p. 43). A recurring pattern in spatial analysis is that there are higher extent values in upland areas, lower values in lowland areas, and higher values again in a narrow coastal fringe. This reflects broad land-use and its history through differences in the amount of semi-natural habitat remaining. Essentially, the lowlands have been preferentially cleared, modified, or developed because they are more accessible and productive than the uplands and much of the coastal fringe.

This trend has continued with the past short term trends in land use change summed up by the ERAMMP Report 105 (Emmett et al., 2025) It found an increase in urban land cover of 28,200ha (+29%) which now represents 6% of Wales and a 7% increase (23,600ha) in woodland cover. The increase in urban areas was primarily due to the conversion of -4% (48,900ha) improved grassland which now represents 44% of Wales, with a 5% loss of the most productive agricultural land (arable and improved grassland) over the same time period.

To assess Wales' sustainable management of natural resources we need to understand the state of those natural resources which is inclusive ecosystem resilience. Natural Resources Wales experts have provided assessments of eight broad ecosystems in Wales (coastal margins, enclosed farmland, freshwater, marine, mountain, moorland and heath, semi-natural grassland, urban and woodlands). Assessing ecosystem resilience is inherently complex, by understanding and protecting these ecosystems, especially semi-natural habitats, we strengthen Wales' ability to respond to known pressures and adapt to the unknown impacts of climate change.

While there is no universally accepted method for quantifying absolute resilience, the assessments use a consistent framework based on four key attributes: diversity, extent, condition, and connectivity. These attributes are key for building ecosystems that are able to adapt to pressures and threats and can therefore be considered to be resilient. Ecosystem resilience stems from the interaction between various attributes, rather than any single attribute in isolation.

Diversity

For a relatively small country, Wales boasts a diverse array of rocks, minerals, fossils, landforms, and natural processes. Its geodiversity is renowned worldwide (Edwards C and York H, 2025) . Geological features and processes should be considered as a natural resource, directly influencing the soil formation and chemistry which is itself a vital natural resource. From sea level to over 1,000 metres, Wales has been moulded by a long history of land management changes and has resulted in a wide representation of species across a broad range of taxonomic groups with the number of species in Wales likely to exceed 50,000 . (Wales Biodiversity Partnership, 2025) Many rare species rely on small fragments of scarce habitats; particularly important are the calcareous fens and raised bogs alongside the more extensive dune systems and ancient oak woodland which characterise Welsh habitat cover (NRW, 2020a) Diversity is a core purpose of SSSIs.

However, as stated by (Blackstock et al., 2010) over 50% of Wales' landcover is improved grassland dominated by a single species, rye grass Lolium spp. This is supported by ERAMMP Report 105 (Emmett et al., 2025) which estimates approximately 44% of Wales is improved grassland. SoNaRR2020 found that just 9% is considered semi-natural grassland habitat (NRW, 2020a). In the woodland ecosystem (Forest Research, 2024) found that non-native woodland is the dominant woodland type making up just under 46% of woodland ecosystem in Wales.

Diversity matters at every level and scale, from genes to species, and from habitats to landscapes. It supports the complexity of ecosystem functions and interactions that deliver services and benefits (Garrett and Ayling, 2020). Most habitat types have seen a reduction in diversity over the last 100 years, with the rate of decline increasing from the 1970s onwards. This indicates that ecosystems are not resilient, and many species are not recovering. If diversity continues to be lost with increasing monocultures or of few species within habitats, then it may result in the collapse of ecosystems and the services they provide (Sanderson Bellamy et al., 2021).

Extent

The extent of semi-natural habitat was estimated in 2018 to inform the Well-being of Wales Indicator 43 for Areas of healthy ecosystem in Wales, which was published in 2022 (Welsh Government, 2022) to cover approximately 30.8% (640,827 ha) of the Welsh land surface. This semi-natural habitat extent is distinctly split with 74% of the upland area being semi-natural and only 19% in the lowlands. The extent of Habitats of Principal Importance (also known as priority habitat or Section 7 habitat) is estimated to be 16.6% (354,827 ha) (Jones et al., 2003) of the Welsh land area, forming over half of the semi-natural habitat remaining (Figure 1).

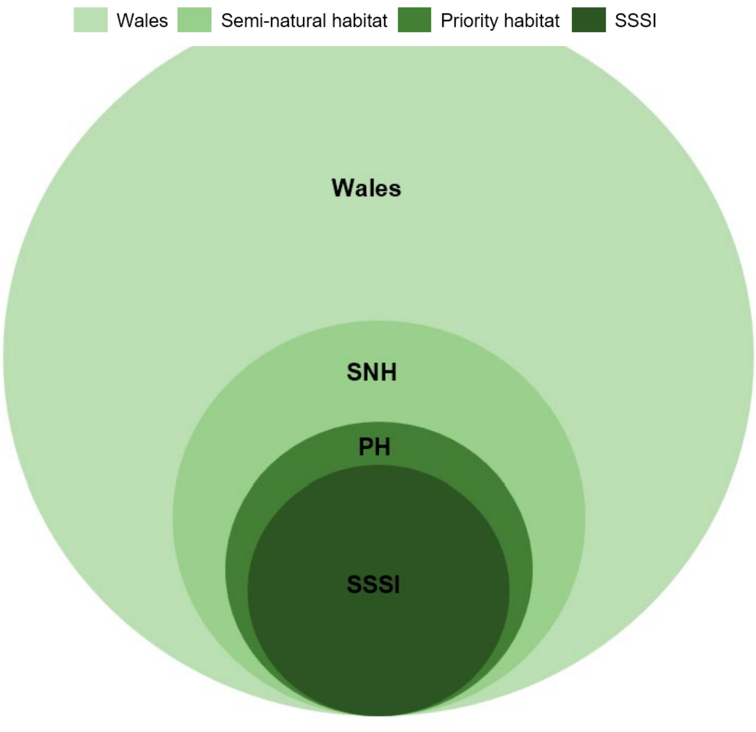

Figure 1 Proportional area chart of the extent of SSSI, priority habitat, and semi-natural habitat relative to the total area of Wales

A significant proportion of semi-natural habitat and priority habitat in Wales are notified as SSSIs. Note that some small areas within SSSIs include improved land for practical boundary reasons, artificial habitat and structures intrinsically linked with the semi-natural and built structures such as breeding roosts for bats. Therefore, less than 100% of SSSI area is classified as semi-natural or priority habitat.

The largest single threat to biodiversity worldwide is the destruction of habitat, along with habitat alteration and fragmentation of large habitats into smaller patches (Mullu, D.,2016). The size of an ecosystem will affect its capacity to adapt to, recover from or resist disturbance (Garrett and Ayling, 2020)). In addition, fewer species can survive in a smaller more fragmented area, and the number of different species as well as abundance of species is altered when habitat is lost, leading to species loss and ecosystem decay (Garrett and Ayling, 2020). At least 40% of Welsh habitats are spread out in small patches implying lower resilience to pressures and threats (NRW, 2020a).

As a result of the Welsh uplands remaining predominantly semi-natural, they account for 59% (156,831 ha) of the total area of SSSIs and, as a consequence, tend to contain very large SSSIs (Edwards C and York H, 2025) (York and Edwards, 2025). This greater distribution is concentrated within just 17% or 191 SSSIs. With greater extent of many upland SSSIs, the largest of these – Eryri SSSI, Elenydd SSSI, and Berwyn SSSI – each exceeding 20,000 ha in size.

In contrast the Welsh lowlands having a lower proportion of semi-natural habitat is reflected in the extent of SSSIs which tend to be much smaller and as a result more fragmented. The coastal fringe contains a relatively high proportion of semi-natural habitats, with protection afforded due their special interest by SSSI designation for example including sand dune and clifftop formations. Although they can also be very narrow and immediately adjacent to heavily modified land increasing the likelihood of edge effects and coastal squeeze. The SoN Report (Burns et al., 2023) identifies fragmentation of habitats as one of the major drivers of long-term declines in species abundance.

Condition

An ecosystem can be defined as a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit. A sites condition is therefore dependent on the geology, soils, hydrology, vegetation, and animal movement, each interacting to shape the biophysical processes and site-specific responses to disturbance and management. These components collectively influence soil temperature, moisture availability, nutrient cycling, and habitat structure

Soil itself is the foundation of all terrestrial ecosystems (ADAS, 2019) and soil biodiversity whilst essential for soil function, is important for every single aspect of our life on Earth, from ecosystem restoration and food production to One Health (Delgado-Baquerizo et al., 2025). Soil is a non-renewable resource critical for human well-being, nurturing the delivery of ecosystem goods with a growing body of scientific literature highlighting the importance of integrating abiotic. factors such as geology, soils, and hydrology with biotic components like vegetation and animal movement to assess ecosystem condition. Recent work emphasises the need for data-driven, spatially explicit approaches that reflect the complex interactions between natural processes and human pressures, supporting more effective environmental policy and management services which support every aspect of the natural and built environment on which well-being depends (SoNaRR 2025 Soils assessment).

The ERAMMP Report 105 (Emmett et al., 2025) identified several indicators for soil exhibiting deteriorating trends. With respect to the quantity of soil stocks, aerial imagery shows 4% of surveyed soil is disturbed or eroded in Wales. This indicates ongoing losses of this finite natural resource (SoNaRR 2025 Soils assessment). Further, ERAMMP Report 105 assessed the condition of ecosystems using biological and environmental factors linked to habitats and species. This assessment stated that very few Welsh habitats are reported as being in good condition due to a number of pressures. The most notable reasons for decline identified in the SoN Wales Report 2023 (Smith et al., 2023)over the last 50 years on land and in freshwater are significant and ongoing changes in the way we manage our land for agriculture, and the effects of climate change. At sea, and around our coasts, the main pressures on nature are climate change and over exploitation (historic fisheries).

This concerning trend is reflected in Wales' protected sites series. The baseline assessment undertaken in 2020 (NRW, 2020a) which reported the condition of many site features found that only around 20% of the features on these sites are in favourable condition, while approximately 30% are in an unfavourable state. For about 50% of the features, there was insufficient evidence to determine their condition.

Connectivity

In terrestrial ecosystems connectivity relates to the relative ability of species movement across different land-uses between habitat patches, this is often referred to as habitat permeability. For most species, the permeability of semi-natural habitats is higher than modified or artificial habitats, and so the overall connectivity in a landscape closely relates to the extent of semi-natural habitat within it. Connectivity involves physical features such as hedges, riparian corridors, or ‘stepping-stones’ of small patches of habitat or individual trees.

Connectivity is often described in terms of habitat networks. A habitat network is a spatial arrangement of habitat patches and other connective features that form a functionally linked landscape. Modelled habitat networks are available via Data Map Wales that provide insights into how landscapes are likely to be functioning and inform the location of actions to improve the connectivity and resilience of protected sites.

Habitat fragmentation is a critical problem in Wales, contributing significantly to biodiversity loss. In Wales connectivity is at its lowest in lowland habitats where the landscape has been simplified by the loss of semi-natural habitats and intensively managed land dominates (NRW, 2020b). The uplands being predominately semi-natural, support extensive networks, as habitats are often structurally connected meaning they are contiguous and provide high permeability for each other. As the coastal fringe also retains a relatively high proportion of semi-natural habitat, the long and narrow corridor is susceptible to pressures and threats due to a large ecotone resulting in increased edge effects. The lowlands, however, have a much higher density of linear features such as hedges and water courses, which are likely to aid rapid movement of species, thereby creating a more functional connection.

In freshwater ecosystems, connectivity relates more often to physical modifications such as weirs and the re-profiling of channels, but also the relative functioning of land within a catchment that influences continuity of biophysical processes such as regulated flow of water and cleanliness of water benefits of passing though the vegetation, soils and rock as it flows into a water channel.

Marine ecosystems are by their nature highly connected, with human impacts on connectivity more limited to local disruptions that could occur through development (e.g. barrages, and construction aspects such laying cables, pipes and drilling) and through constraints around natural processes at the coast. In order to build resilience in the marine area, therefore, the emphasis is more significantly on the diversity, extent, and condition elements of the DECCA framework .

In the context of SSSIs, connectivity is a key factor because, to ensure sites are resilient to pressures and threats, the genetic diversity within species and between species as well as natural processes (e.g. the movement of water through vegetation, soils and rock) facilitates adaption to environmental change.

Pathway to nature recovery

Transformative change for a just and sustainable world is urgent, necessary and challenging, but possible, to halt and reverse biodiversity loss and safeguard life on Earth (O'Brien *et al.*, 2025). This thematic report on transformative change draws on a broad and rapidly expanding body of evidence, including the earlier Global Assessment Report (IPBES, 2019). It highlights the importance of tackling the root causes of biodiversity loss, emphasizing that the issue is not only about what actions people take, but also about the underlying principles and perspectives that shape how those actions are carried out.

In the UK, the devolved administrations working collaboratively have responded to the GBF with the publication of the UK National Biodiversity Strategy and Action Plan (NBSAP) (DAERA *et al.*, 2025) . Simultaneously the devolved administrations have been investigating and developing ways to ensure nature's recovery in their respective jurisdictions.

In 2022, the Ministerial Biodiversity Deep Dive developed a set of recommendations (Welsh Government, 2022) including actions that could be taken to support nature recovery in Wales. Target 3 of the GBF to effectively conserve and manage at least 30% of land and sea by 2030, was chosen as a strategic focus for the purpose of the deep dive to consider where and how action could be accelerated.

Recommendation 8 included the need to set overarching nature recovery targets in primary legislation together with a commitment of more detailed statutory nature recovery targets to deliver Wales' contribution to the GBF. Recommendation 8 also included the need for Welsh Government and Natural Resources Wales to lead by example.

Environment (Principles, Governance and Biodiversity Targets) (Wales) Bill

In June 2025, the Environment (Principles, Governance and Biodiversity Targets) (Wales) Bill was introduced to the Senedd providing the framework for setting the more detailed targets which are to establish the trajectory for improvement and guide actions needed to halt and reverse biodiversity loss.

The Bill confirms that any target that is set must contribute to one or more of:

i) increasing the abundance of native species.

ii) enhancing the resilience of ecosystems.

iii) increasing genetic diversity.

In practice, most targets set will contribute to more than one of these three fundamental elements, as for example, where there is a larger population of a species there are likely to be more differences between individuals. Similarly, if ecosystems are enhanced, it is likely that there will be more niches for which plants and animals can exist meaning abundance and diversity is likely to increase.

The Bill is being designed to ensure the right decisions are made in the right way and at the right time based on biodiversity evidence. This is important because to be able to halt and reverse biodiversity loss, there is a need to have access to readily available and understandable data and information to be used by decision makers.

This Bill is a significant stepping stone in ensuring that biodiversity is enhanced when decision makers are applying the sustainable development principles into routine work. This primary legislation includes provision for a strategic nature recovery framework with nature positive targets via secondary legislation expected to be place during 2027-8, which is intended to put nature on a path to recovery by 2050.

Agriculture (Wales) Act 2023

The Agriculture (Wales) Act 2023 establishes the Sustainable Land Management (SLM) framework for agricultural support and regulation in Wales. It sets out four SLM objectives, one of which is to "*maintain and enhance the resilience of ecosystems and the benefits they provide*". This is highly significant given that over 90% of Wales' land area is given over to farming (Welsh Government, 2024b), meaning agricultural policy is pivotal for nature recovery. The Acts ecosystem resilience objective aligns with directly with the Sustainable Management of Natural Resources (SMNR) principle and the biodiversity duty under Section 6 of the Environment (Wales) Act 2016, ensuring consistency across environmental legislation.

Furthermore, it complements the intended direction of the forthcoming Environment (Principles, Governance and Biodiversity Targets) (Wales) Bill which will embed environmental principles and legally binding biodiversity targets. Together, these frameworks create a coherent legislative approach that positions farming as a key driver for delivering public goods, supporting biodiversity, climate resilience, and sustainable resource management at scale.

Conservation action underway

Since SoNaRR2020, Wales has undertaken several significant biodiversity initiatives to address the nature emergency and enhance the resilience of its ecosystems. Notable Initiatives include:

- The **Natur Am Byth! Programme**, established in 2023, supported by the National Lottery Heritage Fund and Natural Resources Wales, is Wales' species recovery programme. A total of nine environmental NGOs are working with Natural Resources Wales to deliver widescale and species specific projects across terrestrial, freshwater and marine environments that will reconnect communities with nature and save threatened species. The programme is targeting 67 threatened species such as the upright apple-moss *Bartramia aprica* which in the whole of the UK is found only on the igneous rock outcrops of Stanner Rocks in Powys.
- Welsh Government have invested approximately £54 million (Welsh Government, 2025b) since 2020 in the **Nature Networks Programme** to improve protected sites and connect people to nature. This fund typically includes competitive grants

administered by the National Lottery Heritage Fund (NLHF) and direct delivery on protected sites through Natural Resources Wales' mechanisms such as Environment (Wales) Act 2016 Section 16 Land Management Agreements. The Nature Networks programme is a flagship for halting and reversing the decline of habitats and species with key thematic achievements including:

- Restoration of degraded habitats and species recovery across SSSIs, SACs, SPAs, NNRs and Ramsar sites.
- Marine projects such as seabird recolonisation, biosecurity planning, and water quality improvements.
- Terrestrial projects such as sand dune restoration, peatland recovery, and lowland grassland enhancement.
- Emphasising and building community engagement, skills development, and local economic benefits.

- The **National Peatlands Action Programme** targets peatland bodies most in need of restoration as well as safeguarding those in good and recovering condition. The 5 year programme (2020-25) aimed to deliver 600-800 Ha of restoration per year, restoring 3,600Ha damaged peatland, 20% over it's target (NRW, 2025) . Activity is delivered across a range of land uses on both private and public land by Natural Resources Wales and partner organisations.
- The biodiversity focus of the **EU LIFE Programme** is central to its mission of protecting and restoring nature across Europe. Prior to EU Exit in Wales and across the UK the following projects have been completed or remain underway for key Special Areas of Conservation:
    - **Sands of LIFE (2019–2024)**. £5 million. Restored 2,400 ha of sand dunes across four SACs addressing the loss of open sand by reintroducing natural dune movement, removing invasive species, restoring wet dune slacks, and promoting sustainable grazing. In addition, the project included the designation of fixed dune grassland (H2130) as a new feature at Morfa Harlech a Morfa Dyffryn SAC.
    - **The Welsh Raised Bogs LIFE** (2017–2024). £5.2 million. Addresses threats such as poor hydrology, invasive scrub, and inadequate grazing management by implementing actions like peat bunding, scrub removal, and water level restoration. These interventions were implemented to improve habitat condition, promote the growth of sphagnum mosses, and enhance carbon storage, biodiversity, and climate resilience.
    - **Celtic Rainforest LIFE** (2018–2027). £9 million, Focuses on improving the ecological condition of Celtic Rainforests by removing invasive non-native plants, restoring native woodland structure, and enhancing habitat connectivity. It also promotes sustainable land management, engages local communities, and supports species recovery particularly for rare lichens, mosses, and liverworts.
    - **LIFE Dee River** (2019–2026). £7 million. Targeted at restoring natural river processes and improving spawning grounds, enhancing water quality and oxygenation and engaging land managers and farmers, and local communities

    in sustainable land and water management for the River Dee and Bala Lake SAC.
    - **LIFEquake** (2022–2026). £5 million. Works with partners including Pembrokeshire Coast National Park, Snowdonia National Park and the National Trust to restore peatland and quaking bog habitats across Wales to a favourable conservation status, addressing both biodiversity loss and climate change.
    - **Four Rivers for LIFE** (2021–2026). £10 million. A strong focus on restoring habitats and ecological and hydrological processes by removing fish barriers, improving river corridors, removing invasive species, planting trees, in-river enhancement, fencing watercourses, and engaging with local communities on the Cleddau, Teifi, Tywi, and Usk SACs to provide conditions to restore and maintain populations of migratory fish species including Atlantic salmon, bullhead, shad, sea lamprey and river lamprey
- **Local Places for Nature** were established in 2020 to create 'nature on your doorstep'. The idea was to create areas that support nature within communities, in particular urban and peri-urban areas; encourage a greater appreciation and value of nature and create more green spaces.

  Local places for nature is not prescriptive in what it supports. It promotes a bottom-up approach where activity is community led.
- **The National Forest for Wales** will:
    - stretch the length and breadth of Wales, making it accessible to everyone
    - be a real community venture with new woodland being planted by communities, farmers and landowners right across Wales
    - create new areas of woodland as well as restoring and maintaining Wales' unique and irreplaceable existing woodlands
    - protect nature and address biodiversity loss, also supporting the health and wellbeing of communities
- The **Marine Protected Area (MPA) Network Management Grant Scheme** is designed to support projects that enhance the management of the Welsh MPA network. This scheme is open to applications from Welsh Management Authorities, interested organisations, and third sector organizations that meet the eligibility criteria. The grant scheme focuses on revenue projects that deliver benefits, enhancements, or improved understanding of the management of the Welsh MPA network.

What is the future for Nature Recovery in Wales?

As Wales aims to halt and reverse the decline in biodiversity, and to meet GBF targets, there is still much more to do. The science is clear. The key question is no longer whether a transformation towards global sustainable resource consumption and production is necessary, but how to make it happen now (United Nations Environment Programme, 2024).

The SoNaRR 2020 Biodiversity Assessment set out the benefits of taking a landscape scale approach to nature recovery and the role of a regenerative economy in transformative change. It was highlighted that this approach was supported by the Welsh Policy context.

Opportunities for biodiversity enhancement were also highlighted around Resilient Ecological Networks connecting our protected sites, and targeted action for species. Continued policy development is crucial for turning the biodiversity deep dive recommendations into actionable plans.

Nature Recovery can be achieved by linking existing policy and delivery mechanisms and initiatives including those provided by Area Statements, Resilient Ecological Networks, a Framework for 30 by 30 for Wales (Wales Environment Link, 2023) (Welsh Government, 2025a), Sustainable Land Management, and by supporting existing and creating new networks, local nature partnerships and landscape partnerships.

The financial requirements for nature recovery in Wales are substantial. There is a significant gap between current funding levels and what is actually needed to make a meaningful impact. However, Wales are not alone in tackling this financial challenge. The Transformative Change Assessment (O'Brien *et al.*, 2025) report estimated that global biodiversity conservation funding, between $124 billion and $143 billion in 2019, a global biodiversity financing gap (per year, until 2030) $598-824 billion, whilst global direct subsidies to sectors most responsible for nature's decline, were estimated between $1.3 trillion and $3.1 trillion in 2021. The Finance Gap for UK Nature Report for the Green Finance Institute estimated the cost of a programme to prevent extinction of red listed species in Wales at £86 million over 10 years 2022-31, an average of £8.6 million per year (Green Finance Institute, 2021). The Pathways to 2030 (Wales Environment Link, 2023) outlines the financial requirements for nature-positive interventions across Wales. For protected areas, the report estimates a total of £89.3 million is needed and estimates that there is a funding gap of £5 billion to £7 billion between current resources and what is needed to meet priority outcomes for nature recovery in Wales.

While the current funding efforts are a positive step, such as initiatives including the Nature Networks Programme and the Local Places for Nature Programme, there is still a significant shortfall in the resources needed to reverse biodiversity decline. This includes both increasing public funding and encouraging private investment in nature recovery projects.

Overall greater investment is needed in long-term monitoring of protected areas; for example, a positive relationship between capacity and resources and improvements in species abundance highlights the importance of adequate resourcing to halt biodiversity loss (Geldmann *et al.*, 2018).

Resilient Ecological Networks & Protected Sites

The 2010 'Making Space for Nature' report summarised conservation planning as 'bigger, better, more and connected' (Lawton, J.H *et al.*, 2010) . This remains as highly relevant today as it did 15 years ago, with an ever pressing need for larger, well-managed, and interconnected habitats to support biodiversity and ecosystem resilience with protected sites (vital strongholds for biodiversity) at their core.

Resilient Ecological Networks (RENs) offer an effective and transformative framework through which existing and new programmes and projects can be organised and prioritised to better maintain, and crucially build, ecosystem resilience at scale and pace.

Protected sites serve as the foundational core areas within RENs and require sustained investment to enhance their ecological condition and spatial extent. Adjacent and functionally connected areas can play a critical role in reinforcing these core sites, improving ecological interactions within and between species, increasing habitat integrity, and supporting species movement. Where appropriate, these surrounding areas may qualify as Other Effective area-based Conservation Measures (OECMs), contributing to the delivery of the 30 by 30 target while simultaneously strengthening and expanding the ecological resilience.

RENs core zones provide the framework to support Wales' approach to delivering 30 by 30. Nature recovery zones provide a more opportunistic and realistic approach to safeguarding connectivity. The landscape approach facilitates the incorporation of the wider working landscape to deliver SMNR. They can provide ecological, hydrological, geological and social footprints for landscape scale collaborations of private, public, voluntary and community actors to come together to manage and restore nature in protected areas and the wider landscape.

Nature recovery zones provide flexibility to expand RENs through the landscape, using regional and local expertise to identify areas of structurally or functionally connected habitat.

Nature in Wales is in decline, primarily driven by the intensification of agriculture and climate change (Smith *et al.*, 2023). Welsh Government acknowledges the unique challenges and opportunities of less favoured areas; it is this lower-grade agricultural land that can hold significant potential for nature recovery whilst maintaining and supporting these cultural landscapes.

The Sustainable Farming Scheme aims to support sustainable food production, enhance nature recovery, climate change (adaptation and mitigation) and preserve cultural heritage, aligning with the SLM objectives. SLM is a key tool for delivering this action. It also helps align land management practices outside protected areas with the goals of those within. By encouraging farmers and land managers to adopt SLM practices, it contributes to a more integrated and effective network of protected sites, contributing to RENs.

Wales has seen the largest change in land use in the UK due to increasing urban areas. The concept of "net benefit for biodiversity" means that any development should leave biodiversity and ecosystems in a better state than before. This principle is embedded in national planning policy, which requires that developments not only avoid significant loss of habitats or species but also provide tangible improvements to biodiversity (Welsh Government, 2024a).

Species

Investment is needed in key areas such as habitat restoration and species recovery initiatives to reverse the decline of wildlife populations through fully funded long-term programmes. Species conservation has targeted action for our rare and declining species across Wales including on SSSIs, SACs and NNRs. Initiatives have often been focussed on single species (Annex 1 Biodiversity Assessment Case Studies) with localised efforts or sometimes Wales wide recovery efforts. This has been enhanced in recent years by specific programmes, including the Nature Networks Programme and Natur am Byth! although considerably more action is needed as highlighted by the State of Nature Report (Smith *et al.*, 2023) and Species in Peril Report (Bosanquet *et al.*, 2025)

The Natur am Byth! Partnership is delivering an ambitious species recovery programme across Wales for 67 target species in 11 place based projects. Now halfway through the four year programme, the partnership is considering how to build on the legacy the Natur am Byth! will bring. Strategic thinking is required to review species of conservation concern and to develop targeted actions that are linked to mechanisms of delivery.

Priority Species Action

As has been described, we continue to see significant declines in species abundance, in particular species identified as of principle importance for maintaining and enhancing biodiversity in Wales (Section 7 list). Welsh Ministers are required by the Environment (Wales) Act 2016 to take steps to maintain and enhance these listed species and habitats, and to encourage others to do the same. However, we need a shift in narrative from ‘business as usual’ to a strategic and focused approach to species recovery in Wales, which joins with other approaches such as 30 by 30 for nature’s recovery. This will require a fundamental change to our current approach.

Therefore, developing actions for priority species could play an important role in supporting biodiversity and strengthening ecosystem resilience, by identifying and prioritising those that are at high risk of extinction. Providing a decision support tool to make timely, consistent, and transparent decisions maximising the benefit from available resources, and allowing for more effective policy interventions against pressures like land use change, climate change, invasive species, pests and diseases, and pollution. Wales needs to include such an approach as part of a wider Nature recovery strategy or in delivering statutory targets for biodiversity.

The limitations of time-bound funding must be addressed to enable a transition towards more sustainable and flexible financing models that support long-term conservation objectives and facilitate adaptive management. Such an approach will strengthen the resilience and effectiveness of conservation efforts across Wales, ensuring they are better equipped to respond to evolving ecological and climate challenges.

Conservation Translocations (Species Reintroductions)

A conservation translocation is the deliberate movement of organisms from one site for release in another. It must be intended to yield a measurable conservation benefit at the levels of a population, species or ecosystem, and not only provide benefit to translocated individuals (IUCN/SCC, 2013).

Conservation translocations can be carried out for different reasons, to reintroduce a species, to reinforce a species, to avoid extinction of a species or to promote a particular ecological outcome.

There have been a number of conservation translocations in Wales that have played a role in restoring and conserving species populations.

For example, following evidence of a long term decline of pine marten populations in Wales, the Vincent Wildlife Trust commenced a population reinforcement project in 2015, translocating a total of 51 martens from Scotland to mid-Wales over a three year period. Pine martens are now established in many areas across Wales and populations appear to be expanding.

Sand lizards went extinct in Wales in the 1960s. The rarest and most threatened lizard species within the UK, it is restricted to sandy heathlands and sand dunes in southern and north-western England and North Wales. The species has suffered extensive declines and extinctions across the UK due to development of its coastal and heathland habitats. Ex-situ captive breeding and reintroduction programmes have been successful in restoring populations in North Wales (Owens *et al.*, 2022) as part of a Species Recovery Programme initiated in 1995.

More recently there have been further conservation projects reintroducing and reinforcing lost species. For example, in 2024 Shore Dock Rumex rupestris was reintroduced to the Southerndown Coast SSSI to bolster the population in the SSSI and the Dunraven Bay SAC. Protecting white-clawed crayfish *Austropotamobius pallipes* in Montgomeryshire is a project aimed at reinforcing existing populations . Work at Natural Resources Wales' Cynrig hatchery began in 2008 investigating captive rearing techniques and the potential to introduce hatchery reared juveniles to Ark sites in Wales and the borders. Captive reared crayfish have been released at various sites between 2010 and 2021 and a successful species licence application in 2023 will see the continuation of this work.

As part of Natur am Byth! the Welsh Marine Treasures project will reintroduce native oyster to Milford Haven. Building on the success of trials in other parts of the UK, The Marine Conservation Society will release juvenile oysters and develop containment systems to encourage reef development whilst running a citizen science network to monitor impact and promote sustainable management.

Conservation Translocations are a vital tool for nature recovery in Wales, and support Wales to achieve ambitious biodiversity recovery targets. However, they do not replace the need for in-situ site conservation and should only be considered when all other methods of resolving the issue have been attempted and failed or have been discounted after appropriate consideration.

Priority Actions

The latest evidence presented in this assessment re-affirms that of the 2020 Biodiversity Assessment. The state of biodiversity in Wales is critical, with numerous species facing significant threats to their survival. Policy and legislation is now being created and amended to facilitate the actions and innovative solutions that are needed to halt and reverse biodiversity loss by 2030. However, these will take time to implement and will require collaborative action to halt the loss of biodiversity and put nature on a path to recovery. Critical interventions needed to enable nature's recovery include:

- **Improve** the extent and condition of protected sites and identify ecological networks (RENs) and OECMs which supports 30 by 30.
- **Implement Strategic Conservation Plans.** Develop a suite of species recovery actions in long-term programmes that identify priorities for species conservation in Wales and supports the Biodiversity Deep Dive Recommendations for nature recovery.
- **Build capacity.** Effectively implement and monitor biodiversity policies that bring together a societal approach to restore nature by combining with climate change action, improved educational programmes and projects on natural history, and enabling sustainable finance and investment readiness for the biodiversity sector.
- **Enhance Funding.** Increase investment in nature recovery initiatives including private finance to bridge the substantial funding gap.
- **Strengthen Policy Frameworks.** Enact and enforce robust environmental laws and regulations to protect biodiversity. For example, nearly half of public authorities have not prepared or published a biodiversity plan, and around a quarter have never produced a biodiversity report under Section 6 of the Environment (Wales) Act 2016.
- **Sustainable decision-making.** Ensure that the value of ecosystems, biodiversity, and natural resources is systematically accounted for in public policy, economic planning, and infrastructure development.
- **Fill evidence and data gaps.** Evidence-based action is crucial for effective conservation planning and resource allocation. Reliable information on where and when biodiversity decline is most severe is increasingly needed to plan smart conservation interventions.
- **Effectively evaluate the impact of policy and programme interventions.** High-quality information is needed to track the effectiveness of policy, planning, and management decisions in reversing declines and becoming nature positive.

Taking these steps urgently is essential to halt the current trajectory of species extinction and will significantly contribute to halting biodiversity loss and ensure the sustainable use of natural resources.

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Biodiversity Annex 1 Case Studies

North East Wales

Atlantic Salmon *Salmo salar*

This majestic and iconic fish, once a cornerstone of Welsh ecology and culture, has declined rapidly in Welsh rivers and may even be on the brink of disappearing completely from some. The IUCN Red List, a global barometer of biodiversity, has delivered a stark verdict: endangered.

Photo 1 Atlantic Salmon (c) Peter Lewis NRW

Conservation status – IUCN red list Wales: Endangered

Intervention type: river restoration

Atlantic salmon start their life in freshwater and after 1-2 years undergo metabolic changes (smoltification) that enables them to migrate to the sea (Hendry K & Cragg-Hine D 2003). After spending one of two years (sometimes longer) on an extensive migration across the North Atlantic, the now much larger adults, then return to Welsh rivers to breed, typically from spring to late autumn. Usually, salmon return to their native river to spawn, and even the same stretch of stream from which they were born, with amazing accuracy (NatureScot 2025).

Worryingly, Atlantic Salmon populations in Wales have declined at unprecedented rates over the past decade. The recent IUCN Red List assessment of extinction risk for fish in Great Britain and in Wales has categorised Atlantic salmon as endangered (Nunn *et al*. 2023). Atlantic salmon are under threat not only in Wales but throughout most of their range, but there are indications that they could disappear completely from some Welsh rivers within the next few decades (Milner & Garcia de Leaniz, 2023). On-going work to assess the pressure on salmon in Wales highlights ‘climate change changing weather patterns / river temperatures’ as the most significant impact in Wales in terms of impact and likely future development (NRW, 2024b). This threat was highlighted during the particularly warm and wet winter of 2015, which caused a near collapse of salmon recruitment in 2016. High river temperatures and flooding hampered spawning and the survival of young salmon emerging from river gravels in the spring (Gregory *et al* 2020).

Poor survival at sea, however, seems to be the having the most damaging impact. Where the return rates for salmon migrating to sea used to be 10-20%, currently they are typically less than 3% (ref). The causes of reduced sea survival are not fully established, but climate driven changes in sea surface temperature and food availability, as well as high sea fisheries bycatch, have been implicated (Thorsad *et al* 2021). It is also possible that factors affecting young salmon in freshwater may affect sea survival, for example by reducing the size and fitness of ocean bound smolts (Thorsad *et al* 2021).

For some years, salmon numbers in particular have experienced a pronounced decline across their southern Atlantic range. On all Welsh rivers, this means that, on many rivers, the numbers of fish returning to spawn are now below safe levels. NRW’s Dee Stock Assessment Programme has been monitoring the abundance and composition of salmon populations in the Welsh Dee for the last 25+ years. Returning adults are caught, measured and tagged at Chester Weir and Weir and the seaward migrating smolts assessed as they migrate downstream. We also survey juvenile abundance in the spawning tributaries. Such intensive and long-term (‘index’) programmes are rare throughout Europe and North America, but the biological information they collect plays a key role in developing our understanding of how and why populations change and informs our response in trying to manage and mitigate adverse changes (NRW 2024).

The River Dee is one of 6 Special Areas of Conservation designated for Atlantic Salmon in Wales, it is also probably the most regulated river in Western Europe, providing drinking water for a large population in NW England and NE Wales, in addition to providing water for the Shropshire Union Canal (NRW 2022).

The LIFE Dee River project is a £6.8m initiative, which aims to transform the River Dee and its catchment by restoring the ecological function of the river and its riparian habitat. Running from 2019 to 2026, this project will bring many benefits to the environment, most notably by improving the quality and accessibility of habitat on which salmon and other fish populations depend. The project aims to fully or partially remove five weirs that impede fish migration on the Dee and to tributaries and install fish passage solutions in a further six weirs. So far, we have fully removed three barriers on the Afon Tryweryn, Morlas and Meloch, and altered three other weirs including two in Llangollen and one at Nant Gwryd in the Ceiriog Valley. This will increase access for fish and improve hydro morphology in 33km of river.

This LIFE Dee River project aligns with our national and international commitments to biodiversity conservation. It demonstrates how we can reconcile human needs with the needs of nature. By restoring the Dee, we are not just saving a fish; we are safeguarding a vital ecosystem, strengthening our connection to the natural world, and ensuring a more sustainable, resilient river for the future.

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North West Wales

Whiteworm lichen Thamnolia vermicularis

Photo 2 Thamnolia vermicularis, Romania, by Schaude, published under the terms of the GNU Free Documentation Licence

Conservation status – IUCN red list Wales: Critically Endangered (Potentially Extinct)

Intervention type: SSSI surveillance

The whiteworm lichen *Thamnolia vermicularis* is a widespread species in the far north of Eurasia and North America, also growing on exposed mountain ridges further south in Europe (ref). It inhabits very open, lichen-rich heathland with a very limited cover of grasses and dwarf shrubs and is able to survive extreme cold and regular snow cover (ref). The southernmost British records are from Cadair Idris, where it is a notified SSSI Feature, and it has been recorded in Wales from eight sites on four mountains in total, the remainder being in central Eryri.

As recently as 2003, whiteworm lichen was widely distributed on the summit ridge of Cadair Idris. However, a brief visit in 2019 failed to locate any patches of this distinctive lichen and there were concerns that it might have declined. NRW commissioned an expert on montane vegetation to survey all of its former sites. This survey was carried out in 2022, and involved close examination of extensive areas of vegetation, often on hands and knees and sometimes in very poor weather.

The results were worse than feared: no *Thamnolia vermicularis* was found on any of its former sites. The open vegetation in which it formerly grew on Cadair Idris has been replaced by a closed sward of grasses and sedges, leaving no space for the lichen to grow.

Turner (2022) highlights three potential causes of the extinction of whiteworm lichen in Wales: Climate Change, long-range air pollution by nitrogen compounds, and sheep grazing and dunging favouring grass growth. It seems likely that all three factors have combined to cause the closing in of open habitat on our mountain tops, leading to the loss of this lichen and also to declines in other specialist lichens, bryophytes and invertebrates.

People tend to think that species found in remote areas are safe from harm, but Climate Change and air pollution are affecting species across the whole of Wales. Sustainable Farming Scheme actions to reduce ammonia pollution in lowland Wales can therefore help safeguard our montane ecosystems, as can global action to halt Climate Change. There is also a tendency to think that extinction is a potential problem for the future, but that we can make changes now to stop those extinctions from happening; the loss of whiteworm lichen less than 20 years since it was last found 'doing well' shows that extinctions are happening right now in Wales and that significant action is needed now for many rare species.

The *Species in Peril* report (Bosanquet, S. *et al.* 2025) identifies 304 species that have been lost from Wales since systematic biological recording began in the 1800s, of which 114 were last seen in Wales in the 1950s or later. 11 Welsh species have slipped into extinction since 2000, tabulated below, mostly from very limited former Welsh ranges because of their ecological specialisms. Many more are perilously close to extinction: *Species in Peril* lists 2956 species that are known from five or fewer Welsh sites, almost any of which could be lost from Wales if their habitats deteriorate.

Table 2 Post-2000 species extinctions in Wales and the likely cause of losses (from Species in Peril report).

Scientific name	English name	Reason for Extinction in Wales
Anas acuta	Pintail	Low level breeding from 1988 to 2004
Bryum calophyllum	Blunt Bryum	Loss of dune pioneer dune slacks to vegetation succession
Chaenotheca phaeocephala	Dark-headed Pinhead-lichen	Lost to timber treatment of wooden barns
Daphne mezereum	Mezereon	Lack of woodland management
Emberiza calandra	Corn Bunting	Agricultural intensification and population fragmentation
Lycia zonaria	Belted Beauty	Loss of open dune grassland to vegetation succession
Meesia uliginosa	Broad-nerved Hump-moss	Loss of dune pioneer dune slacks to vegetation succession
Odontomyia hydroleon	Barred Green Colonel	Loss of open seepages to vegetation succession
Podalonia affinis	Mud Wasp	Loss of bare sand?
Streptopelia turtur	Turtle Dove	Agricultural intensification and population fragmentation
Thamnolia vermicularis	Whiteworm Lichen	Climate change and air pollution

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Mid Wales

Invertebrates of Welsh Exposed Riverine Sediments

Photo 3 Wolf spider, *Arctosa cinerea*, August 2023 © NRW (Godfrey, A. 2024)

Exposed Riverine Sediments (ERS) are mineral deposits of sand, gravel, pebble and cobble bars in river channels, usually without or with limited vegetation cover, that are exposed during low flows, particularly in the spring and summer. They are very dynamic and mobile habitats, dependent upon constant erosion and deposition and, as such, are highly sensitive to changes in river flow patterns. The scouring action of winter floods plays a vital role by removing vegetation and flushing out organic matter that would promote plant growth and creating and re-working ERS bars to provide pioneer conditions. ERS can represent one of the few natural habitats left in highly modified landscapes (Eyre & Lott, 1997).

ERS which are reliant upon dynamic and open conditions. Welsh rivers rank as some of the most important for ERS invertebrate assemblages in the UK, with eight having nationally important faunas – Mawddach, Monnow, Rheidol, Tywi, Upper Severn, Usk, Wye and Ystwyth. ERS invertebrate assemblages are SSSI qualifying features on six of these. Together, these rivers support 225 UK and Welsh specialist ERS species including 114 beetles, 100 flies, nine spiders and two bugs (Howe, 2020). Key species include Minutest Diving Beetle *Bidessus minutissimus*, which in the UK is mostly restricted to Welsh ERS, Newbery's Rove Beetle *Thinobius newberyi*, Shingle Rove Beetle *Meotica anglica*, Pale Pin-palp *Bembidion testaceum*, Five-spot Ladybird *Coccinella quinquepunctata*, Southern Silver-stiletto *Cliorismia rustica*, Yellow-tipped Soldierfly *Oxycera terminata* and the wolf spider *Arctosa cinerea*.

ERS has suffered major losses and on Welsh rivers there has been a halving in ERS since the 1940s to 3,000,000 square metres and a decline in the number of ERS bars by 30% (Brewer *et al*., 2006). Longer-term data for four rivers (1890 to 2002) has confirmed these trends and suggest that the 1990s represented a low point in ERS abundance, although losses continue (Brewer & Swain, 2010). The reduction in ERS has been attributed principally to the increase in the amount of vegetation on active and formerly active bars as a result of river engineering. Continuing threats to the remaining Welsh ERS resource include engineering to alleviate flooding and reduce river flow rates, removal of gravels to protect infrastructure such as bridges and roads and for hardstanding for livestock, the compaction and eutrophication of sediments by cattle, siltation, agricultural runoff and vegetational succession as sediments become less mobile.

Recent surveys of the Welsh ERS invertebrate fauna have been few. Buglife undertook a survey of the fly faunas of UK ERS in 2005 which included key ERS stations on the River Monnow and River Usk (Drake *et al*., 2007, 2010), and the University of Birmingham has continued its studies on the fauna of the Upper Severn ERS (Henshall, 2011; O'Callaghan, 2011). To address this, Natural Resources Wales commissioned a survey of the fauna of the Llanelltyd ERS on Afon Mawddach in 2016 (Fowles, 2016), as well as targeted searches in 2018 for Newbery's Rove Beetle on the Afon Rheidol and Afon Ystwyth and Yellow Crucifer Weevil *Aulacobaris lepidii* on the River Dee (Fowles, 2018). More recently, ERS faunas on the Afon Tywi were surveyed in 2023 (Godfrey, 2024) and on the Rheidol and Ystwyth in 2024 (Ramsay, in prep).

Twelve of the 44 ERS specialist species on the Mawddach were recorded at Llanelltyd in 2016, and the need for reprofiling the main bar or at least removing encroaching birch saplings to prevent the loss of open sediment to established vegetation was highlighted (Fowles, 2016). Newbery's Rove Beetle was not found at Gro Ty'n yr Helyg SSSI on the Ystwyth where most of the former bar has been lost, nor on Rheidol Shingles & Backwaters SSSI where the original site now supports dense willow carr (Fowles, 2018). Other previously suitable bars on the Rheidol have also scrubbed over or have a high silt load in the sediment. The Yellow Crucifer Weevil, last seen on the Dee in 1998, was not found at any of the five sites surveyed where a combination of vegetation succession and livestock grazing resulted in little exposed sand and a scarcity of its foodplants (Fowles, 2018).

A survey of Afon Tywi ERS invertebrate fauna from June to September 2023 was the first detailed assessment since 1998 (Godfrey, 2024). A total of 45 ERS specialists were recorded from twelve sampling sites between Carmarthen and Llandovery including Minutest Diving Beetle and Newbery's Rove Beetle. Eleven species were new to the Tywi including two new to Wales – Eugen's River-splay Cranefly *Rhabdomastix eugeni* and the scatopsid fly *Rhegmoclemina lunensis*. As a result, the cumulative list of Tywi ERS specialists now stands at 106 species. The survey also found the water beetle *Pomatinus substriatus* on the Tywi for the first time since 2003 where it is associated with submerged logs and stone or exposed tree roots. Whilst the Tywi still supports a nationally important ERS invertebrate fauna, management issues were encountered at all twelve sampling sites. Himalayan Balsam and/or Japanese Knotweed were a problem on most sites, with cattle trampling and dunging, small scale gravel abstraction, water abstraction and silt deposition also noted at some.

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South West Wales

Barbastelle bat Barbastella barbastellus

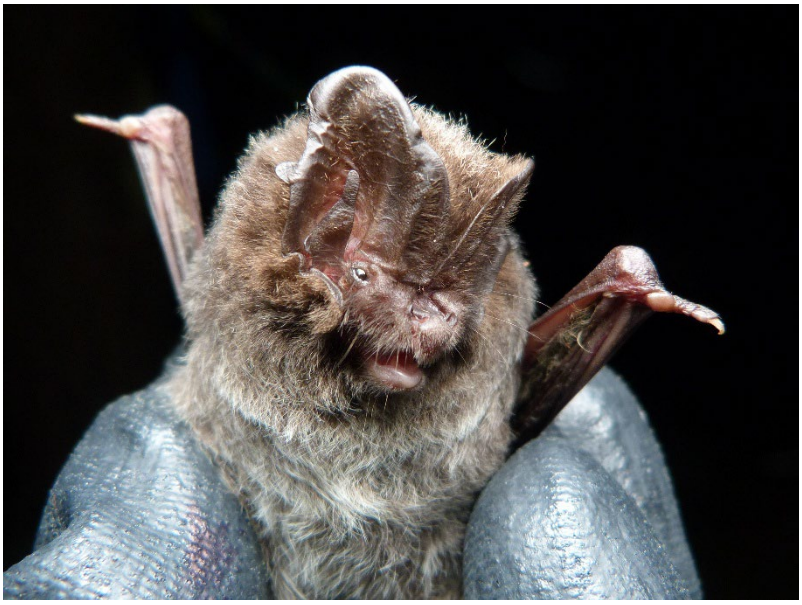

Photo 4 Barbastelle bat (c) Sam Dyer, NRW

Conservation status – IUCN red list GB: Vulnerable

Intervention type: Habitat creation

The barbastelle is one of the UK's rarest bat species, with an estimated population of 500 in Wales (Battersby, 2005). A study in 2024 by Razgour et al found Britain's barbastelle population have dropped by 99% over several hundred years. In Wales, their only confirmed breeding colonies occur within Pembrokeshire, making it an isolated stronghold for the species.

They are a woodland specialist bat, relying on crevice type roosting features synonymous with decay processes of old growth, particularly broadleaf, woodland with plenty of growth variance, standing deadwood, and dense understory (Greenaway, 2004). They can travel up to 20km from their roosts to feed, so rely on having a varied wider landscape of grassland and flowering meadow, waterways, mature hedgerows and treelines for effective foraging (Hillen et al, 2009; Zeale et al, 2012; Ancillotto et al, 2014). Barbastelles are specialist feeders, with up to 95% of their diet being made up of lepidoptera (moths) (Sierro and Arlettaz, 1997). Their complex roosting ecology is impacted by deforestation and unsensitive woodland management; combined with significant insect decline the species faces significant challenges (Carr et al, 2020). Their apparent isolation in Pembrokeshire also threatens to affect the resilience of the species in Wales.

Barbastelles are notoriously difficult to find and monitor due to a variety of reasons including their light and sound sensitivities, reclusive nature, tendency to roost in small colonies and switch roosts every two to three nights (O'Malley et al, 2023). A single colony can have over 50 different roosts in a forested area at any one time (Hillen et al, 2010; Zeale et al, 2012), and their tendency to move around more than many bat species makes it difficult to track colonies, get accurate colony counts and pinpoint roost trees in order to protect them. This has historically made monitoring and understanding barbastelle populations a conservation challenge.

In 2023, K O'Malley published his PhD thesis which included simplifying the process of finding the presence of maternity colonies using data collected through passive acoustic surveys. O'Malley created a methodology for carrying out surveys which optimised barbastelle detection and created thresholds to determine the probability of finding a barbastelle maternity roost within the immediate area, significantly increasing survey success. It is this methodology which has been adopted for use in the Natur am Byth Barbastelle Bat Project's surveys, and which is being carried out by dedicated volunteers. Data collected from passive surveys will inform more advanced methods of monitoring, including radio tracking and possible genetic testing, so that a more detailed understanding of Pembrokeshire's barbastelle population can be formed, thus enabling conservationists to continue to protect them long into the future.

The project is also tackling the threat of habitat loss by creating new habitats and identifying those areas in most need. Working with local community groups, specialised bat boxes are being built and installed around the county to increase the number of roosting options in areas of known barbastelle activity. Though the boxes were designed for barbastelles, studies indicate that they are used by a wide variety of bat species. Tree veteranisation for bats is a relatively new technique of habitat enhancement, we are creating immediate and future bats roosts in younger trees by creating features that accelerate the development of microhabitats associated with large, old trees. The project is working with bat-specialised arborecologists to provide training on this work for tree surgeons and create veteranised features at a number of key sites around Pembrokeshire.

It is hoped that the methods developed in Pembrokeshire can be used in other areas of Wales where it is suspected that small populations exist, and to help build a better understanding of this rare species in Wales.

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South Central Wales

This case study explores the collaborative efforts led by Natural Resources Wales (NRW) to reintroduce and recover Shore Dock populations in the Southerndown Coast Site of Special Scientific Interest (SSSI) along the Glamorgan Heritage Coast

Shore Dock Rumex rupestris

Photo 5 Shore Dock, *Rumex rupestris,* planting in the Southerndown Coast SSSI (c) NRW

Conservation status – IUCN red list Wales: Vulnerable

Intervention type: Conservation Translocation - Reintroduction

Shore Dock (*Rumex rupestris*) is one of Europe's most threatened endemic vascular plants. The UK is the world stronghold for this globally threatened coastal plant, which has faced significant challenges in Wales due to habitat loss, erosion and more frequent extreme weather events, driven by climate change (JNCC).

Shore Dock is a coarse, stout perennial, 30-50(-70) cm tall, with one or more woody shoots from the stock. It has basal leaves of 10-30cm that are thick dull-green, glaucous, oblong or broadly ovate-lanceolate. Plants form a large, woody rootstock which can last for at least 10 years (Daniels et al, 1998).

Within Wales, Shore Dock is currently found only in coastal areas on Anglesey and in Pembrokeshire (BSBI Plant Atlas, 2020), with the latter's population significantly reduced by storms in 2013 and 2014. Shore Dock is now extinct from the Dunraven Bay SAC on the Glamorgan coast, with the last recording of its presence in 2018. Dunraven Bay SAC was notified as a SAC due to the presence of Rumex Rupestris and without its presence will never achieve favourable condition (Mitchell D, 2008).

In 2022 NRW commissioned a feasibility study into Shore Dock reintroduction, with the hope to restore it to the Dunraven Bay SAC and Southerndown Coast SSSI (Wilson 2023).

Following the study a collaborative project led by NRW was granted funding by Welsh Government's Nature Networks fund, aiming to restore Shore Dock back to its indigenous range along the Southerndown Coast SSSI, recognising the intrinsic value of this rare species, on the brink of disappearing forever.

This kind of project is a conservation translocation, defined as the process of moving plants or animals from one location to another to help conserve a species. This can involve relocating them to areas where they used to live, referred to as reintroduction, or to new places where they can thrive. Reintroduction proposals into protected areas requires careful planning before planting. All conservation translocation proposals in Wales are assessed by NRW using the IUCN guidelines, which provides a comprehensive framework to plan and implement conservation translocations effectively and responsibly (IUCN 2013).

Fortunately, the seed from the Shore Dock plants in Dunraven Bay were collected and banked prior to its extinction, allowing the National Botanic Garden of Wales to grow new plants. Surveys undertaken to identify suitable locations found 11 sites that had some of the correct criteria, such as being flushed, stable ground, vegetation that would not out-compete the Shore Dock, and access to the site. Of those 11 sites, two met all the requirements and were chosen for the reintroduction. In spring 2024 64 plug plants were transplanted to the selected sites, with some additional seed scattering.

The goal for the success of this restoration project is for few populations with several plants reaching maturity, flowering, fruiting and setting seed, this would prevent the need for future interventions at these sites. Therefore, the requirement for future and ongoing monitoring is essential and once the population restoration has been completed, the sites where plants were planted will be monitored yearly to assess the success.

Early surveys have indicated 73% of the plug plants were successfully located. However, there were no signs of germination in the sown seeds, monitoring will resume in spring 2025.

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South East Wales

Wales plays a crucial role in the global effort to halt the extinction of the Eurasian curlew, a species facing significant decline. Wales is home to a notable portion of the UK's curlew population and therefore the conservation interventions in Wales directly impact the overall survival of the species in the UK and beyond

Eurasian Curlew Numenius Arquata

Photo 6 Eurasian Curlew, *Numenius Arquata* (c) Gary Jones/ Clwydian Range and Dee Valley National Landscape

Conservation status – IUCN red list GB: Endangered

Table 3 IUCN Red List Status of the Eurasian Curlew

Global	Europe	GB
NT[1]	**NT**	**EN[2] (br)**

[1] Near Threatened; [2] Endangered

Table 4 Birds of Conservation Concern (BoCC) Status of the Eurasian Curlew in the UK and Wales

UK 2021	Wales 2002	Wales 2010	Wales 2016
Green	Red	Red	Red

Intervention type: Species Recovery

Why do we need to recover breeding Curlew in Wales?

In common with much of the UK and many other parts of Europe, all of Wales' grassland breeding waders: Eurasian curlew (*Numenius arquata*), common redshank (*Tringa Totanus*), European golden plover (*Pluvialis apricaria*) and northern lapwing (*Vanellus vanellus*) are in significant decline both numerically and spatially.

The Eurasian Curlew ("Curlew") is a migratory species in need of urgent conservation action both in the UK (Stanbury *et al.,* 2021) and Wales (Johnstone *et al*., 2022). Owing to rapid national declines and the global importance of the UK breeding population, the Curlew is considered to be the most pressing bird conservation priority in the UK (Brown *et al.,* 2015.) including Wales. The Curlew is predicted to be on the brink of extinction as a viable breeding species in Wales by 2033 (Taylor *et al*., 2020).

Recent Breeding Bird Survey (BBS) data suggest a significant trend change of 77% decline over the last 27 years (1995-2022) and a significant 46% decline in the last ten years (2012-2022) (Heywood *et al*., 2024). These are the largest declines for this species in the UK.

In the absence of contemporary survey data, estimates of the Curlew breeding population range from 400 (extrapolation from a small sample repeat survey) to no more than 1,700 breeding pairs (Taylor *et al.,* 2020). However, consider a Welsh breeding population of 400-500 pairs. Though Wales and the Island of Ireland hold <2% of the UK breeding population, the loss of these populations would have a significant impact on UK and European range maintenance.

Key drivers of Curlew declines

The key driver of Curlew population change is low breeding success. . The maintenance of a stable breeding Curlew population requires an annual productivity of 0.6 fledged chicks per pair. Current productivity in Wales is estimated at 0.3 fledged chicks per pair per year as a result of a combination of three significant pressures: habitat loss, unfavourable habitat management and nest/chick loss to predation and grassland cutting practices. The impact of predation of Curlew eggs and chicks by meso-predators such Red Fox *Vulpes vulpes* and Carrion Crow *Corvus corone* is a significant driver of poor breeding success.

What is being done to aid Curlew recovery in Wales?

The Welsh Curlew Conference held in 2018 brought together a broad range of organisations to work together to benefit curlew and led to in 2019 the creation of Gylfinir Cymru /Curlew Wales, a partnership of 19 organisations from Government, Agency, conservation, farming and game sectors.

The *Wales Action Plan for the Recovery of Curlew* [Recovery Plan | Curlew Wales] was published by Gylfinir Cymru in 2021 identifies the outcomes required to achieve a sustainable recovery in the long-term, especially those interventions relating to land-use management.

The Action Plan identifies twelve Important Curlew Areas (ICAs) each with a lead organisation to develop and deliver beneficial management for breeding Curlew. Since 2020, several collaborative Curlew projects have been undertaken within a number of these ICAs (1, 2, 3, 5, 9 and 12) to aid Curlew recovery by implementing intervention measures such as habitat management, predator control, anti-predator fencing, delay grassland cutting and communication engagement.

Within ICA 7 (Fenn's and Whixall Moss) the National Nature Reserve staff are working with their team of volunteers to benefit breeding Curlew and other grassland breeding waders. In recent years the deployment of anti-predator electric fencing has been undertaken to protect the nests, with predator control also undertaken in the area. Studies have suggested electric fencing increases hatching rate from 20% to 87% in areas with no formal predator management and from 66% to 0.92% in areas with predator management (Ewing et al., in prep). A drone equipped with thermal imagery allows effective Curlew survey of nests and chicks to be carried out on this difficult terrain. This use of modern technology can also benefit breeding Curlew in other areas of Wales. For example, Curlew nests and chicks in hay or silage fields can also be monitored quickly by drones. This vital information can then be used to direct management such as delayed mowing or changes to stock management.

Curlew require a large and coherent network of heath and grassland landscapes that are actively managed to influence breeding success, such management will also provide habitats to benefit other biodiversity priorities and underpin ecosystem resilience. Extensive knowledge of how breeding Curlew utilise habitats to meet their ecological requirements for nesting, chick rearing, feeding and roosting has been gained through the deployment of GPS tags on nearly 40 adult Curlew in both upland and lowland farmed landscapes, throughout Wales (Taylor *et al.* 2020; Mitchell *et al*., 2025).

NRW commissioned and published a report on the wider societal, biodiversity and ecosystem benefits of Curlew recovery in Wales (Goodall *et al*., 2023) and suggested a minimum of 84 species across different taxonomic groups may benefit either directly or indirectly. This includes 20 species of birds listed as Birds of Conservation Concern 4 (BoCC4) Wales and 26 additional species of bird, mammal, reptile, amphibian and invertebrate listed on Section 7, Environment (Wales) Act 2016).

The development and delivery of the Sustainable Farming Scheme to provide long term, landscape scale management along with continued partnership working is vital if the iconic call of breeding Curlew is still to be heard across our farmed landscapes in years to come.

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Marine - South Central Wales

Saltmarsh plays a crucial role in supporting biodiversity, protecting coastlines, and mitigating climate change. This case study explores the significance of saltmarshes in Wales and the conservation actions being undertaken to preserve and restore these valuable ecosystems.

Photo 7Saltmarsh Severn Lower, 2017 (c) NRW

Saltmarsh – Annex I feature of Severn Estuary SAC

Intervention type: Restoration of saltmarsh through polders creation

Saltmarsh habitats form an important part of the health and stability of coastal ecosystems, and their conservation is vital for protecting the diverse range of species that depend on them. They are also highly efficient at capturing and storing carbon dioxide from the atmosphere. A hectare of saltmarsh can capture up to two tonnes of carbon annually, making them crucial in the fight against climate change (WT add ref) and are considered one of the most efficient ecosystems for carbon sequestration (Gore *et. al*. 2024).

Saltmarshes at Rumney Great Wharf (RGW), on the Severn Estuary, have been undergoing long term erosion (Armstrong *et. al*. 2021). This is problematic both from a nature conservation perspective (loss of a priority habitat) and from a flood defence standpoint (the saltmarsh dissipates wave energy in advance of an adjacent flood embankment). It is important to protect the saltmarsh and delay the need for further hard engineering. The nature based solution is one approach, common in the Wadden Sea and other low energy locations, is to construct 'sedimentation fields' out of brushwood fencing; these reduce tidal flows, promote mud accretion and saltmarsh vegetation colonisation.

Sedimentation polders consist of rectangular fields made by inserting long wooden posts into the mud and attaching brushwood in between them. As the tide goes in and out, mud settles out from the sea and is retained within the polder. Over time, the mud builds up sufficiently to allow saltmarsh plants to grow.

In 1999 and 2005, sedimentation fields were installed at RGW. Success was variable, substantial accretion and saltmarsh development occurred in the polders to the east of the site, but little change was noted further west. However, minimal maintenance was conducted, meaning only posts remain. A lack of monitoring means the reason for failure is unknown. It has been postulated that the large tidal range and wind-wave exposure in the Severn Estuary contributed to the variable performance.

Following a feasibility study (Armstrong *et. al*. 2021), it was decided to reinstate and extend the polder scheme. The aim was not only to protect the saltmarsh but treat the project as a pilot study with detailed monitoring to understand the benefits of polders in high energy environments.

The 10 week construction phase was undertaken in summer 2024 (Photo 4). Valuable lessons on construction methodology were noted: particularly related to required brushwood quantities and the need to re-tension ties after a bedding-in period.

This project will help restore the important saltmarsh habitat of the Severn Estuary, supporting local wildlife and helping to trap carbon. This nature based solution could also help to enhance the existing flood defences and reduce future flood risk by reducing pressure from erosion.

The project was funded through the Welsh Government funded Nature Networks programme (2022-2025) which aims to increase environmental resilience and biodiversity.

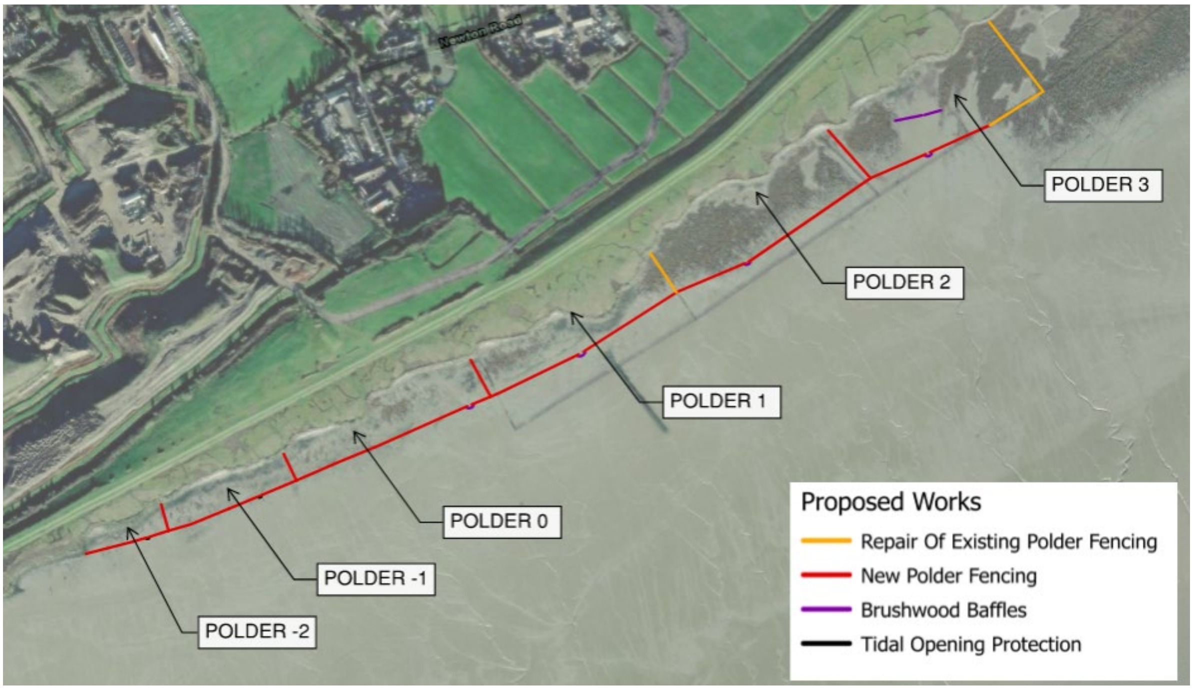

Photo 8 The polder fencing design at Rumney Great Wharf, the remains of the previous polders can also be seen

Photo 9 Polder construction in August 2024.

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Wales National SMNR assessments

Using the evidence from the eight ecosystems and three natural resource assessments, along with other national evidence, we describe progress against the four aims of SMNR at an all-Wales level. This updates the SoNaRR2020 assessments.

Aim 1 assessment: Stocks of natural resources are safeguarded and enhanced

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Executive summary

This assessment evaluates Wales' progress towards Aim 1 of the sustainable management of natural resources (SMNR): to safeguard and enhance stocks of natural resources. It takes a broad view of natural resources, including wild species, air, water and soil, and is not confined to economically valued stocks (which are mostly considered in the Aim 4 assessment).

Despite strong legislative foundations, including the Environment (Wales) Act 2016 and the Well-being of Future Generations (Wales) Act 2015, Wales is not yet achieving this aim. Natural resources—such as air, water, soil, and biodiversity—continue to be degraded. Evidence shows widespread pressures across ecosystems, including unsustainable land use and management, and pollution of air, water and soil. Climate change is intensifying these pressures, with more frequent extreme weather events affecting resource stability and resilience. Invasive non-native species, pests, and diseases further threaten biodiversity and ecosystem function.

Some progress has been made, including peatland restoration, improved air quality legislation, and legacy pollution remediation. However, these efforts are not yet sufficient to reverse long-term trends.

Transformative change is needed—across food, energy, housing, and transport systems—to regenerate natural resources and reduce Wales' global ecological footprint. This requires integrated action across sectors, improved monitoring and research, and community engagement. Most fundamentally, this transformation requires changes in how we value and view nature.

This all Wales Aim 1 assessment synthesises evidence from across SoNaRR 2025 and signposts to related assessments under Aims 2, 3 and 4. It outlines opportunities for action and highlights priority areas for safeguarding and enhancing Wales' natural resources.

Vision for Aim 1

Success would see Wales using natural resources in a way that enables their quantity and quality to improve over time, not be degraded. In this vision, Wales' ecosystems are resilient and able to regulate, maintain and provide natural resources which benefit the people of Wales. Our economy and culture not only protect natural resources and ecosystems from pressures that would degrade them, but also work to improve the quantity and quality of natural resources in Wales and those from around the world that are used by Wales. Use of non-renewable resources would be managed to reduce impacts on ecosystems and to move towards renewable alternatives.

Key messages

Wales is not yet safeguarding and enhancing stocks of natural resources – transformational change is required.

Despite policy frameworks like the Environment (Wales) Act 2016 and the Well-being of Future Generations (Wales) Act 2015, evidence shows that Wales is not sufficiently safeguarding or enhancing its natural resources. Species decline, habitat degradation and pollution of air, soil and water, indicate that current efforts are falling short of reversing degradation or improving resource stocks. We need to transform our food, housing, transport and energy systems so that they no longer degrade our natural resources.

Pollution and land use pressures are undermining resource quality.

Intensive agricultural management, urban development, wastewater and transport are major contributors to pollution across Wales. Nutrient pollution, ammonia emissions, and chemical contaminants are degrading soils, water, and air quality. These pressures are reducing the resilience of ecosystems and the quality of natural resources.

Some progress has been made, but systemic change is essential.

Initiatives such as peatland restoration, the Wales Metal Mines Programme, promotion of resource efficiencies, and air quality legislation represent positive steps toward resource protection. However, these actions are not at the scale or pace required to reverse long-term trends. Site-based restoration and protection remain critical, but to achieve Wales' bold '30 by 30' commitment, to protect 30% of land, freshwater and sea by 2030, these efforts must be accompanied by deeper shifts in the systems that currently drive degradation and unsustainable exploitation. Only then can our natural resources to be truly safeguarded.

Climate change is intensifying risks to natural resources.

Changing rainfall patterns, extreme weather events, and rising temperatures are putting our natural resources under increasing stresses. Peatlands, which store significant carbon and regulate water, are particularly vulnerable. Climate change is also compounding the effects of pressures from invasive non-native species (INNS), pests and diseases to further threaten wildlife, ecosystem resilience, and economically valued productivity. Without targeted adaptation and mitigation, climate change will further erode the quantity and quality of Wales' natural resources.

Evidence gaps hinder effective action and monitoring

Significant evidence gaps exist across many areas including soil health, ecosystem resilience, water management, invasive species, climate impacts and marine pressures. We need evidence to assess progress, prioritise where to target resources and design effective interventions. Addressing these evidence needs is critical to safeguarding and enhancing natural resources.

Introduction

Since the publication of SoNaRR2020, the nature and climate crises have deepened, further impacting on the world's ecosystems and their ability to generate and regulate the natural resources we rely on. Seven out of nine planetary boundaries have been crossed (PBScience, 2025), suggesting that "Earth is now well outside of the safe operating space for humanity" (Richardson *et al.*, 2023). Whilst Wales has made progress on carbon emissions, estimates of our global ecological footprint indicate that we would need around 2 planet Earths to sustain us if everyone lived as we do in Wales (Lin, D. *et al.*, 2023). Within Wales, species are declining and pollution threatens our air, soils and water (see SoNaRR 2025 ecosystem and resource assessments). It cannot, therefore, be said that we are achieving Aim 1 of the sustainable management of natural resources: we are not sufficiently safeguarding or enhancing our natural resources.

Aim 1 of the sustainable management of natural resources requires us to not only protect our natural resources from pressures that degrade them, but also to improve the quality and (where appropriate) the quantity of those natural resources. The conception of natural resources embodied in the Environment (Wales) Act 2016, and in SoNaRR, is a broad one which encompasses not only stocks of economically valued timber, gravel or fish, but all of the components that make up our natural world, including (but not limited to):

- animals, plants and other organisms.
- air, water and soil.
- minerals.
- geological features and processes.
- physiographical features.
- climatic features and processes.

All of the Aims of SMNR are interrelated and dependent on each other. Ecosystems cannot be resilient (Aim 2) if the natural resources which sustain them are polluted, degraded or insufficient. Likewise, resilient ecosystems (Aim 2) create, maintain and enhance natural resources through their functioning. Resilient ecosystems and plentiful, good quality natural resources are essential for providing healthy places for people (Aim 3). Our economy (Aim 4), extracts and uses natural resources and, in its current form, places pressures on our natural resources, degrading their quality and quantity. The vision for Aim 4 is for the economy to work with nature to regenerate our natural resources and ecosystems.

SoNaRR 2025 attempts to assess Wales' progress against each of these aims, although of course no one assessment can be understood in isolation, nor can one Aim be seen as the start of what is a continuous circle. This assessment of Aim 1 offers an overview and introduction to the state of natural resources in Wales, and our use of resources globally, but it cannot be understood without consideration of the other Aims assessments, particularly Aim 2 and Aim 4, which contain much of the detailed evidence and understanding essential to achieving Aim 1. This chapter will summarise or signpost to that evidence.

Objectives and structure of this assessment

This All Wales Aim 1 Assessment synthesises the relevant evidence presented in the SoNaRR 2025 ecosystem, natural resource and biodiversity assessments in order to assess Wales' progress towards safeguarding and enhancing our natural resources. It will also:

- Give a brief overview of evidence about the state of and pressures on our natural resources.
- Signpost to where this evidence is described in more detail in the assessments of Aims 2, 3 and 4.
- Report on actions that have been taken towards achieving Aim 1.
- Recommend priority actions that deliver on the safeguarding and enhancement of natural resources.

Since Aim 1 is particularly closely related to Aim 2 and Aim 4, this assessment should be interpreted in conjunction with the assessments of those aims.

Box 1 gives a brief introduction to Wales' natural resources.

Box 1: Wales' natural resources

Wildlife: Wales has long had rich and varied habitats with a diverse range of plant, animal and other organism species. However, Wales is now considered to be one of the most nature depleted countries in the world, and almost 1 out of every 5 species is at risk of extinction (Burns *et al.*, 2023). See Aim 2 and Biodiversity Assessment.

Timber: Timber removals in Wales between 2014 and 2023 averaged 1,266,000 green tonnes per year for softwood and 33,000 green tonnes per year for hardwood (Forest Research, 2024). The GVA (gross value added to the economy) of forestry and logging activities in Wales is estimated at £61 million in 2023 (Giannelli, 2025). See Aim 4.

Food: The agricultural sector makes use of over 90% of Wales' land area. The main component of this is permanent grassland for livestock grazing, with approximately 5% being arable cropland providing human food, livestock feed and bioenergy, and approximately 0.1% being horticulture and orchards (Welsh Government, 2024b). In 2021, approximately 90,000 tonnes of red meat were produced in Wales; and approximately 20,000 tonnes of fruit and vegetables are produced per year (Coles-Riley *et al.*, 2023). Shellfish and finfish are caught in Welsh waters by Welsh and non-Welsh boats. There is growing interest in seaweed farming and wild seaweed gathering. Food provisioning is discussed in SoNaRR 2025 Aim 4, Enclosed Farmland and Marine assessments.

Air: Long-term exposure to air pollution in Wales is estimated to have a health impact equivalent to 1,000–1,400 deaths per year and cost the country £1 billion per year in lost workdays and healthcare expenses (Welsh Government, 2025b). In 2021 99.1% of sensitive habitats in Wales exceeded their critical load for eutrophication (JNCC, 2024). 45.2% of land area in Wales exceeded the 1µg/m^3 critical level of NH_3 concentration which has been set to protect bryophytes and lichens . See Air assessment.

Soil: Wales' soil landscape is primarily agricultural, covering 90% of the land, with 70% classified as upland, and 85% as non-Best and Most Versatile (BMV) land. Peaty soils cover around 4% of Wales and store between 15% and 30% of Wales' carbon and intercept over a quarter of the UK's drinking water. Soils also support our special places with many designated sites having soil types and climate conditions that specifically support unique habitats and/or flora and fauna (Hannam *et al.*, 2022; Rowe *et al.*, 2024). See Soil assessment.

Water: Wales has a wet climate and currently stable quantities of groundwater, but rivers can suffer low flow in prolonged dry periods. Zones containing 70% of Wales' population could be in water deficit by 2050 unless efficiency measures are put in place now. Water quality is a complex picture, but the majority of water bodies have failed to achieve Good ecological or chemical Status (Water Framework Directive Regulations) and no major changes to this have occurred in the last 5 years. See Water assessment.

Minerals: Mineral resources have played a very important role in Wales' history with huge economic, socio-cultural and environmental impacts. Following a long history, metal mining has largely ceased and there is only localised coal mining and slate quarrying in Wales (NRW, 2016b). The aggregates industry is now the main mineral extraction industry in Wales, including marine and terrestrially derived aggregates. See Aim 4 assessment.

Geological features and processes: 'Wales has some of the most varied geology in the world representing all geological periods and spanning 1.4 billion years of the Earth's history. This diverse geology not only underpins our biodiversity and landscape but also provides important mineral resources.' (NRW, 2016b)

Physiogeographical features: Wales' inshore marine area covers just under 15,000 km^2 with over 2,700 km of varied coastline. Wales' land area is just over 20,000 km^2, with a wide range of geological features and habitats. The land is mainly upland and mountainous with some of the best agricultural land in the lowlands of the south. Numerous rivers and watercourses drain from the uplands.

Climatic features and processes: 'Wales has an essentially maritime climate, characterised by weather that is often cloudy, wet and windy but mild' (Met Office, 2016). However, climate change is already altering Wales' climate, increasing the likelihood of wetter winters, hotter, drier summers and more frequent extreme weather events. See Climate change chapter for details.

Energy: Although not considered as a natural resource within the Environment Act (Wales) 2016, it is worth noting that the natural resources of Wales have long enabled energy generation. A combination of climate and physiogeographical features enable renewable energy generation from solar, wind, bioenergy and hydropower sources. In the past, mineral resources enabled energy generation from fossil fuel sources. See Annex 6: Aim 4 Energy evidence.

Why Aim 1 matters to well-being in Wales

Aim 1 is essential to achieving the well-being goals of Wales, particularly:

- A prosperous Wales (goal 1)
- A resilient Wales (goal 2)
- A globally responsible Wales (goal 7)

Table 6 outlines how safeguarding and enhancing natural resources can contribute to achieving well-being in Wales, and which National Well-being Indicators are linked to that contribution. These indicators help tell a story of progress against the seven well-being goals of Wales. More information on the National Well-being Indicators can be found at: [Wellbeing of Wales: national indicators | GOV.WALES]

Table 5 National Well-being Indicators linked to the achievement of Aim 1 (stocks of natural resources are safeguarded and enhanced)

Contribution of SMNR	Linked National Well-being Indicator
Safeguard natural resources – reduce pressures on our natural resources (including reducing consumption and increasing efficiency of resource use) and protect against the damaging effects of those pressures	**Indicator 4:** Levels of nitrogen dioxide pollution in the air **Indicator 14:** The global footprint of Wales **Indicator 15:** Amount of waste generated that is not recycled
Enhance natural resources – regenerate the stocks of natural resources and improve their quality and quantity	**Indicator 13:** Concentration of carbon and organic matter in soil **Indicator 43:** Areas of healthy ecosystems in Wales **Indicator 44:** Status of biological diversity in Wales **Indicator 45** (Percentage of surface water bodies, and groundwater bodies, achieving good or high overall status)

Transformative change

Since the publication of the last State of Natural Resources Report (NRW, 2020b), and despite global efforts, the nature and climate crises have deepened as we continue on a course of business-as-usual over-exploitation and conflict. But there has also been an increasing shift in the thinking of global institutions (including the UN, IPBES, the EU, the Well-being Economy Alliance and the Dasgupta report on The Economics of Biodiversity (Dasgupta, 2021)) – all recognising the need for deep transformational change. This transformation needs to encompass not only the way we meet our needs for food, transport and energy (as highlighted in SoNaRR2020) – but we must also transform the way we measure our economy, the way we govern ourselves and the way we view nature and our place in it. In its 2025 assessment of transformative change, IPBES has described this as a need for "fundamental, system-wide shifts in views, structures and practices" (O'Brien *et al.*, 2025, p. 12). Their report "emphasizes that overcoming these challenges is not just a matter of what people do, in terms of strategies and actions, but also how they do it, in terms of principles and shifts in views, structures and practices, taking into account different visions, world views and values" (O'Brien *et al.*, 2025, p. 9).

This shift in thinking is supported by evidence from across the assessments in SoNaRR 2025, which show that if we are to safeguard and enhance our stocks of natural resources, we must act across sectors, changing our production and consumption of food, energy and materials, increasing equitable access to the benefits nature provides and working with people in their communities. As detailed in the assessment of Aim 4 on progress towards a regenerative economy, changing how we value nature on a personal, cultural and economic level are interlinked; and this fundamental change is essential to enable us to halt nature decline and achieve SMNR. Research from academics at Welsh universities is at the forefront of exploring how to widen the sorts of values used within the economics of biodiversity (Kenter *et al.*, 2025), recognising nonmaterial values that may not be able to be monetised. In order to do this, we must also "reimagine our relationship with the natural world" (Christie, 2025). See Aim 4 assessment for more discussion of valuing nature.

Policy and legislative framework

Wales has long been at the forefront of change and because of the innovative legal foundations already in place we are in a strong position to seize opportunities for change. Wales has a number of policy and legislative tools which should enable progress towards achieving Aim 1, particularly the Well-being of Future Generations (Wales) Act 2015 and the Environment (Wales) Act 2016. These two Acts put into law the requirement for public bodies to act to work towards the well-being of Wales now and for future generations, and to safeguard and enhance our natural resources through the sustainable management of natural resources. For discussion of other relevant legislation and policy frameworks, see the assessments for Aim 2, 3 and 4.

Overview of the safeguarding and enhancement of natural resources in Wales by natural resource

This section gives an overview of the main pressures on our natural resources, the state they are in and progress towards safeguarding and enhancing them. It is structured into sections by natural resource type, according to the different types of natural resources named in the Environment Act (Wales) 2016.

These natural resources provide immense benefits to the people of Wales – indeed without them our ecosystems would collapse, and our economy and society with them. The particular and varied benefits are not covered here as these are intended as brief, introductory summaries. More detail and evidence can be found throughout the other aims assessments, the ecosystem and natural resource assessments, and in the SoNaRR 2025 evidence portal.

Animals, plants and other organisms

Animals, plants and other organisms in Wales are under threat from a range of pressures including climate change, invasive non-native species (INNS), pests, diseases, management practices (particularly agricultural intensification), pollution and land use changes (including built development and infrastructure). These pressures are impacting different species and habitats in varied ways: for more details on this see Aim 2. For details on economically valued bio-stocks, such as timber and fisheries, see Aim 4. See the Biodiversity Assessment for more information on state and trends of species in Wales, including headlines from the First Habitats Regulations 9A Report for Wales 2025 (NRW, 2026).

The State of Nature (SoN) Report 2023 (Burns *et al.*, 2023) highlights that Wales is one of the most nature depleted countries in the world. It reveals that almost 1 out of 5 (18%) of species in Wales are at risk of extinction, and states that 95 species have already gone extinct in Wales since 1970 (Burns *et al.*, 2023). The SoN report finds that, historically, land management for agriculture and climate change have had the greatest impact on wildlife in Wales. Similarly, the SoNaRR 2025 Natural Resource Assessments highlight climate change and pollution from agriculture and land management as top pressures.

Nutrient pollution poses a significant threat to Welsh ecosystems. Many native plants are not adapted to high nutrient levels, and their decline due to pollution negatively impacts entire ecosystems, leading to a decrease in insects and birds. This evidence is supported by the report *We need to talk Nitrogen,* which highlights that 63% of the UK's most sensitive wildlife habitats are affected by excessive nitrogen (Plantlife, 2017). The report suggests that land-use change and agricultural intensification are dominant drivers of these pressures, with climate change also being a crucial factor. These findings are also supported by Habitat Regulation 9A reporting (NRW, 2026) (see SoNaRR 2025 Biodiversity Assessment for more information).

Around half of the species and habitats assessed in Welsh marine protected areas (MPAs) are in unfavourable condition (Hatton-Ellis, *et al.*, 2025). Although there are multiple causes, one of the main causes is water pollution. The condition of habitats outside MPAs is thought to be an equally mixed picture (NRW, 2026).

Invasive non-native species (INNS), pests and diseases also place pressures on Wales' ecosystems and the plants, animals and other organisms within them. INNS are recognized as one of the leading threats to global biodiversity, with an estimated economic impact of £343 million annually in Wales alone – impacting particularly on agriculture and forestry. INNS are recognised as a pressure within all of the eight ecosystem assessments in SoNaRR 2025. Over the past 50 years, the rate of new INNS establishment in Great Britain (GB) has surged, reflecting a worldwide trend driven by factors such as climate change and the increased movement of goods and people. Pests and diseases also pose a significant threat in a number of ecosystems across Wales, including marine, coastal margins, urban, woodland and enclosed farmland ecosystems, and they impact upon economically important sectors such as forestry and agriculture. (See SoNaRR 2025 INNS chapter for more detail.)

Direct exploitation of wild species, such as through the catching of shellfish and finfish, can exert pressure on the target species, and other species through by-catch. The evidence to determine whether marine fisheries in Welsh waters are sustainable or not is limited. By-catch is a significant threat to several species of marine mammal in UK waters and is of particular concern for certain fisheries operating in the wider Celtic and Irish seas and beyond. However, there is limited information on by-catch in net fisheries in Wales and further work is required to provide robust estimates in Wales. (See Marine assessment.)

We have a better understanding of Freshwater fisheries in Welsh rivers and lakes, particularly migratory salmonids and eels. Eel stocks internationally are currently below sustainable limits and NRW has effectively closed the fishery since 2021. Stocks of Atlantic Salmon are also below sustainable limits, with all 22 Principal stocks classed as At Risk. There is also increasing concern about sea trout fisheries with 32 of 33 stocks being classed as At Risk. Byelaws introduced in 2020 currently require all net and rod salmon to be released unharmed, and also provide size, method and season restrictions to protect sea trout. (See Freshwater assessment.)

Since SoNaRR2020, there have been many actions taken towards safeguarding and enhancing the plants, animals and other organisms in Wales. These include habitat restoration and INNS-management projects, as well as projects targeting particular species recovery (for example pine martens and red squirrels). In response to the rising threat of INNS, pests and diseases, various legislative and policy measures have been implemented in Wales that prioritise prevention and early intervention (see SoNaRR 2025

INNS evidence pack). These include the embedding of the Invasive Alien Species Order 2019, the implementation and refresh of the GB INNS Strategy (2023-2030), the establishment of the Great Britain Non-native Species Inspectorate and the Wales plant health sentinel site network, which monitors for plant pests, diseases and INNS (Welsh Government, 2022a). Other progress includes projects to reduce risks associated with wildfire, grant funding to support restocking of non-native woodlands following removal of infected larch, greater protection for woodlands in planning policy, and a focus on increasing urban tree-canopy cover through the development of strategies and targeted grant funding. Despite this progress, the future outlook for many of the pressures on our plants, animals and other organisms show likely deterioration unless action is taken to transform the systems which are driving them. See the Aim 2 assessment for more information on Wales' response to the nature emergency and bold ambition to achieve the '30 by 30' target to protect and effectively manage 30% of our land and sea for nature by 2030.

Air

Clean air is a vital natural resource, essential for human health and resilient ecosystems. Despite progress in reducing some pollutants, air pollution continues to impact our health and ecosystems (see Air assessment).

Key pollutants include nitrogen oxides (NO_x), sulphur dioxide (SO_2), particulate matter ($PM_{2.5}$ and PM_{10}), ozone (O_3), heavy metals (lead, cadmium, nickel), and persistent organic pollutants (POPs). These substances contribute to respiratory and cardiovascular issues, with $PM_{2.5}$ being particularly harmful due to its ability to penetrate deep into the lungs and bloodstream.

Ecosystems suffer from nitrogen and acid deposition, primarily driven by NO_x, ammonia (NH_3), and SO_2. Sensitive plant species, adapted to low-nutrient environments, are threatened by nutrient overload, leading to biodiversity loss and cascading ecological impacts. Ground-level ozone, formed through reactions involving NO_x, VOCs and sunlight, damages crops and habitats.

From 2005 to 2022, emissions of most pollutants declined, notably SO_2 (−78%) and NO_x (−61%), due to shifts in energy production and transport. $PM_{2.5}$ and PM_{10} emissions declined but are increasingly influenced by residential wood burning. Emissions of lead and benzo[a]pyrene (B[a]P) showed minor changes. However, NH_3 emissions rose by 2%. Agriculture currently contributes over 85% of the total ammonia emissions in Wales (Welsh Government, 2019a). NH_3 emission pressures from agriculture have generally increased across much of Wales in recent years (see SoNaRR 2025 Ammonia case study). Future projections under the Clean Air Plan for Wales and Net Zero Wales policies anticipate further reductions, especially in PM emissions, though NH_3 remains a significant concern.

There has been a substantial reduction in the number of grassland, woodland and crop fires from around 10,000 per year in the early to 2000s to around 2,000 in recent years (Welsh Government, 2024a), possibly driven by a drop in the incidence of deliberate arson. However, the continuing grassland, woodland and crop fires continue to have effects on wildlife and forests, people and property and generate significant greenhouse gases and air pollutants. These air emissions pose serious risks to both human and wider environmental health (Brownlow *et al.*, 2025).

There has been notable progress made in tackling air pollution in Wales. Welsh Government have made a strong commitment to this aim through the Clean Air Plan for Wales, the Environment (Air Quality and Soundscapes) (Wales) Act 2024 and the climate change net zero plan, *Prosperity for all: A Low Carbon Wales* (Welsh Government, 2019b), which includes policies to improve efficiency of livestock production, crop and nutrient management, and farm fuel and energy efficiency. The Sustainable Farming Scheme, which will start in 2026, includes measures to support farmers to reduce ammonia emissions. Ambitious industrial decarbonisation and a move towards electric vehicles, as well as Welsh Government funding for active travel, are all expected to improve air quality. Other progress has been the installation of ammonia sensors to monitor emission levels (NRW, 2023), production of Site Nitrogen Action Plans and the increase in the percentage of dwellings with adequate energy performance.

Such actions are making progress towards safeguarding and enhancing our air, but despite improvements, parts of Wales still have some of the worst air quality in Britain, with major pollution sources including transport, agriculture, industry, and domestic burning. Long-term exposure to air pollution in Wales is estimated to have a health impact equivalent to 1,000–1,400 deaths per year and cost the country £1 billion per year in lost workdays and healthcare expenses (Welsh Government, 2025b), and in 2021, 99.1% of sensitive habitats in Wales exceeded their critical load for eutrophication (JNCC, 2024).

Soil (including peat)

Soils are a vital part of Wales’ natural environment, playing a central role in influencing historic land use and regulating carbon, nutrients, and water, while supporting biodiversity and ecosystem services essential to human well-being. Their condition directly influences the resilience of terrestrial ecosystems and the sustainability of land use.

Wales’ soil landscape is predominantly agricultural, with 90% of land area used for agricultural purposes, 70% classified as upland and 85% as non-Best and Most Versatile (BMV) land (Welsh Government, 2024b). Soils also support our special places with many designated sites having soil types and climate conditions that specifically support unique habitats and/or flora and fauna (Hannam *et al.*, 2022). The main soil types include podzol, brown earth, and surface water gleys. Despite their importance to ecosystem functioning and agricultural productivity, Welsh soils are under increasing pressure from climate change and land use and management.

ERAMMP data show that 4% of surveyed soils are disturbed or eroded, primarily due to livestock poaching and compaction. Soil compaction has increased over the last decade, affecting plant growth and increasing flood risks. While topsoil carbon levels are stable overall (Welsh Government, 2022b), arable and horticultural soils have experienced an 8% decline in carbon content (Emmett, Bentley, *et al.*, 2025). There are increased phosphorus levels, and risk of losses of phosphorus via runoff, erosion and leaching, particularly in improved grasslands (Emmett, Bentley, *et al.*, 2025) and soil biodiversity has declined (Welsh Government, 2022b).

Air pollution impacts on soil have declined due to reductions in nitrogen and sulphur dioxide emissions (DEFRA, 2024; National Atmospheric Emissions Inventory, 2024). However, ammonia emissions are increasing, and nitrogen deposition continues to affect soils, particularly in upland areas, risking nutrient enrichment and acidification (Tomlinson *et al.*, 2021). Land pollution remains a concern, with contaminants such as benzo(a)pyrene, lead, and arsenic still present (NRW, 2016a). Agricultural practices have led to phosphorus accumulation, which, despite some decline, still exceeds agronomic needs and poses risks to water quality (Cordell *et al.*, 2022; Emmett, Anthony, *et al.*, 2025).

Climate change continues to pose significant threats to soil health. Predicted increases in extreme weather events, such as wetter winters, more intense rainfall, and rising sea levels, are expected to exacerbate soil erosion, reduce soil workability, and increase the risk of landslides and wind erosion (Met Office, 2018, 2023; NRW, 2021a). Changes in air temperature and rainfall patterns may also alter soil chemistry and biology, potentially leading to salinization and reduced productivity (Egidio, Luca and Lasagna, 2024).

Peaty soils, covering around 4% of Wales, are especially vulnerable but crucial for climate regulation and water supply (NRW, 2020a). They store between 15% and 30% of Wales' carbon and intercept over a quarter of the UK's drinking water (Welsh Government, 2025a). However, degraded peatlands—affected by drainage, historic afforestation, and overgrazing—release carbon. Only 10% of Welsh peatlands are in good condition with emissions from poor condition peatlands estimated to equal 10% of transport emissions, or 550 kilo tonnes of CO2 emissions a year (NRW, no date). Most peatlands are in poor condition and face additional pressures from pollution, grazing, fire risk, increased dry weather due to climate change, and renewable energy development, with many windfarm sites overlapping peaty soils.

Despite these challenges, Wales has made progress in safeguarding and restoring soil and peatland resources. Since 2000, 771 km of ditches have been blocked and 3,000 hectares of peatland restored. The National Peatland Action Plan aims to restore 45,000 hectares by 2050—half of Wales' estimated peatland area. Broader efforts include

reducing inorganic fertiliser use, improving land management, and exploring biodegradable alternatives to agricultural plastics (Cusworth *et al.*, 2024). However, organic manure application remains high, with an estimated 10 million tonnes applied annually.
The Sustainable Farming Scheme (SFS), launching in 2026, aims to support sustainable food production and soil health (Agriculture (Wales) Act 2023). The Environment (Air Quality and Soundscapes) (Wales) Act 2024 and the Agricultural Soil Policy Statement (Welsh Government, 2025a) provide frameworks for improved soil and air quality management. Additional efforts include industry guidance on soil management (British Society of Soil Science, 2022), biodegradable alternatives to agricultural plastics (Cusworth *et al.*, 2024), and ammonia monitoring projects (NRW, 2023).

While these interventions are promising, ERAMMP data (Emmett, Anthony, *et al.*, 2025) shows that erosion and compaction remain in localised areas, and while evidence of the full extent of nutrient imbalances is limited, indications raise concerns on soil phosphorous levels in some habitats. Healthy, sustainably managed soils will be more resilient to climate change and other pressures, and better able to provide vital ecosystem services, but we must recognise and manage synergies and trade-offs between the demands we place on our soils. Continued monitoring, targeted restoration, and sustainable land management will be essential to reverse degradation and protect Wales' soils and peatlands for future generations.

Water

According to the SoNaRR 2025 SMNR Water assessment, water resources in Wales face pressures from climate change, pollution, land use change, and direct exploitation. These pressures affect both water quantity and quality, with implications for ecosystems, human health, and economic resilience.

Climate change is beginning to alter rainfall patterns, with drier summers, wetter winters and an increased frequency of extreme events, including floods and droughts, observed over the last five years. Dry weather events can reduce pollutant dilution, increase algal blooms, and impact costs of drinking water treatment. The quantity of groundwater is not currently considered to be an overall concern, with 100% of groundwater bodies achieving good quantitative status in 2024. However, groundwater levels are becoming more variable, suggesting there is a changing resilience in resource. The Enhanced Future Flows and Groundwater project estimates that river flows in Wales will further reduce by between 10 and 40% by 2049 (Hannaford *et al.*, 2022). Threats to water quantity and supply are associated with reduced water availability in summer months, with 3 out of 27 Water Resource Zones in Wales anticipated to go into deficit by 2050 unless efficiency measures are implemented. (Note: flooding is covered in the Aim 3 assessment.)

Pollution remains a significant concern, with no evidence of major change in overall water quality over the last 5 years. In 2024, only 40% of water bodies achieved good or high status under the Water Framework Directive Regulations (WFDR). Groundwater quality is assessed in the SoNaRR 2025 Water assessment as mixed, with 55% of bodies rated good. River water quality is assessed as medium, with 42.7% achieving good WFDR status. Organophosphate levels have improved, but phosphorus breaches remain widespread in SAC rivers. Transitional and coastal waters are particularly impacted by pollution, with 79% of the 56 waterbodies assessed in 2024 classified as less than good status. Other water bodies show varied status including only around a quarter of lakes and reservoirs at good status. Elevated nutrient levels and chemical contaminants were cited as a main pressure or threat (ranked medium or high) for all seven Annex I marine habitats in Wales for Regulation 9A reporting (NRW, 2026), which was also the case for the previous round of Article 17 reporting in 2019 (NRW, 2021b).

Rural pollution is the primary reason for 23% of water bodies (rivers, lakes, canals, estuaries, coastal waters and groundwater) failing to meet good status. Urban and transport land use accounts for 14% of failures, and wastewater impacts another 14%. Source apportionment modelling identifies rural land use as the main source of phosphorus pollution in 7 out of 10 SAC river catchments, and wastewater treatment as the main source in the remaining 3 (data derived from Dŵr Cymru Welsh Water (2023)).

The Nutrient Review (NRW and ARUP, 2023) highlights phosphate pressures as more widespread than nitrate, with no expected reduction by 2031. Persistent pollutants such as polybrominated diphenyl ethers (PBDEs) and polychlorinated biphenyls (PCBs) show little improvement, and emerging contaminants like microplastics, pharmaceuticals, and antimicrobial resistance genes are increasingly detected. Historic metal mine discharges continue to affect 700 km of rivers.

Additionally, 115 water bodies are heavily modified for drinking water supply and water flow regulation, which can restrict flow, impede species movement, and limit sediment and nutrient transfer—negatively affecting freshwater ecosystems. Although abstraction licenses will have conditions such as Hands off Flows (a flow rate below which abstraction cannot occur) to prevent abstraction at low flows.

Progress towards improving water efficiency and protecting water resources in Wales has been marked by a range of policy, regulatory, and investment initiatives. A water efficiency labelling scheme is set to be introduced by 2026, aligning with the UK Water Efficiency Strategy to 2030 (DEFRA, 2022; Waterwise, 2022). The Ofwat Water Efficiency Fund, launched in 2025, will allocate £100 million over five years to behavioural change campaigns and research into water-saving technologies. Water companies in Wales, such as Dŵr Cymru and Hafren Dyfrdwy, offer water-saving services including audits, leak repairs, and subsidised rainwater butts.

There has also been progress on safeguarding and enhancing water quality. Regulatory measures include the 2021 Water Resources (Control of Agricultural Pollution) (Wales) Regulations and the 2024 statutory implementation of Drainage and Wastewater Management Plans (DWMPs). Dŵr Cymru's business plan (2020-2025) included £218 million for targeted investment to reduce the impacts of high spilling combined sewer overflows (CSOs), the UK Chemicals Investigation Programme third phase (UKCIP3), and further investment at wastewater treatment works to meet Urban Waste Water Treatment (England and Wales) Regulations 1994 requirements. Natural Resources Wales is working with the Welsh Government and UK administrations to reduce chemical pollution through enhanced monitoring and restrictions on use and disposal. The projects DeeLIFE and 4 Rivers for LIFE have been working to improve land management practices across catchments. Updated River Basin Management Plans (Environment Agency, 2022; NRW, 2022a, 2022b) and initiatives like the SAC Rivers Project, Opportunity Catchments, and the River Restoration Programme reflect a strategic, integrated approach to water quality and habitat resilience. The Wales Metal Mines Programme, active since 2020, is addressing pollution from abandoned mines. Community engagement is also growing through citizen science initiatives like the Catchment Systems Thinking Cooperative (CaSTCo). The Independent Water Commission's 2025 report is expected to further shape future water sector governance and planning. Growing public concern highlights how important our freshwater and marine environments are to the people of Wales and the ongoing need for action to tackle pollution.

This progress needs to be continued and strengthened in future in order to achieve Aim 1 for water. These actions must include adapting water distribution to climate variability, managing nutrient and chemical pollution, promoting sustainable agriculture, and reducing urban pollution.

Minerals

Mineral resources have played a very important role in Wales' history with huge economic, social, cultural and environmental impacts. Following a long history, metal mining has largely ceased and there is only localised coal mining and slate quarrying in Wales (NRW, 2016b). The aggregates industry is now the main mineral extraction industry in Wales, including marine and terrestrially derived aggregates. The ONS (2024) estimate that around 14.658 million tonnes of construction minerals were extracted from Welsh ecosystems in 2022. These were extracted from marine (estimated at 7.5 million tonnes) and Mountain Moorland and Heath (estimated at 7.1 million tonnes). (See SoNaRR 2025 Aim 4 for details.) Marine aggregate extraction off the South Wales Coast and in Liverpool Bay has continued at approximately the same rate between 2011 and 2020 (The Crown Estate and MPA Marine Aggregates, 2022), although ONS accounts indicate an overall increase in Wales' marine aggregate extraction of nearly 1 million tonnes between 2016 and 2022 (Office for National Statistics, 2025). Future demand is unknown.

Mineral resources are finite and not evenly distributed, being limited to a particular outcrop or deposit, and their exploitation is also governed by demand and accessibility to markets (NRW, 2016b, p. Technical annex).

Mineral extraction processes can have negative effects on ecosystems and natural resources. Marine aggregate extraction can disrupt natural hydrodynamic and sediment transport processes. The effects of historic metal mining are still greatly impacting Wales' waters and landscape. Since 2020, the Welsh Government-funded Wales Metal Mines Programme has investigated over 50 sites and is developing long-term remedial measures to reduce pollution from abandoned metal mines. Historic discharges continue to affect 700 km of rivers, with 41 river water bodies, 2 lakes, and 5 transitional waters failing to meet Environmental Quality Standards for metals such as zinc, cadmium, and lead. Metals are the most common substances detected in groundwater above drinking water standards, with chlorinated volatile organic compounds, nitrate, sodium and pesticides also identified above drinking water quality standards (NRW, 2025). These findings highlight the ongoing legacy of industrial pollution and the need for continued investment in both surface and groundwater protection.

Whilst it isn't possible to use non-renewable resources in a fully sustainable way, progress has been made towards considering environmental impacts from extraction processes and in remediating historic impacts of extraction. NRW have developed maps showing environmental considerations for strategic marine planning, including for use by the aggregates sector, in order to support future opportunities for sustainable use and management of the Welsh marine area.

There is a need to balance demands for minerals with political considerations around security and consideration of environmental impacts both within Wales and globally. The 2022 UK critical minerals strategy includes an emphasis on UK domestic production, accelerating the circular economy to increase recovery, reuse and recycling rates and resource efficiency, and collaborating with international partners (Department for Business, Energy and Industrial Strategy, 2022).

Climatic, physiographical and geological features and processes (including productivity)

'Wales has an essentially maritime climate, characterised by weather that is often cloudy, wet and windy but mild' (Met Office, 2016). Species in Wales have evolved under these relatively stable conditions, however climate change is now already altering Wales' climate, increasing the likelihood of wetter winters and hotter drier summers and more frequent extreme weather events (see SoNaRR 2025 Climate change chapter). Evidence from the SoNaRR 2025 assessments shows climate change as a major driver putting pressure on all of Wales' eight broad ecosystems and on our water and soil resources, and that these pressures are expected to increase into the future.

For a relatively small country, Wales boasts an incredibly diverse array of rocks, minerals, fossils, landforms, and natural processes (NRW, 2016b), and these are of great scientific, cultural and ecological importance. Geodiversity is an important part of ecological networks as it has a direct influence on the diversity of habitats and species and provides a range of natural processes essential to functioning ecosystems, as well as wider ecosystem services that include carbon capture and natural flood regulation. Soils form as a result of the interaction between the underlying geology, climate, management, and the vegetation and its decomposing organic matter.

Wales' soils and their climatic relationship largely determine the land use activities that can be supported sustainably. Agriculture is the main use of Wales' land, with over 90% of Wales' land area supporting agricultural use. Agricultural productivity in Wales is shaped by climate, site, and soil. Agricultural practices can exert pressures on our natural resources, but sustainable management of agricultural land offers a key opportunity for safeguarding and enhancing the natural resources of Wales.

Wales' use of global natural resources

The majority of the SoNaRR 2025 report focuses on Wales' management of natural resources in Wales. But we are also a part of planet-wide systems, environmentally, socially and economically. If we are to achieve the well-being goal 'A globally responsible Wales', we must consider the impacts we have on the quality and quantity of global resources, particularly through our consumption and production, and our interaction with the global economy.

Calculations of Wales' resource use show that we are using more than our fair share of the world's natural resources. Latest estimates of our ecological footprint indicate that we would need around 2 planet Earths if everyone in the world were to use natural resources in the way that we do in Wales (Lin, D. *et al.*, 2023). This estimate, from the Joint Nature Conservancy Council (JNCC), includes the area of land needed to provide raw materials, energy and food and absorb the pollution and waste created from the consumption of goods and services in Wales. Research in the same report indicates that Wales' "consumption of global crop commodities (and in some cases cattle and timber) in 2018 was associated with impacts including: predicted loss of 1.2 to 1.6 species; 669 to 884 ha of tropical and subtropical deforestation; emission of 335 to 439 thousand tonnes of CO_2 associated with this deforestation; use of 7 to 9 billion cubic metres of scarcity-weighted water; and use of 314 to 414 thousand ha of land for crop harvests" (Lin, D. *et al.*, 2023, p. ii). The countries in which Welsh consumption is having greatest impact on species loss are the UK, India, Indonesia, the Philippines, Viet Nam, Nigeria, Thailand and Spain. Estimates of Wales' material footprint (the total tonnes of material extracted or produced to support consumption) suggest that we are close to the global average on this measure, but that the world average is both increasing and unsustainable and that Wales' material footprint is also unsustainable.

Wales' ecological footprint is estimated to have decreased by around a third since 2004, driven mostly by decarbonisation of energy generation, which shows that great progress can be made. However, we are still using natural resources at twice the biocapacity of Wales, and it is essential that we act with urgency to reduce our global impact. This is considered in more detail in the Aim 4 assessment, including links with national indicators, and opportunities for a regenerative economy which safeguards and enhances global natural resources.

Opportunities for action

The evidence in SoNaRR 2025 makes clear that we are not achieving Aim 1 of SMNR, to safeguard and enhance natural resources in Wales. However, the evidence also makes clear what progress has been made and how we can build on that progress to transform our management of natural resources.

We must act together, ensuring that strategies and delivery are integrated across sectors to create transformative change for nature, people and the economy. Research, technology and monitoring are essential to enable us to gather evidence of the state of our natural resources, and both positive and negative impacts of our actions. We also need to empower the people of Wales through awareness-raising, training and knowledge exchange – speaking to people not only as consumers but as business owners, public and private sector workers, citizens and members of families and communities, so that their decisions and creativity can be harnessed to help safeguard and enhance our natural resources for all. If people value nature and our place in it, we will be able to transform how we manage resources to meet our food, energy, home and transport needs.

Across the ecosystem and natural resource assessments in SoNaRR 2025 we see that pollution management and sustainable land management practices (particularly in agriculture and built development) are essential. These are key parts of transforming our food, energy, transport and housing systems. Pollution must be tackled through better control of nitrogen and other chemical contaminants across air, water, and soil. This can be supported by national strategies such as the Clean Air Plan, Noise & Soundscape Plan, Sustainable Farming Scheme, Control of Agricultural Pollution Regulations 2021, and National Environment Programme investments in nutrient reduction, storm overflow mitigation, wastewater treatment expansion, peatland restoration, and leakage reduction. Sustainable agricultural practices have a key role to play in pollution management and soil protection. Central to these efforts is the reduction of nitrogen and ammonia emissions, which are critical to preventing nutrient enrichment and acidification, particularly in upland and woodland areas. Pollution control is also essential, with emphasis on managing agricultural runoff, urban wastewater, and marine litter, alongside regulating harmful substances like pesticides, microplastics, and sheep dip chemicals.

Other important focuses for action include climate adaptation, requiring changes in agricultural practices, water distribution, and land management to address drought, flooding, and temperature extremes. Invasive non-native species (INNS), pests and disease control is also a priority, with a need for widespread monitoring, community engagement, and targeted interventions. Enhancing urban environments through improved air, soil, and water quality, and adapting green infrastructure to climate pressures, are key opportunities for enhancing natural resources within urban areas. Protecting and restoring habitats, including peatlands, grasslands, rivers and woodlands, is essential for biodiversity and carbon storage. It is important to view all these actions as interconnected and plan and deliver them in an integrated way. Together, these measures will help to safeguard Wales' natural resources, playing a part in the necessary transformations of our practices, governance and relationship with nature.

See the Aim 1 Appendix 1: priority actions for a list of priority actions which have been identified throughout the SoNaRR ecosystem and natural resource assessments as being key to safeguarding and enhancing our natural resources. Many of these actions cut across opportunity categories, ecosystems and natural resources, delivering benefits on multiple fronts.

Evidence needs

Evidence needs have been identified across the different ecosystem and natural resource assessments in relation to assessing and achieving Aim 1 (safeguarding and enhancing stocks of natural resources). These evidence needs can be grouped into the following areas:

Soil and Land Use: There is a need for improved understanding of soil health, erosion, contamination, and carbon stocks. Evidence is lacking on the impacts of land-use change, microplastics, pesticides, and climate-induced changes such as flooding and drought. These gaps hinder the ability to monitor soil sustainability and inform land management practices that protect soil as a vital resource.

Ecosystem Condition and Resilience: Many habitats—including mountains, moorlands, and heath, woodlands, coastal margins, and freshwater systems—require updated data on their extent, condition, and connectivity. Without this, it is difficult to determine whether ecosystems are resilient enough to support natural resource stocks over time.

Water: We need to better understand and manage water availability, quality, and flood risk in the face of climate change, land use change, and increasing demand. Evidence needs include: the impact of exempt and previously unregulated abstractions, and effectiveness of water efficiency interventions; the effects of agricultural intensification and built development on water quality and quantity; tracking development within floodplains; and hydrological impacts of natural flood management and sustainable drainage systems across larger catchments.

Climate Change Impacts: There is limited evidence on how climate change affects soil moisture, water flows, and some species distributions. These changes directly influence the sustainability of natural resources and require targeted monitoring and modelling.

Invasive Non-Native Species (INNS), pests and diseases: Data on the distribution, impact, and management of INNS is insufficient. There is also need for improved evidence on the impacts and control of pests and diseases in woodlands, urban trees and animals in enclosed farmland.

Renewable Energy and Land Use: Evidence is needed on the environmental impacts of renewable energy developments and land-use practices to ensure they do not compromise natural resource stocks.

Marine: Evidence is needed to better understand pressures and impacts from human activities. Key gaps include the extent, distribution, and effects of commercial and also recreational fishing, including bycatch of marine mammals, impacts on fragile habitats, and the sustainability of fisheries. There is also a need to assess the consequences of nutrient inputs and invasive non-native species.

Air: Improving air quality in Wales requires a stronger evidence base across multiple dimensions, including enhanced local and national monitoring; data on how air pollution affects biodiversity across ecosystems and crop yields; and evidence to assess the impact and cost-effectiveness of current and future air quality policies. There is also need for evidence on: how effective soundscapes can enhance human health and ecosystems; and odour-related issues at national and local scales.

Conclusion

Wales is not yet achieving Aim 1 of the sustainable management of natural resources: to safeguard and enhance the stocks of natural resources. Despite strong legislative and policy frameworks in place, the evidence presented in this assessment shows that our natural resources continue to be degraded by pollution, unsustainable land use, INNS, pests and diseases, and climate change. Continued species decline, and poor water, soil and air quality, all point to the urgent need for change.

However, this assessment also highlights areas of progress. Peatland restoration, air quality legislation, and the Wales Metal Mines Programme are examples of targeted interventions that are beginning to address long-standing environmental challenges. These efforts demonstrate that change is possible—but they must be scaled up and embedded within broader systems of governance, production, and consumption. The safeguarding and enhancement of natural resources cannot be achieved through isolated actions; it requires coordinated, cross-sectoral strategies that address the root causes of degradation.

To move forward, Wales must embrace a systems-based approach to natural resource management—one that integrates ecological, social, and economic considerations. This includes transforming how we produce food, generate energy, build homes, and move around, while ensuring that communities are empowered to take part in shaping solutions. Evidence gaps must be addressed to support effective monitoring and decision-making, particularly in relation to soil health, water abstraction, and the impacts of renewable energy development.

Achieving Aim 1 will require bold action, long-term commitment, and a shared vision for a Wales where natural resources are not only protected, but regenerated—supporting resilient ecosystems, thriving communities, and a globally responsible nation.

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Aim 1 Appendix 1: priority actions

Priority actions which have been identified throughout the SoNaRR assessments as being key to safeguarding and enhancing our natural resources. There actions are presented here by SoNaRR opportunity category. Many of these actions cut across categories, ecosystems and natural resources, delivering benefits on multiple fronts.

Pollution Management

- Coordinate efforts to reduce nitrogen pollution in air and water; cut ammonia and nitrogen emissions from agriculture; enforce agricultural pollution regulations.
- Protect water resources from metals, chemicals, microplastics, and pharmaceuticals; remediate affected waters.
- Improve urban water quality by retrofitting SuDS, reducing combined sewer overflow (CSO), fixing misconnections, and increasing surface permeability.
- Improve urban air quality by implementing *The Clean Air Plan for Wales*, creating clean air zones, and promoting cleaner home-heating options.
- Reduce light pollution by mandating public bodies to follow *Good Practice Guidance: Planning for the Conservation and Enhancement of Dark Skies in Wales*.
- Reduce noise pollution by following the *Noise and Soundscape Plan for Wales 2023–2028* and improving transport technology and infrastructure.

- Control marine water pollution from storm overflows, nutrient enrichment, and litter (including beach litter).
- Manage noise impacts on marine animals from offshore construction and maritime activities.
- Address land contamination (benzo[a]pyrene, lead, arsenic, microplastics from fertilisers and agricultural films).
- Regulate sheep dip disposal (diazinon-containing dips).
- Mitigate floodwater pollution mobilising contaminants.
- Manage phosphorus leaching in agricultural soils.
- Improve urban soil quality through remediation and fly-tipping control.

Sustainable Agriculture

- Control nitrogen pollution via sustainable practices: reduce emissions, manage fertiliser use, and enforce regulations.
- Control chemical pollution: address soil contamination, regulate sheep dip disposal, manage phosphorus leaching, and monitor pesticide/fertiliser impacts.
- Enhance soil organic carbon, especially in arable/horticultural areas.
- Adapt practices to reduce pressure on watercourses during low supply periods.
- Continue peatland restoration to maintain carbon storage and reduce GHG emissions.
- Monitor and control invasive non-native species (INNS) and diseases.

Forestry

- Monitor and control impacts of grey squirrels, deer, and plant INNS.
- Diversify tree species and manage pests/diseases.
- Support woodland adaptation to climate change.
- Plant more trees to support sustainable timber production, mitigate pollution, and improve ecosystem resilience.

Fisheries

- Reduce by-catch to protect native species.

INNS and Other Species Management

- Widespread monitoring and control of INNS, pests, and diseases across ecosystems.

- Use citizen science and community engagement for INNS management.
- Develop collaborative frameworks for INNS issues.
- Include INNS action in future land management schemes.
- Promote biosecurity through campaigns and initiatives.
- Implement INNS policy and legislative drivers.

Species Conservation and Enhancement

- Monitor, protect, and restore key habitats.
- Support habitats to adapt to climate change.
- Reduce by-catch in marine fisheries.
- Control pressures such as INNS, pests, diseases, and pollution.
- Enhance opportunities for wildlife in gardens and public spaces.

Resource Protection

- Enhance native habitats and species protection.
- Manage pollution to protect soil, water, and air.
- Restore drained peatlands to enhance carbon storage.
- Improve soil resilience to extreme weather.
- Protect peat and organo-mineral soils from carbon loss.
- Monitor and manage salinization risks in coastal areas.

Increasing Resource Efficiency

- Adapt water distribution and demand to mitigate climate change impacts.

Sustainable Manufacturing and Construction

- Ensure practices that protect water resources from metals and chemicals.
- Manage noise impacts on marine animals from offshore development.
- Plan development to avoid soil sealing.
- Increase use of sustainably produced timber and long-lived wood products.

Waste Prevention

- Remediate contaminated land and control fly-tipping.

- Control waste management in farmland to reduce pollutants and regulate sheep dip disposal.

Research and Technology

- Research air pollution effects on freshwater ecosystems.
- Study soils in Mountain, Moorland, and Heath ecosystems.
- Monitor and control INNS and diseases.
- Continue ecosystem monitoring and research into pressures and interventions.

Community Engagement

- Work with communities on INNS data collection and management.
- Engage residents to improve biodiversity in public spaces.
- Support farmers in water use and climate adaptation.
- Collaborate with landowners and planners on future risks.
- Enable community-led wildlife-friendly gardens and public spaces.
- Educate communities on water distribution and climate change impacts.

Integrated Plans, Strategies and Delivery

- Coordinate monitoring and response for INNS and diseases.
- Deliver national air and water quality improvements via existing plans.
- Implement guidance to reduce light and noise pollution.
- Use integrated urban water management approaches.
- Plan and manage urban green spaces strategically.

Aim 2 assessment: Ecosystems are resilient to expected and unforeseen change

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External reviewer: Steve Spode (Welsh Government)

Achieving Aim 2 is closely linked to Aims 1, 3, and 4, and should be read in conjunction with those chapters

Executive Summary

Wales stands at a turning point. The latest evidence from SoNaRR 2025 confirms SoNaRR 2020 and what many have sensed: our ecosystems are struggling to withstand the pressures from how we manage the land in Wales. Biodiversity is in decline, natural systems are under strain, and the landscapes that sustain health, prosperity, and culture are struggling to adapt to new and existing pressures.

Yet, within this challenge lies powerful opportunities. Across Wales, particularly in agricultural Less Favourable Areas, farmers and land managers are already playing a vital role in caring for the land, preserving rural culture, and supporting community resilience. They hold deep knowledge and commitment and with the right support, tools, direction, they can become central protagonists in restoring nature and building resilience.

Aim 2 provides the foundation for this transformation. It builds on SoNaRR's robust evidence base, illuminating the pressures on Wales' ecosystems and highlighting where action is most needed. It shows how thoughtful land use, especially in uplands and coastal fringes, can restore biodiversity, strengthen ecosystem resilience, and support rural livelihoods for generations to come.

Recovery must be delivered across the whole landscape and our wider seas. Protected sites serve as vital anchors, places where nature still holds ground, but real resilience comes from making these sites bigger, better, and more connected. Resilience depends on connecting these sites through well-designed Resilient Ecological Networks (RENs). These networks, supported by landscape-scale partnerships enable species and habitats to move, adapt, and thrive in the face of climate change. Delivering resilience at scale requires collaboration, between land and sea managers, communities, and policy makers, to restore connectivity, enhance habitat quality, and embed nature into everyday decision-making.

Maintaining and enhancing nature everywhere, including on productive farmland and within our communities, is essential. This landscape-scale approach, delivered through partnerships, is key to building resilient ecosystems and ecological networks.

Wales' commitment to the 30by30 target, to protect 30% of land, freshwater and sea by 2030 is a bold and galvanising ambition. It offers a shared goal that can unite policy, funding, and action. This SoNaRR 2025 Aim 2 assessment helps identify where effort will have the greatest impact, and how land use decisions can align with this national mission.

The policy landscape is evolving. New frameworks and funding mechanisms are emerging, rewarding those who deliver public goods: clean water, carbon storage, thriving wildlife, and vibrant cultural landscapes. The Agriculture (Wales) Act 2023 and the Sustainable Land Management framework provide the tools to reward land managers not just for producing food, but as stewards of ecosystem resilience, delivering public goods, clean water, carbon storage, thriving wildlife, and cultural heritage. Regulation also plays a pivotal role, securing baseline protections, guiding development and unsustainable practices away from sensitive areas, and ensuring fairness and accountability. Not as a barrier, but as a guarantee of fairness and long-term success.

To turn ambition into delivery, we have identified 4 key opportunities that align with the priority areas to develop biodiversity targets proposed in the Environment (Principles, Governance and Biodiversity Targets) (Wales) Bill 2025:

1. Species Recovery – strategies such as a Wales Species Recovery Framework would help restore threatened species across the landscape.

2. Effective Management of Ecosystems– focusing on Resilient Ecological Networks (RENs), Protected Sites, and OECMs to build ecological networks that are resilient and connected.

3. Reducing Pollution – tackling nutrient loading and other pollutants that undermine ecosystem health.

4. Evidence Availability and Place-Based Delivery – ensuring decisions are grounded in robust data and tailored to local needs.

This is a moment for courage and vision. With the right support, those who manage the land can become champions of resilience. Wales has tools, evidence, and the commitment. The choices made now will determine whether our story is one of continued decline, or bold recovery. Aim 2 shows how nature and people can thrive together.

Key messages

Wales' ecosystems are not resilient, urgent action is needed to reverse decline and build adaptive capacity.

SoNaRR 2025 confirms that ecosystem resilience remains low across most habitats, including terrestrial, freshwater, and marine ecosystems. Semi-natural habitats have declined in extent and condition, and marine assessments show significant pressures from pollution, climate change, and unregulated development. Without transformative change, resilience will continue to erode, threatening biodiversity, ecosystem services, and long-term well-being.

Land use is one of the most significant and persistent drivers of ecosystem degradation.

Decades of intensive land use, particularly agricultural intensification and urban expansion, have fragmented habitats and degraded soils and water, resulting in pollution across land, freshwater and sea. Strategic land and sea use planning is essential to restore resilience.

Climate change is accelerating ecosystem pressures and driving cascading effects.

Climate change is now a dominant driver of change across all ecosystems. It interacts with and amplifies other pressures, such as habitat fragmentation, pollution, and invasive species, reducing the ability of ecosystems to recover, adapt, and continue delivering essential services. In marine systems, warming is increasingly likely to drive changes in species distribution and ecosystem structure which must be considered in marine spatial planning and infrastructure development. Nature-based solutions, such as restoring and improving habitat condition, improving connectivity, and integrating climate adaptation into planning, can turn climate risks into opportunities for building resilient, thriving ecosystems.

Resilience must be built across the whole landscape and seascape, not just in protected sites.

Protected sites are vital anchors for biodiversity, but real resilience depends on connecting these sites through well-designed Resilient Ecological Networks (RENs) and ecologically coherent Marine Protected Area (MPA) networks. Delivering resilience at scale requires landscape and seascape-scale partnerships.

Farmers and land managers are central to delivering ecosystem resilience.

With over 90% of Wales’ land under agricultural use land managers are key protagonists in restoring nature. The Agriculture (Wales) Act 2023 and planning frameworks provide tools to support them, not just as producers, but as stewards of biodiversity and climate resilience.

Regulation and incentives must work together to secure long-term success.

Regulation is not a barrier; it is a safeguard. Stronger Environmental Impact Assessment (EIA) rules, pollution controls, and planning policies are needed to protect sensitive habitats. Long-term funding is essential to provide management certainty. Ecological recovery takes time and cannot be measured within short project cycles.

Wales’ nature targets must drive delivery, not just ambition.

The commitment to halt biodiversity loss by 2030 and achieve recovery by 2050 is bold. Statutory nature targets must be measurable, time-bound, and embedded across sectors. Future SoNaRRs must demonstrate what has been delivered.

Evidence gaps must not delay action, but monitoring is essential for accountability.

New evidence since SoNaRR 2020, such as the potential scale of deterioration in MPA features due to coastal squeeze, highlights the need for robust monitoring. While gaps remain, especially in resilience and species recovery, Wales must act using the best available evidence. Monitoring must be embedded within investment for nature recovery.

Ecosystem resilience and nature-based solutions must be place-based

Nature-based solutions (NbS) are most effective when designed to address local pressures and opportunities, while enhancing ecosystem resilience. Area Statements provide a framework for delivering NbS and embedding ecosystem resilience into marine and terrestrial planning, funding, and delivery.

Wales must move beyond protection, to nature recovery and enhancement

The shift from protection to recovery is essential. Delivering this ambition will require coordinated investment from both public and private finance. Mechanisms such as the Sustainable Farming Scheme (SFS) provide structured support for land managers to effectively manage and restore habitats, improve biodiversity, and deliver public goods. At the same time, emerging opportunities around health, economy and private finance also offer new ways to engage communities and unlock long-term restoration funding. By aligning financial tools with nature targets and resilience goals, Wales can move from ambition to delivery, restoring ecosystems across land and sea.

Vision for Aim 2

Our vision for 2025 and beyond is clear

Along with governments across the world, the Welsh Government has committed to halting and reversing the loss of nature.

Wales will achieve this through a comprehensive network of healthy, and resilient ecosystems. Through sustainable land management and a regenerative economy, harmful pollution is eliminated, we will halt and reverse biodiversity loss, ensuring our landscapes provide enhanced wellbeing benefits and consistently deliver vital ecosystem services for the health and prosperity of future generations.

The Environment (Wales) Act 2016 says that the objective of SMNR is to maintain and enhance the resilience of ecosystems and the benefits and ecosystem services they provide. We must do this in a way that can meet the needs of present generations of people without compromising the ability of future generations to meet their needs.

The SMNR objective has been broken down into four aims. In SoNaRR we use the four Aims to assess Wales' management of natural resources and to identify opportunities for achieving SMNR.

1. Natural resources are safeguarded and enhanced
2. Ecosystems are resilient to expected and unforeseen change
3. Wales has healthy places for people, protected from environmental risks
4. Contributing to a regenerative economy, achieving sustainable levels of production and consumption

Ecosystems are resilient to expected and unforeseen change

SoNaRR assesses Wales' progress towards SMNR individually against four aims of SMNR, but it is important to note that they are inextricably linked and should not be seen in isolation (Figure 1). Wales cannot work towards healthy places for people without resilient ecosystems and cannot make our ecosystems resilient without safeguarding stocks of natural resources. The regenerative economy safeguards and restores those stocks and is the route to the transformational change needed to achieve SMNR.

SoNaRR 2020 Aim 2 assessment (Natural Resources Wales, 2020) concluded that ecosystems in Wales are unlikely to have sufficient resilience to cope with expected and unforeseen change and disturbance, including the challenges of climate change, and so are unlikely to be able to deliver goods, services and benefits into the future.

SoNaRR 2020 highlighted that Wales had failed to meet the EU 2020 Biodiversity Target 'Halting the loss of biodiversity and the degradation of ecosystem services in the EU by 2020, and restoring them in so far as feasible, while stepping up the EU contribution to averting global biodiversity loss.'

It reasoned resilience could, however, be significantly improved by adopting a sustainable management strategy for life across land, freshwater and seas. It recognised that the regulatory and policy frameworks are already in place, but concluded that society needs to act faster, more joined up, at a better and larger spatial scale.

Welsh Senedd declare a Nature Emergency

Since missing the 2020 target, Welsh Government and others have responded. In June 2021 the Welsh Senedd declared a nature emergency. It acknowledged the significant loss of biodiversity caused by humans and set out its expectations for action to restore it, including recognising **there should be parity between the actions taken by Welsh Government to tackle climate change and biodiversity loss** (Welsh Parliament, n.d.).

In 2022 at the Kunming-Montreal Global Biodiversity Framework or the (GBF), countries including the UK agreed to achieving 4 goals and 23 targets, with a central mission *to take urgent action to halt and reverse biodiversity loss to put nature on a path to recovery for the benefit of people and planet by conserving and sustainably using biodiversity and by ensuring the fair and equitable sharing of benefits from the use of genetic resources, while providing the necessary means of implementation*.

In November 2022, the Welsh Government set national milestones to deliver on the Well-being of Future Generations (Wales) Act 2016. Recognising that protecting our precious natural resources is key to building a resilient Wales and Wales' response to the climate and nature emergencies, the Welsh Government have committed to a national milestone to reverse the decline in biodiversity with an improvement in the status of species and ecosystems by 2030 and their clear recovery by 2050.

In December 2022 the Welsh Government reiterated its commitment to addressing the nature emergency in response to the COP15 Kunming Montreal Global Biodiversity Framework (CBD, 2022) and identified its intent to become a “global leader” through implementation and “learning from people all over the world on forestry and nature restoration (Welsh Government, 2024a). Strengthening their commitment to halt and reverse the loss of nature by 2030 and achieve recovery by 2050. In doing so Wales has committed to a number of targets including to effectively conserve and manage 30% of land, water and sea for nature by 2030 (known as ‘30 by 30’).

Welsh Government Approach to halting the decline in biodiversity:

The Welsh Government have acknowledged that maintaining and enhancing biodiversity will rely on existing areas of high nature value from the past as well as enabling recovery of ecosystems in areas where they are currently degraded. Stating that their approach to restoring nature will encompass both, and be forward looking, drawing on their wider approach in respect of ecosystem resilience. This approach recognises that nature is complex and dynamic, that factors like climate change mean that healthy ecosystems in Wales in the future will look different to those in the past. Nature restoration can in this way be evidence-based and fit for the future (Welsh Government, 2024a)

Why Aim 2 matters to well-being in Wales.

Ecosystem resilience is not just an environmental concern; it is a cornerstone of Wales’ long-term well-being. Resilient ecosystems underpin the Sustainable Management of Natural Resources (SMNR), enabling nature to continue providing essential services such as clean water, carbon storage, flood regulation, and biodiversity. These services are vital to our health, prosperity, and ability to adapt to change.

This section outlines key frameworks, policies, and mechanisms that demonstrate how ecosystem resilience contributes to the well-being goals of Wales. From the DECCA framework to national planning policy, each element reflects a strategic lever through which resilience is built and maintained. Together, they show that achieving Aim 2 is not only necessary for ecological health but also for delivering economic, social, and cultural benefits across Wales.

Ecosystem Resilience definition

Ecosystem resilience is defined in Wales as “The capacity of ecosystems to deal with disturbances, either by resisting them, recovering from them, or adapting to them, whilst retaining their ability to deliver services and benefits now and in the future” (NRW, 2016).

In Wales, ecosystem resilience is described using the attributes diversity, extent, condition, and connectivity (the DECCA Framework (Sanderson Bellamy et al., 2021), which are known to be linked to the resilience of an ecosystem. (The final ‘A’ can refer to adaptability or ‘aspects’; see Aim 2 SoNaRR 2020 for a detailed overview of DECCA).

A resilient Wales

The **Well-being of Future Generations (Wales) Act 2015** places a duty on public bodies (including planning authorities) to achieve the seven well-being goals for Wales, one of which is "**A Resilient Wales**" – A nation which maintains and enhances a biodiverse natural environment with healthy functioning ecosystems that support social, economic and ecological resilience and the capacity to adapt to change (for example climate change) (Senedd Cymru, 2016).

The Natural Resources Policy (NRP) (Welsh Government, 2017) is designed to drive the delivery of the goals of the Well-being of Future Generations Act (WFG Act) and delivery of the Environment (Wales) Act (Welsh Government, 2016). The core concept underpinning these priorities is the Sustainable Management of Natural Resources (SMNR), setting out the national priorities for managing natural resources sustainably, itself informed by SoNaRR.

Key National priorities in the NRP include delivering Nature-based solutions using natural processes and features to address societal challenges, Increasing Renewable Energy and Resource Efficiency Shifting away from fossil fuels and minimizing the consumption of natural resources through efficiency and a circular economy approach, and Taking a Place-Based Approach.

Resilient Ecological Networks (RENs)

The NRP and the Nature Recovery Action Plan (Welsh Government, 2020a) state the need to proactively develop Resilient Ecological Networks (RENs) to maintain and enhance the wider resilience of Wales' ecosystems. In doing so, Wales would also address the Convention on Biological Diversity's Strategic Plan for Biodiversity and the associated Aichi biodiversity targets.

Updated National Planning Policy (James, 2023) also highlights the importance of planning system in enhancing and safeguarding RENs.

Sustainable Land Management (SLM)

The Sustainable Land Management Framework established in the Agricultural (Wales) Act 2023, sets out the government's commitment to building on sustainable farming practices to deliver high animal health and welfare standards, respond to the challenges of the climate and nature emergency and support the sustainable production of food. The four objectives identify key contributions our agricultural industry makes to Wales. The objectives capture the sustainable production of food and other goods while also addressing the declared climate and nature emergencies.

SLM is a key tool for delivering SMNR. With over 90% of the land area of Wales given over to farming (including farm woodland and other uses) (Welsh Government, 2024b) this recognises the key role farmers and other land managers play in the environmental and cultural health of Wales across both land and sea.

Welsh National Marine Plan

The Welsh National Marine Plan (WNMP) provides the strategic framework for managing Wales' seas in a way that supports sustainable development while safeguarding marine ecosystems. Covering inshore and offshore waters, the WNMP integrates economic, social, and environmental priorities, ensuring that marine activities—from renewable energy and fisheries to tourism and transport—are planned coherently and sustainably. By embedding the principles of the Sustainable Management of Natural Resources (SMNR), the WNMP helps maintain and enhance ecosystem resilience at sea, complementing terrestrial efforts and supporting the Well-being of Future Generations (Wales) Act goals. Healthy marine ecosystems underpin vital services such as carbon sequestration, coastal protection, and biodiversity, which are essential for climate adaptation and the prosperity of coastal communities. The WNMP also plays a critical role in delivering Wales' 30by30 commitment, ensuring that Marine Protected Areas form an ecologically coherent network and that development is managed to avoid cumulative impacts on biodiversity.

Area statements

Area statements play a key role in delivering the spatial element of the Natural Resources Policy through identifying the areas in Wales where taking action at the right scale, both directly by NRW and through advocating action by others, can maximise benefits and identify synergies across policy areas (Welsh Government, n.d.) whilst enhancing ecosystem resilience.

Table 7 summarises how Ecosystems that are Resilient to Expected and Unforeseen Change can enhance well-being in Wales

Objectives of this assessment

- Analyse the current state of **ecosystem resilience**
- Understand the Key Issues; Priorities Risks and Opportunities to achieving ecosystem resilience
- Understand what we can do. How do we lay the foundations for nature positive future. Halt and reverse loss of nature by 2030, Nature recovery by 2050.

Table 6: Why Aim 2 matters to well-being in Wales

Contribution of Ecosystem Resilience	Linked National Wellbeing Indicator*
Assessment of Ecosystem Resilience – Understanding ecosystems, semi-natural habitats and their current state (recent trends) from the ecosystem assessments of DECCA).	**Indicator 13** (Concentration of carbon and organic matter in soi), **Indicator 43** (Ares of healthy ecosystems in Wales) **Indicator 44** (Status of biological diversity in Wales)
Key pressures on our ecosystems – understanding key current and future pressures on our landscapes. Land use change, focusing on recent significant and increasing pressure from urbanisation and scale of prolonged pressure from agricultural intensification.	**Indicator 4** (Levels of Nitrogen Dioxide (NO2) pollution in the air) **Indicator 13** (Concentration of carbon and organic matter in soil) **Indicator 14** (The global footprint of Wales) **Indicator 41** (Emissions of greenhouse gases within Wales) **Indicator 42** (Emissions of greenhouse gases attributed to the consumption of global goods and services in Wales), **Indicator 45** (Percentage of surface water bodies and groundwater bodies achieving good or high overall status).
Opportunities for Action to Enhance Ecosystem Resilience Taking a place based approach to delivering nature-based solutions (using Area Statements) can provide positive and cost effective responses to our key societal challenges. Ecosystem Resilience priorities for policy makers. Laying the foundations for delivery of ecosystem resilience through Resilient ecological networks, sustainable land management, nature targets and landscape management and potential of Less Favourable areas.	**Indicator 4** (Levels of Nitrogen Dioxide pollution in the air) **Indicator 13** (Concentration of carbon and organic matter in soil) **Indicator 14** (The global footprint of Wales) **Indicator 32** (Number of properties (homes and businesses) at medium or high risk of flooding from rivers and the sea), **Indicator 41** (Emissions of greenhouse gases within Wales), **Indicator 42** (Emissions of greenhouse gases attributed to the consumption of global goods and services in Wales), **Indicator 43** (Ares of healthy ecosystems in Wales). **Indicator 44** (Status of biological diversity in Wales), **Indicator 45** (Percentage of surface water bodies and groundwater bodies achieving good or high overall status).

Contribution of Ecosystem Resilience	Linked National Wellbeing Indicator*
Opportunities for Action Reverse the Decline in Biodiversity with an improvement in the Status of Species and Ecosystems by 2030 and their Clear Recovery by 2050 Role of future SoNaRRs in monitoring evidence informed delivery. Aligning with areas of nature targets, Species, ecosystems, reducing pollution and evidence.	**Indicator 4** (Levels of Nitrogen Dioxide (NO2) pollution in the air) **Indicator 13** (Concentration of carbon and organic matter in soil) **Indicator 14** (The global footprint of Wales) **Indicator 32** (Number of properties (homes and businesses) at medium or high risk of flooding from rivers and the sea) **Indicator 41** (Emissions of greenhouse gases within Wales), **Indicator 42** (Emissions of greenhouse gases attributed to the consumption of global goods and services in Wales), **Indicator 43** (Ares of healthy ecosystems in Wales) **Indicator 44** (Status of biological diversity in Wales), **Indicator 45** (Percentage of surface water bodies and groundwater bodies achieving good or high overall status).

Assessment of ecosystem resilience

Understanding and assessing ecosystem resilience is central to Wales' ability to respond to environmental pressures and deliver the Sustainable Management of Natural Resources (SMNR). This chapter begins by introducing the classification of Wales' ecosystems using UK National Ecosystem Assessment (UK NEA) and Office for National Statistics (ONS) broad habitat types. It then explores the ecological importance of semi-natural habitats, those most critical for resilient ecosystems, before presenting the DECCA framework used to assess resilience across ecosystems (Table 9). Together, these elements provide the foundation for understanding how resilient Wales' ecosystems are to expected and unforeseen change.

Assessing ecosystem resilience is inherently complex. To support consistent monitoring and reporting, We use a standardised framework based on the UK National Ecosystem Assessment (UKNEA, 2011) and the Office for National Statistics (ONS) Broad Habitats and Semi-Natural Habitats (Office for National Statistics, 2022), which is based on the UK Biodiversity Action Plan (UK BAP) Broad Habitat Classification (JNCC, 2024), to describe the natural environment. These categories help us understand how different ecosystems function, how they are impacted by human activity, and how resilient they are to pressures such as climate change, pollution, and land use change.

Broad habitats, such as woodlands, intertidal areas, enclosed farmland, freshwaters, and coastal margins provide a high-level view of the land and seascape. Within these, semi-natural habitats offer more detailed ecological insight, including areas like peatlands semi-natural grasslands and saltmarshes. These habitats are often more sensitive to change and are critical for biodiversity, carbon storage, and water regulation.

This classification system underpins the State of Natural Resources Report (SoNaRR) and supports the delivery of Sustainable Management of Natural Resources (SMNR). It enables us to track changes over time, identify pressures, and target interventions that build resilience.

By understanding and protecting these ecosystems, especially semi-natural habitats, we strengthen Wales' ability to respond to known pressures and adapt to the impacts of climate change.

Ecosystems

The Office for National Statistics (ONS) broad habitat types used by the UK National Ecosystem Assessment (UKNEA, 2011)) best embody the ecosystems present in Wales and therefore are a representation of the natural resources within that ecosystem.

A spatial distribution of the ONS broad habitat types (ecosystems) across Wales is available online (WINS ONS Broad Habitats - Wales for GIS layers) You can find a similar map on the SoNaRR 2025 landing page.

The most dominant land cover type covering 50% of Wales is classed as enclosed farmland. You can explore more in the Power Bi report.

These ecosystems allow us to:

- distinguish and group together the different habitats generally found there.
- describe the services we get from them and map the benefits across to well-being.
- look at threats or risks to the resilience of those ecosystems.
- identify opportunities and design management interventions around the land, water and sea uses that occur there.

Semi-Natural Habitats

To support a clearer understanding of habitat classification and the transition from ecosystems to semi-natural habitats, we refer to the framework presented *Habitats of Wales* (Blackstock et al., 2010, tbl. 4.1) outlines a typology of habitat naturalness and modification, providing a structured basis for distinguishing semi-natural habitats from those subject to more intensive land use. This classification underpins the terminology and definitions adopted in subsequent sections.

Table 7 Definition of terms describing habitat naturalness and modification. From Habitats of Wales A Comprehensive Field Survey 1979-1997, (Blackstock et al., 2010, tbl. 4.1)

Naturalness term	Definition
Natural	Habitats in which vegetation composition is entirely influenced, or almost so, by natural as opposed to anthropogenic processes. Examples include inaccessible sea cliffs, pristine raised bogs and upland rock exposure; such cases are extremely limited and are of course, exposed to the insidious effects of atmospheric sources of contamination.
Semi-Natural	Habitats in which the vegetation is mostly composed of native plant taxa, but where human land use and other activities play a key role in community development and maintenance. Examples are numerous, ranging across the spectrum of major habitat classes in Wales, including most forms of deciduous woodland, dwarf-shrub heathland, and many coastal formations. Habitat expressions least influenced by human activities are sometimes called ‘near natural’; at the other end of the spectrum certain degraded habitats, such as modified bog, are also treated as semi-natural.
Improved or highly modified	These terms are used for the most intensively managed, artificial and impacted habitats. In some cases, e.g. conifer plantations and arable crops, they are characterised by non-native species, while in other formations, e.g. improved grassland, selected strains or cultivars of native grasses, clovers and other species are prominent. Also included are entirely man-made environments, including urban and industrialised landscapes, roads and coastal defences.

Naturalness term	Definition
Semi-Improved	This term is often applied to grasslands that occupy an intermediate position along the floristic gradient from natural to improved or highly modified swards, where species composition includes elements from both ends o the spectrum. Such grasslands have often been partially improved or are in a state of reversion following sowing and fertiliser treatment.

Blackstock et al.'s (2010) classification of habitat naturalness has been formally incorporated into the Phase 1 Habitat Survey methodology undertaken by the Countryside Council for Wales (now Natural Resources Wales), where it has directly informed the consistency and repeatability of habitat mapping across Wales. This framework continues to underpin NRW's current Habitat Mapping approach, providing the methodological basis for distinguishing semi-natural habitats and supporting evidence-based reporting and policy delivery(NRW, 2023a).

Alternative, practical definitions of Semi-natural habitats are also used in Welsh environmental monitoring and regulation. Within the ERAMMP Wales National Trends and Glastir Evaluation (Emmett et al., 2025) semi-natural habitat defined as all land that isn't Arable, Improved Grassland, Coniferous, or Built-up/ Urban, so includes semi-improved grassland for example.

Under the Environmental Impact Assessment (Agriculture) (Wales) Regulations 2017, "semi-natural land" is defined by ecological composition and management intensity: i.e. the plants and wildlife they support, and by their low levels of physical and chemical disturbance. For example, grasslands with less than 25% improved agricultural species (such as ryegrass or white clover) are considered semi-natural under the Regulations. These habitats may have experienced low levels of physical disturbance, such as light harrowing, and/or low levels of nutrient input, but still maintain much of their ecological integrity. This definition distinguishes such areas from highly modified agricultural land, which is exempt from EIA screening requirements (Welsh Government, n.d.).

Semi-natural habitats are recognised as having higher ecosystem resilience than intensively managed land. This is reflected in their use within Indicator 43 of the Well-being of Future Generations (Wales) Act 2015, which tracks the extent of "healthy ecosystems" across Wales (Figure 2) . According to the 2019 Wellbeing of Wales report, approximately 31% of Wales' land area was considered semi-natural, including confirmed semi-natural habitats, bracken-dominated areas, and "candidate" habitats with potential for restoration (Welsh Government, 2025a) . These areas of what we term 'candidate' semi-natural habitat might be viewed as presenting opportunities for exploring the enhancement of ecosystem resilience, given their frequent proximity to established areas of semi-natural habitat

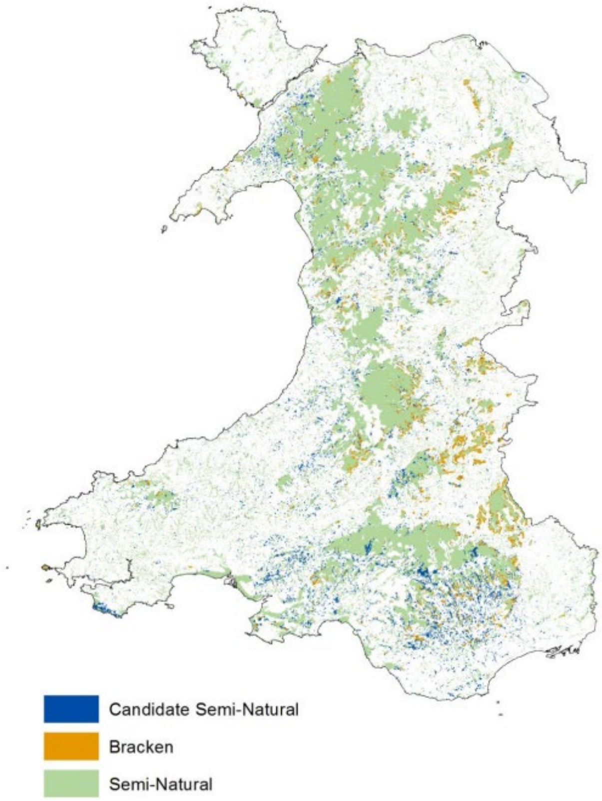

Figure 2 Indicator 43 semi-natural habitats © NRW

There is a marked spatial variation in semi-natural habitat coverage (NRW, 2019) :

- Upland areas: ~74% semi-natural
- Lowland areas: ~19% semi-natural

This pattern reflects historical land use, with lowlands more likely to have been cleared, improved, or developed due to their accessibility and productivity. In contrast, uplands and coastal margins have retained more of their semi-natural character. Most of the larger remaining areas of semi-natural habitat in Wales are found in the uplands and areas along the coast (NRW, 2019).

While semi-natural habitat extent is a useful proxy for biodiversity and resilience, it does not capture other critical attributes such as condition, connectivity, and species diversity. These factors are essential for understanding the true resilience of ecosystems and their ability to adapt to pressures such as climate change, pollution, and land use change.

Unlike some countries, Wales does not have untouched wilderness areas. Instead, its landscapes are shaped by centuries of human activity, resulting in a mosaic of anthropogenic and semi-natural habitats. Recognising and valuing these semi-natural areas is essential, as they hold the greatest potential for restoring ecosystem resilience and delivering vital services for future generations.

Section 7 Priority Habitats

Priority habitats in Wales are officially known as "Habitats of Principal Importance for the purpose of maintaining and enhancing biodiversity in relation to Wales", listed under Section 7 of the Environment (Wales) Act 2016.

Public authorities in Wales have a legal duty to take all reasonable steps to maintain and enhance these habitats and encourage others to do the same.

Priority habitats cover the full range of semi-natural habitat types and were identified as being the most threatened and requiring conservation action under the UK Biodiversity Action Plan (UKBAP) (Joint Nature Conservation Committee definition). Priority habitats in Wales are listed under Section 7 of the Environment (Wales) Act 2016. They cover around 18% of the land area of Wales (Jones et al., 2003).

The Section 7 list is extensive and covers a wide range of terrestrial, coastal, freshwater, and marine environments: Habitats include:

- **Woodlands:** Including traditional orchards, wood pasture & parkland, upland oak woodland, lowland beech and yew woodland, upland mixed ash woodland, wet woodland, and lowland mixed deciduous woodland.

- **Grasslands and Heathlands:** Including lowland meadows, coastal and floodplain grazing marsh, lowland calcareous and acid grasslands, upland calcareous grassland, lowland and upland heathland, and purple moor grass and rush pastures.

- **Wetlands and Bogs:** Including upland flushes, fens and swamps, lowland fens, reedbeds, lowland raised bog, and blanket bog.

- **Marine habitats:** Including carbonate reefs, Honey comb worm reefs, Intertidal mudflats, Horse mussel beds, subtidal mix mud sediments and seagrass beds.

Habitat Networks

Ecological connectivity is a key consideration in planning for effective biodiversity conservation and building ecosystem resilience through Resilient Ecological Networks (RENs). Modelled habitat networks can provide insights into how landscapes are likely to be functioning and inform the location of actions to improve the connectivity and resilience of protected sites (NRW, 2022).

Priority Ecological Network (PEN) Maps are a version of the habitat networks that specifically show areas of connectivity between Protected Sites for their respective habitats. As such they provide a framework for targeting action to build connectivity and hence functional connectivity between sites (NRW, 2025a).

*An **ecological network** can be understood as a number of core, well connected, high quality areas of well-functioning ecosystems, together with those parts of the intervening* *landscape that are ‘wildlife-friendly’ and which, collectively, allow wildlife to thrive* (Natural England, 2020).

PENs are the starting point, based on best available evidence to develop ecological networks. They are outputs of best available phase I habitat survey data and habitat modelling and national expert opinion. They provide some guidance on strategic ecosystem resilience but like all models should be used with caution as they are based on assumptions and modelled quantitative data and need to be verified and improved.

PENs mapping is limited, it is currently only available based on connecting Native Woodland, Semi-natural lowland grassland, Heathland, Bog, Fen, Sand dune, and Marine. It is also based upon phase I mapping which has its own limitations and modelled data from 2012.

PENs, however, are the starting point for developing Resilient Ecological Networks (RENs). RENs build upon the model output to refine with local and regional expertise, through co-productive and participatory mapping methodologies to define resilient ecological networks. To be successfully delivered spatial prioritisation of activities requires the views of all legitimate stakeholders and success dependent on the formation of steering and delivery bodies such as landscape partnerships.

Resilient Ecological Networks (RENs) have been defined as: “… networks of habitat in good ecological condition linking protected sites and other biodiversity hotspots across the wider landscape, providing maximum benefit for biodiversity and well-being. Such nature networks have existing or potential for healthy resilient ecosystems which provide a range of important ecosystem services as well as allowing the movement of species across landscapes in response to climate change (Welsh Government, 2020a)

The Nature Networks Map, outlining key focus areas has also been made available on public data portals to inform the delivery of the Nature Networks Programme in line with Deep Dive into biodiversity recommendations. The first stage of the Map was completed in July 2023, which made available some key datasets that can be used to inform the delivery of Nature Networks. It built upon existing and ongoing work on modelled maps of habitat connectivity, bringing it into a consistent form and making it available via on-line portals.

Stage 1 of the Nature Networks Map includes:

- Modelled habitat networks for All-Wales (NRW, 2022).
- Priority Ecological Networks (PENs) for terrestrial habitats (NRW, 2025a).
- A Priority Ecological Network (PEN) for the marine environment (NRW, 2025a).
- A generic buffer around terrestrial protected sites (Welsh Government, 2021)

Ecosystem Resilience Assessment

Ecosystem resilience is a cornerstone of the Sustainable Management of Natural Resources (SMNR). In SoNaRR2020, the assessment under Aim 2 concluded that *ecosystems in Wales are not resilient* (Natural Resources Wales, 2020). This finding carries serious implications: the continued degradation of ecosystems threatens both human wellbeing and ecological stability, with potentially catastrophic consequences for Wales and beyond.

Building on the methodology used in 2020 (Natural Resources Wales, 2020), the 2025 ecosystem resilience assessment again draws on expert judgement to evaluate resilience across Wales' ecosystems. While there is no universally accepted method for quantifying absolute resilience, the assessment uses a consistent framework based on four key DECC attributes:

- Diversity
- Extent
- Condition
- Connectivity

SoNaRR 2025 provides evidence through ecosystem assessments, natural resources assessments, it explores drivers of change as well as SMNR assessments for each ecosystem

Using the evidence complied for SoNaRR 2025, ecosystems are rated low, medium, or high for each DECC attribute, based on NRW subject matter expert evaluation (Table 8 to Table 15). This approach enables the detection of national patterns and supports strategic decision-making. A full description of the evidence behind this assessment is in the SoNaRR evidence portal.

Table 8 Assessment of state of ecosystem resilience (DECC) for Coastal margins ecosystem 2025

Habitat type	Diversity	Extent	Condition	Connectivity
Coastal/Saline lagoon	Medium	Low	Low	Low
Saltmarsh	Medium	Medium	Low	Medium
Sand dune	Medium	Medium	Low	Medium
Sea cliff	Medium	Medium	Low	Medium
Shingle	Medium	Medium	Low	Low

Table 9 Assessment of state of ecosystem resilience (DECC) for enclosed farmland ecosystem 2025

Habitat type	Diversity	Extent	Condition	Connectivity
Arable land	Low	Medium	Low	Low
Hedgerows	High	Medium	Low	High
Improved grassland	Low	High	Low	High
Parkland, wood pasture and individual trees	High	Low	Low	Medium
Traditional orchards	High	Low	Low	Low

Table 10 Assessment of state of ecosystem resilience (DECC) for freshwater ecosystem 2025

Habitat type	Diversity	Extent	Condition	Connectivity
Flood plains	Low	Low	Low	Low
Lakes - Low nutrient and upland	High	High	Medium	
Lakes - Lowland / higher nutrient	Low	Low	Low	
Marl lakes	Medium	Low	Low	High
Ponds	Medium	Low	Low	Medium
Rivers - lowland	Low	Low	Low	Low
Rivers - upland	Low	Medium	Medium	Medium

Table 11 Assessment of state of ecosystem resilience (DECC) for marine ecosystem 2025

Habitat type	Diversity	Extent	Condition	Connectivity
Intertidal	Medium	Medium	Low	High
Subtidal	Medium	Medium	Medium	High

Table 12 Assessment of state of ecosystem resilience (DECC) for mountain moorland and heath ecosystem 2025

Habitat type	Diversity	Extent	Condition	Connectivity
Alpine and boreal heath and grassland	Low	Medium	Low	Low
Lowland heathland	Medium	Low	Low	Low
Lowland peatland	Medium	Low	Low	Low
Upland heathland	Medium	High	Medium	Medium
Upland peatland	Low	Medium	Low	Medium
Upland rock habitats	Medium	Medium	Medium	Medium
Wider upland matrix	Low	High	Low	Medium

Table 13 Assessment of state of ecosystem resilience (DECC) for semi-natural grassland ecosystem 2025

Habitat type	Diversity	Extent	Condition	Connectivity
Lowland semi-natural grassland	Low	Low	Low	Low
Upland semi-natural grassland	Medium	High	Low	High

Table 14 Assessment of state of ecosystem resilience (DECC) for woodland ecosystem 2025

Habitat type	Diversity	Extent	Condition	Connectivity
Native woodland	Medium to High	Medium	Medium	Medium
Non-native woodland	Low to Medium	High	Medium	High

The urban ecosystem is not assessed in the same way. We use Indicators to describe the extent and condition of aspects of the Urban ecosystem (Table 10)

Table 15 Assessment of state of Urban ecosystem 2025

Habitat type	Extent	Condition
Light		Low
Noise		Low
Publicly accessible green space	Medium	Medium
Soils, contaminated land and sealed surfaces		Low
Temperature		High
Trees	Low	
Water - Flood	Medium	

SoNaRR 2025 findings reinforce the conclusions of SoNaRR 2020: most ecosystems in Wales currently show low overall resilience highlighting the vulnerability of ecosystem resilience as a foundation for sustainable management of natural resources and climate adaptation.

Whilst resilience is generally low, the assessments reveal some spatial variation: Upland areas tend to retain a higher proportion of semi-natural habitats and score more favourably across resilience attributes. Lowland areas, which have been more intensively modified, show consistently lower resilience.

This ongoing low level of resilience poses risks not only to the natural environment but also to the well-being of current and future generations. The evidence indicates that, without significant changes in how land, sea, and natural resources are managed, ecosystems will continue to degrade, limiting their ability to recover from shocks and adapt to future challenges.

To understand what is happening in Wales (state, pressures, trends, threats), the following sections of AIM 2 SoNaRR provide some analysis of what are the priorities, risks and opportunities to ecosystem resilience and suggests how to we can lay the foundations for delivery to halt the loss of nature by 2030 and achieve nature recovery by 2050.

This assessment should be read alongside the Biodiversity Assessment, which provides a complementary overview of ecosystem resilience using the DECCA framework.

Key pressures on ecosystems

Wales' ecosystems are under strain from a combination of longstanding land use practices and emerging global and local pressures. These pressures often overlap, making it harder for nature to recover and continue providing vital services like clean water, flood protection, and biodiversity. This chapter focuses on the pressures Wales can directly influence, such as land use and management, development planning, and pollution control, tackling these offers the greatest opportunity to restore nature, strengthen ecosystem resilience, adapt to climate change and support well-being for current and future generations.

Land is a finite and a valuable resource, essential for supporting both the built and natural environments. The marine area also provides a range of important resources such as aggregates for building, food and renewable energy. The natural environment underpin the delivery of ecosystem goods and services that contribute to the health, wellbeing, and prosperity of people and nature.

The UN Environment Programme's situational analysis for their Medium-Term Strategy (2022-2025) highlights the world is facing three major environmental challenges: biodiversity and nature loss, climate change and pollution and wastes (UNEP, 2021).

This chapter explores the key pressures affecting ecosystem resilience, drawing on evidence from the State of Nature Wales 2023 report (Burns et al., 2023) and SoNaRR 2025. The State of Nature report identifies agricultural management, climate change, urbanisation, pollution, hydrological change, invasive non-native species (INNS), and woodland management as the most significant pressures on terrestrial and freshwater nature in the UK. At sea, pollution, climate change, overexploitation, invasive species, and marine development dominate.

To provide clarity and focus, the chapter is structured around the most persistent and impactful pressures. It begins with climate change, a pervasive and accelerating driver, before examining land use, with a focus on built development, renewable energy infrastructure, and agricultural intensification.

The way land and sea is used and managed is placing increasing pressure on Wales' ecosystems. Some of the key impacts on semi-natural habitats, drawn from ecosystem and natural resource assessments are summarised in Aim 2 Annex 1 Key Pressures from aims and ecosystem assessments**)**. Together, these pressures form a complex landscape of risk and opportunity, shaping the future of nature recovery and ecosystem resilience in Wales.

Climate change

Climate change is one of the most pervasive and accelerating pressures on Wales' ecosystems. It interacts with and amplifies other pressures, such as habitat fragmentation, pollution, and invasive species, reducing the ability of ecosystems to recover, adapt, and continue delivering essential services.

Climate change is a major and escalating pressure on Wales' ecosystems, influencing water availability, species distributions, and ecosystem functions. SoNaRR2020 identified impacts on hydrological systems, with projections of more frequent and intense droughts, floods, and heatwaves (IPBES, 2019). Climate change is and will continue to impact all ecosystems in Wales, with warmer, wetter winters, hotter, drier summers, and a higher number of more intense extreme events predicted to occur. The biggest threats from climate change are to vulnerable habitats that include mountains, moorlands and heaths, and coastal margins (SoNaRR 2025 Climate change evidence). Climate change is leading to increasing pressures affecting the Welsh marine ecosystem with rising sea temperatures and sea level contributing to biodiversity loss and habitat degradation (SoNaRR 2025 marine ecosystem assessment).

Some impacts, including sea level rise and coastal erosion, are likely irreversible (IPBES, 2019). UK Climate Projections (UKCP18) show increasing sea level rise and increased likelihood of more intense and frequent storm events, which will inevitably result in increased wave action (NRW, 2021a). Coastal squeeze is a both a pressure and a threat to marine and coastal ecosystems and is causing (or likely to cause) the deterioration or loss of coastal and intertidal features around the coast of Wales (Oaten et al., 2024).

SoNaRR 2025 Land and sea use management and change evidence highlights the role of terrestrial ecosystems in climate mitigation and supporting nature, especially in the uplands, over the long term reporting that the net sink of emission has actually been declining. Climate mitigation is considered in other policy frameworks, and future land use decisions must consider suitability and capability of climate mitigation interventions, including whether they enhance biodiversity and ecosystem resilience, to be guided by a robust decision-making framework. More information on this can be found in SoNaRR 2025 Land use and management change evidence.

While climate change is a global challenge, its effects are felt locally. In Wales, the resilience of ecosystems to climate change depends on how well we manage known pressures, such as land use change, pollution, and habitat degradation. Strengthening ecosystem resilience is therefore not just a response to climate change, but a proactive strategy for adaptation.

In Aim 2 we acknowledge the overarching influence of climate change and more information on climate change as a driver of pressures can be found in the Climate change chapter, but the remainder of the chapter focus is on direct pressures within our control.

Land use

Land use, and land use change is one of the most significant and long-standing pressures on ecosystem resilience in Wales. Unlike climate change, which is largely global in origin, land use decisions are made locally and nationally, making them one of the most direct levers for improving ecological outcomes.

The impact of land use decisions, particularly intensive land use (built development, renewable energy infrastructure, and agricultural intensification) are shaping the resilience of terrestrial, freshwater and marine ecosystems across Wales.

Over recent decades, Wales has experienced notable shifts in land use. Urban expansion, infrastructure development, and changes in agricultural practices have reshaped the landscape, often at the expense of semi-natural habitats. These changes have fragmented ecosystems, reduced habitat connectivity, and placed increasing pressure on our natural resources.

Understanding how Wales' land is used, and how it is changing, is essential to identifying current and future anthropogenic pressures on ecosystems. The ERAMMP Report-105 (Emmett et al., 2025) provides a detailed analysis of land use change between 2010 and 2021, using satellite data to track national trends. Over this 11-year period it identified that, 6.8% of Wales' land area changed use. Urban land cover has also increased of +29% (28,200 hectares), now accounting for almost 6% of Wales, primarily at the expense of improved agricultural land. Woodland like cover[1] expanded 7% (23,600 hectares), There was no change in the area of Semi-Natural Habitat (Welsh Government, 2025a, p. 43).

Despite a 5% reduction (48,900 hectares), intensively managed farmland (arable and improved grassland) continues to dominate the landscape, covering 44% of Wales' land area. Expert review in ERAMMP Report-105 (Emmett et al., 2025) of habitat and landscape features concluded that over the 10 years studied: 12 habitats and landscape features measured were in a state of concern or had declined, 6 were stable, and only 1 had improved (hedgerows). No change in the area of Semi-Natural Habitat was detected between 2010 and 2021 which represents 42.6% of Wales (This is larger than that reported previously by NRW of 31% for 2017-18 due to a difference in methodology) (Emmett et al., 2025).

SoNaRR 2020, reported that since the end of the Second World War, levels of agricultural production have increased greatly. Semi-natural habitats were cultivated, drained, limed and fertilised to create more productive land (Blackstock et al., 2010). Intensity of management of agricultural land has been identified as the most significant factor driving species population change in the UK (NRW, 2021b). Agricultural intensification has resulted in the loss of habitats, declines in species populations and increased habitat fragmentation (NRW, 2021b). Agricultural practises involving manufactured fertilisers and animal waste cause pollution and eutrophication of both freshwater and terrestrial

[1] Please note that the definition of woodland identified by satellite data for the ERRAMP study is different to estimates used by NRW. See woodland assessment

ecosystems (NRW, 2021b). Refer to Aim 1 for more information on pressures on natural resources.

The natural resource and driver assessments consistently highlight intensive anthropogenic land use, particularly urban (development and renewable energy) and enclosed farmland ecosystems as key pressures on ecosystem resilience. In Wales, all ecosystems are shaped by human activity. Around 90% of land is under agricultural use (Welsh Government, 2024b), 6% is urban. Land use and land use change continues to be a major pressure on biodiversity and ecosystem resilience.

While climate change presents an overarching challenge, addressing known pressures, such as urban expansion, agricultural intensification, and land conversion, can significantly enhance the resilience of ecosystems to future climate impacts. See the SoNaRR2025 land use and management change evidence for more information on land use in Wales.

Evidence in SoNaRR 2025 ecosystems assessments (see Aim 2 Annex 1 Key Pressures from aims and ecosystem assessments) reinforces this, highlighting the current and future pressures from urban expansion and intensive agricultural practices. The following sections provides a focused overview of these key pressures and their implications on ecosystem resilience.

Focus on Built Development, Infrastructure and Renewable Energy:

Wales is undergoing transformation in land and sea use, driven by policy ambitions in housing, energy, and economic development. These changes are essential for societal wellbeing and climate goals, but they also place increasing pressure on ecosystems and natural resources.

SMNR Aim 4 highlights that the Welsh Government recognises that demand for land will intensify, particularly from the construction and energy sectors. A key commitment is to deliver 110,000 new homes by 2040 (Welsh Government, n.d.), which will require careful spatial planning to avoid further fragmentation of habitats and loss of ecosystem services.

In the marine environment, the Freeport Programme (Welsh Government, 2025b) will stimulate economic activity and infrastructure development, but it also increases competition for land and sea space, with implications for marine biodiversity and coastal ecosystem resilience.

The transition to renewable energy is another major driver of land and sea use change. Wales aims to meet 70% of electricity consumption from renewables by 2030, rising to 100% by 2035 (Senedd Cymru, 2023; Welsh Government, 2023a, 2023a) (SoNaRR2025 land use and management change evidence). To support this, large areas of land and sea have been pre-assessed for wind energy development (Welsh Government and NRW, 2024); (Welsh Government, 2019). UK Government has committed to the upscale of offshore wind development from the current 15GW capacity to 50GW by 2030 (Department for energy, security and net zero, 2023). While essential for decarbonisation, this expansion renewable energy infrastructure needs careful management to meet the joint Nature and Climate Emergencies, a sustainable approach that enables ecosystem resilience will be critical.

Energy demand also affects agricultural land. Between 2015 and 2020, the UK saw a rise in maize cultivation for anaerobic digestion (AD)(DEFRA, 2021), and ground-mounted solar panels now cover an estimated 230 km² (Rankl and Sutherland, 2023). These developments, if not carefully managed, can reduce habitat connectivity, degrade soil health, and displace semi-natural habitats.

Afforestation is another key strategy for climate mitigation. The Climate Change Committee recommended planting 43,000 ha of new trees by 2030, rising to 180,000 ha by 2050, targets that exceed current commitments in the Woodlands for Wales Strategy (Welsh Government, 2021). This presents both opportunities carbon sequestration and habitat creation, it also presents challenges to ecosystem resilience if implemented on sensitive habitats especially if planting occurs on sensitive habitats or without consideration of landscape context (SoNaRR2025 land use and management change evidence).. Woodland Creation Plans which propose planting on priority habitats are unlikely to be verified.

These pressures are anthropogenic and within society's control. By integrating nature-positive planning, ecosystem safeguards and spatial frameworks such as Resilient Ecological Networks (RENs) and Marine Protected Areas (MPAs) into development and energy strategies, Wales can build resilience to climate change while meeting its economic, net zero and environmental goals.

The SoNaRR "Bridges to the Future" framework calls for transformative change in how we use land and sea. This means rethinking infrastructure, housing, and energy systems to work with nature, not against it. Strategic choices made today will shape the health and resilience of Wales' ecosystems for decades to come.

Focus on Agricultural Intensification:

Agriculture dominates land use in Wales, covering around 90% of the land area (Welsh Government, 2024b). This scale of activity means that historic, current, and future agricultural intensification has profound implications for the resilience of ecosystems, the sustainability of soils, and the quality of natural resources.

According to the 2024 Survey of Agriculture and Horticulture, Wales supported:

- 8.7 million sheep and lambs (lowest since 2011),
- 1.1 million cattle and calves, and
- 53,000 ha of cereals, up 4% from 2023 but still below recent peaks (accounting for less than 3% of all agricultural land in Wales)

These figures reflect a productive sector; they also highlight the scale of pressure on ecosystems that can extend right out to sea. Agricultural activity contributes significantly to nutrient pollution, soil degradation, and water quality impacts (SoNaRR 2925 water assessment). Nutrients such as nitrogen and phosphorus are essential for food production, but their overuse, particularly through NPK fertilisers and organic manures, can lead to eutrophication of freshwater ecosystems, greenhouse gas emissions, and reduction of soil function (NRW, 2024a).

Wales applies an estimated 10 million tonnes of organic manures annually (Rollett and Williams, 2022a), mostly derived from livestock farming. When managed well, these materials support soil health, circular economy principles, and food security. However, poor management, such as over-application or spreading in unsuitable conditions, can turn a valuable resource into a pollution risk. Organic manures should be seen as a useful resource and any over application a disposal activity (NRW, 2024b).

Many ecosystems are vulnerable to intensive agricultural practices; semi-natural grasslands, for example, are highly sensitive to elevated soil nutrient levels from fertiliser application and can be degraded by agricultural practices such as ploughing and herbicide use. Evidence gaps remain around where and when organic materials are spread, and how much landbank is truly available for sustainable nutrient recycling (NRW, 2021b, 2021c) (SoNaRR 2025 land use and management change evidence). Modelling suggests that while Wales has capacity, regional pressures, especially in South Wales, North Wales, and Pembrokeshire, may require redistribution of organic materials to avoid environmental harm (Rollett and Williams, 2022b). Managing the environmental impacts of NPK usage is essential for sustainable farming practices in Wales (Welsh Government, 2024c).

Between 2010 and 2021, Wales lost 5% of its most productive agricultural land, partly due to urban expansion. This trend, combined with competing demands from housing, renewable energy, and carbon sequestration, underscores the need for strategic land use planning see SoNaRR 2025 land use and management change evidence.

Climate change adds further complexity. Under high-emission scenarios, Wales' Best and Most Versatile (BMV) agricultural land is projected to decline by 2050 due to summer water deficits, increasing the need for irrigation and adaptive land management (SoNaRR 2025 soils assessment).

By adopting nature-positive farming, improving nutrient management, and investing in soil health, Wales can enhance ecosystem resilience while supporting food production and climate goals. The SoNaRR "Bridges to the Future" framework calls for transformation in the food system. Agricultural intensification must evolve to work with nature, not against it, ensuring that farming remains productive, sustainable, and resilient in the face of climate change and competing land demands.

Enhancing Ecosystem Resilience: the Need for Transformation

The evidence is clear: Wales' ecosystems face growing pressures from climate change, historic and present land and sea use, and ongoing changes in how these areas are managed, and other associated pressures such as pollution, invasive non native species and lack of suitable management. These pressures are driven by societal choices and economic demands (housing, energy, agriculture) and are expected to intensify. Without a significant shift in how we manage land, sea, and natural resources, ecosystems will continue to degrade, reducing their capacity to recover from shocks and adapt to change.

The Global Biodiversity Framework (GBF) sets out an ambitious vision to halt biodiversity loss and secure nature's recovery. Achieving this requires action at scale and pace, across sectors, institutions and delivery mechanisms, with full integration of nature into all agendas.

In December 2024, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services published a Transformative Change Assessment (IPBES, 2024), identifying the underlying causes of biodiversity loss and the system-wide changes needed to meet the GBF's 2050 Vision. The Assessment makes clear that promoting and accelerating transformative change is essential to meet the GBF's targets and goals for a world where all life can thrive.

The Assessment's Summary for Policy Makers (IPBES, 2025) describes transformative change as fundamental system-wide shifts in views (ways of thinking, knowing and seeing), structures (ways of organising, regulating and governing), and practices (ways of doing, behaving and relating). It explains that transformative change is best understood as changes all individuals can create, and multiple cascading shifts that trigger and reinforce one another.

The Assessment provides key messages showing the significance of the interdependencies between nature and economic production, the impact of harmful subsides, and the external costs of sectors most responsible for nature's decline. It highlights 5 strategies (aka priorities) that all need pursuing to enable transformative change address biodiversity loss and support nature recovery:

- Conserve, restore and regenerate places of nature and biocultural value
- Drive systematic change and mainstream in sectors most responsible
- Transform economic systems for nature and equity
- Transform governance systems to be inclusive, accountable & adaptive
- Shift views & values to recognize human-nature interconnections

The Assessment identifies the sectors that are most responsible (agriculture and livestock, fisheries, forestry, infrastructure and urban development, mining and fossil fuel) are also levers for change.

In Wales, land and sea use choices in renewable energy infrastructure, urban development and agriculture must be aligned with ecosystem resilience goals, to build adaptive capacity in the face of climate uncertainty.

The findings from SoNaRR 2025 reinforce the need for integrated land use planning and nature-positive management to protect ecosystem function while meeting economic and social goals.

The Well-being of Future Generations (Wales) Act 2015 provides the framework to deliver integrated change across society, economy and the environment. The SoNaRR 2020 “Bridges to the Future” highlighted the importance of transforming systems in particular the food, energy, transport systems to tackle the nature and climate emergencies. Tackling these pressures head-on is not just about protecting nature, it’s about securing the long-term wellbeing of people and communities.

Strategic land use and marine planning, nature-positive farming, and integrated infrastructure development are actionable areas where policy can make a measurable difference. However, growing and competing demands on land from housing and infrastructure to food production and climate mitigation, raise concerns that land in Wales may already be overpromised, with limited capacity to meet all policy ambitions simultaneously (SoNaRR 2025 Land use and management change evidence).

SoNaRR 2025 confirms the continuation of low ecosystem resilience across Wales, with most ecosystems expected to deteriorate further, (see indicative assessment of pressure trends in the SoNaRR evidence portal), undermining their ability to deliver essential benefits such as clean water, carbon storage, biodiversity, and climate regulation.

This erosion of resilience threatens not only the health of the natural environment but also the well-being of current and future generations. Without a significant shift in how we manage land, sea, and natural resources, ecosystems will continue to degrade, reducing their capacity to recover from shocks and adapt to change.

The SoNaRR “Bridges to the Future” framework calls for a transformative approach. This means moving beyond incremental improvements to system-wide change in how we plan, invest, and make decisions. It requires:

- Integrating nature-based solutions into infrastructure, energy, and farming systems.
- Restoring semi-natural habitats to strengthen ecological networks.
- Reducing pollution and nutrient loading through innovative nature friendly farming practices.
- Aligning policy and investment with long-term resilience goals.

By rethinking how we use land and sea, manage resources, and design our policies, we can restore resilience to our ecosystems and build a healthier, more sustainable future for Wales. The time to act is now.

Wales’ Response: Opportunities for Action Enhance Ecosystem resilience:

This section sets out how Wales can respond to the evidence presented in SoNaRR 2025 by embedding ecosystem resilience into policy and delivery. It is designed for policy makers across sectors, agriculture, planning, energy, and environment, who are responsible for shaping the future of Wales’ natural resources. Building on the legislative foundations of the Environment (Wales) Act 2016, the Agriculture (Wales) Act 2023, the Planning (Wales) Act 2015 and the Well-being of Future Generations (Wales) Act 2015, this section identifies strategic priorities and practical mechanisms to halt biodiversity loss and restore ecosystem function. It highlights the role of nature-based solutions, place-based planning through Area Statements, and the development of Resilient Ecological Networks. By aligning policy with the 30by30 commitment and the Global Biodiversity Framework, Wales can move from ambition to delivery, ensuring that ecosystem resilience becomes the foundation of a healthy, prosperous, and climate-ready nation. By using this section to inform planning, funding, and regulation, policy makers can help build a climate-ready, resilient Wales.

Nature-Based Solutions - A Place-based Approach

Ecosystem resilience can be enhanced through the implementation of nature-based solutions, interventions that use nature/ natural processes to address societal challenges such as climate change, biodiversity loss, and public health. These solutions are most effective when tailored to the specific pressures, characteristics, and priorities of a place. In Wales, this means recognising that challenges vary across landscapes, between places and so must the responses.

Nature-based solutions are a key priority of Welsh Governments Natural Resources Policy (Welsh Government, 2017) which promotes the use of nature and natural processes to address Wales’ big challenges, including the climate emergency, biodiversity decline, and public health issues such as air quality, obesity, mental wellbeing.

To deliver the Sustainable Management of Natural Resources (SMNR), Welsh Government are committed to understanding how nature-based solutions can provide positive and cost effective responses to our key societal challenges and which can maximise our contribution across the well-being goals

It should be noted that nature-based solutions (NbS) are most effective when they are designed in response to the specific pressures, characteristics, and priorities of a place. Indeed, the sustainable management of natural resources (SMNR) requires us to recognise that pressures on ecosystems are not uniform across Wales. They are expressed differently in different places, and their manifestation influences which ecosystem services are most needed and valued locally.

The State of Natural Resources Report (SoNaRR)provides a national overview of the ecosystem condition and trends, but it also highlights that critical importance of local variation. Pressures such as land use change, pollution, climate impacts, and socio-economic drivers manifest differently depending on its landscape context, historical development, and community needs. As a result, the ecosystem services most needed and valued are also context dependent. For example:

- In urban dominated landscapes like South Central Wales, woodlands may be under pressure from fragmentation and recreational use, and are highly valued for air quality regulation, biodiversity, access to nature, and health and wellbeing.
- In rural landscapes such as Mid-Wales, woodlands may face pressures related to land management and are more likely to be valued for timber production, tourism, and supporting rural economies.

This variation underscores the need for a place-based approach to NbS, one that is locally informed, spatially targeted, and responsive to both ecological pressures and community priorities. A generic or one-size-fits-all approach risks delivering solutions that are ecologically inappropriate or socially irrelevant, potentially undermining both ecosystem resilience and wellbeing outcomes.

Ecosystem resilience is defined as *the ability of ecosystems to withstand, recover from, or adapt to disturbances* ***while continuing to provide services and benefits.*** Resilience is inherently linked to place: ecosystems must be able to resist external pressures, bounce back from damage, or adapt to changes while maintaining their ability to support life and people. But resilience cannot be built through generic solutions.

To maximise the benefits of NbS, we must adopt a landscape approach, informed by local evidence, stakeholder knowledge, and the unique characteristics of each site. NbS must be designed to work with natural hydrological, coastal, and geomorphological processes (Environment Agency, n.d.), and should enhance rather than compromise ecosystem resilience. For instance, tree planting for carbon sequestration must avoid damaging semi-natural grasslands, which provide irreplaceable biodiversity and ecosystem services, including storage of appreciable amounts of soil carbon in their own right. The value of the natural environment to health and economy are explored further in Aims 3 & 4

Nature-based solutions are a key mechanism for delivering Resilient Ecological Networks (RENs), Sustainable Land Management (SLM), and biodiversity targets. They should be integrated into landscape-scale planning and supported through Area Statements, which provide the spatial framework for place-based delivery. Policy makers are encouraged to use this section to identify opportunities for embedding NbS into their strategies, aligning with Wales’ commitment to halt biodiversity loss by 2030 and achieve nature recovery by 2050, and the Environment (Wales) Act 2016 Part 1 – Section 6 duty sets out requirements for the Welsh Government and other public authorities which are to maintain and enhance biodiversity and promote the resilience of ecosystems (Welsh Government, 2022).

Area Statements – Translating National Priorities into Local Action

Area Statements are a cornerstone of Wales' place-based approach to delivering the Sustainable Management of Natural Resources (SMNR). We develop the seven Area Statements through co-production to translate national priorities into locally relevant, strategic actions. They are informed by the evidence base of SoNaRR and aligned with the Welsh Government's Natural Resources Policy.

Area Statements identify local challenges and opportunities for SMNR, facilitate collaborative working across sectors and communities, and promote joined-up responses to complex environmental issues. They support the co-production of locally relevant actions, informed by stakeholder knowledge and evidence (NRW, n.d.)

These place-based assessments provide a nuanced understanding of natural resources, environmental pressures, and opportunities within specific regions of Wales. They highlight how natural resources can be better managed to deliver multiple benefits, from biodiversity and climate resilience to community wellbeing and economic sustainability for the benefit of current and future generations.

By embedding action in a local context, Area Statements ensure that interventions particularly NbS, are strategic, effective, and resilient. They help deliver multiple benefits, from biodiversity enhancement and climate adaptation to community wellbeing and economic sustainability, all aligned with the goals of the Well-being of Future Generations (Wales) Act 2015.

In essence, Area Statements operationalise SMNR at the regional and landscape scale, making them a vital mechanism for achieving resilient ecosystems and a sustainable future for Wales. The map on the SoNaRR 2025 landing page allows you to see the area statement boundaries with the broad ecosystems we use in SoNaRR.

Across Wales, there is a clear consensus across all Area Statements that reversing biodiversity decline and enhancing natural habitats is a critical priority to enhance ecosystem resilience and provide the benefits that are needed. A major challenge lies in restoring and connecting vulnerable protected areas to ensure they are resilient and able to deliver broader social and economic advantages. This is achieved through identification of Resilient Ecological Networks to help identify the opportunities for SMNR.

An overview of each of the seven area statements can be found in Aim 2 Annex 2 Area Statements SMNR overview Key opportunities for nature-based solutions identified through ecosystem assessments undertaken by NRW technical experts can be found within each of the Ecosystem and Natural Resource assessments of SMNR.

Recognising Shifting Baselines: A Call for Long-Term Perspective for Policy Makers

It is important to note that much of the land use change referenced in SoNaRR 2025 represents shifts since SoNaRR 2020 or 2010 (Emmett et al., 2025). However, Wales has experienced profound ecological change over the past century. Much of our current monitoring and policy response is based on data from the last 50 years, creating a challenge known as shifting baselines, where each generation accepts a progressively degraded natural environment as “normal” (Pauly, 1995; Soga and Gaston, 2018)

The State of Nature Wales 2023 report highlights that, 42% of flowering plant species and 44% of bryophytes have declined in distribution since 1970. The average abundance of monitored species has dropped by 20% since 1994, but this follows centuries of habitat loss and degradation.

Many habitats and species that were once common are now rare or locally extinct, yet their absence may no longer be widely recognised. For example, (Moore et al., 2024) found that temperate marine ecosystems have undergone a marked shift in the species targeted by historic fisheries. Until the early to mid-20th century, fisheries were primarily based on herring and a variety of demersal fish. Today, these have largely been replaced by fisheries dominated by invertebrates such as shellfish and crustaceans. The paper suggests that this change reflects a significant alteration in ecosystem structure and resource use, with implications for management, monitoring, and long-term resilience.

Policy makers must keep this consideration in mind when forming strategies. A nature-positive future cannot be built on a baseline that already reflects significant ecological degradation. Without recognising the full scale of historical loss, policy responses may lack the ambition needed to restore ecological health.

To avoid the trap of shifting baselines, Wales must ensure that future SoNaRRs, biodiversity targets, and policy frameworks are informed by a long-term ecological perspective, not just recent trends. While historical baselines can be incomplete or contested, they offer valuable insight into the scale of ecological change and help us avoid setting ambitions too low. Rather than aiming to restore ecosystems to a fixed point in the past, we should use historical context to inspire bold enhancement goals, guided by current frameworks such as DECCA and the statutory duty to maintain and enhance ecosystem resilience. This approach recognises that nature recovery is not about returning to what was, but about building resilient, thriving ecosystems for the future, drawing on the past to inform ambition,

This will help ensure that recovery efforts are truly transformative for future generations, not merely incremental.

Ecosystem Resilience Priorities for Policy Makers

Since the publication of SoNaRR 2020, Wales has taken significant steps to respond to the growing evidence of ecological decline. The Senedd’s declaration of a Nature Emergency in 2021, and commitments to international targets such as 30by30, signal a shift in ambition and urgency. These commitments are now embedded as ecosystem resilience across multiple policy areas, laying the legislative and strategic foundations for delivery

- The Agricultural (Wales) Act 2023 promotes Sustainable Land Management (SLM) with a statutory objective to maintain and enhance ecosystem resilience and the benefits it provides.

- The Planning (Wales) Act 2015 underpins Future Wales: The National Plan 2040, which seeks to safeguard Resilient Ecological Networks (RENs) including, supporting green infrastructure, enhancing connectivity between habitats, and promoting nature-based solutions.

- The Environment Act (Wales) 2016, includes the Biodiversity and Resilience of Ecosystems Duty, with Area Statements playing a key role in delivering SMNR, identifying and supporting Resilient Ecological Networks and translating the national goals into local action.

- The Well-being of Future Generations (Wales) Act 2015 establishes a legal duty on public bodies to work towards seven well-being goals, including A Resilient Wales, defined as a nation which maintains and enhances a biodiverse natural environment with healthy functioning ecosystems that support social, economic and ecological resilience and the capacity to adapt to change

These frameworks collectively recognise that ecosystem resilience is not a standalone goal, but a cross-cutting priority essential to delivering climate adaptation, biodiversity recovery, and long-term well-being. They provide the tools and mechanisms to move from ambition to action.

The consistent message across SoNaRR and supporting evidence is clear: ecosystems must be resilient to deliver the benefits communities rely on. This resilience can be achieved by establishing a better-connected network of protected sites and landscapes, supporting biodiversity and enabling species and habitats to thrive.

In line with the nature emergency and commitments to international targets, the following section explores the key strategic priorities for policy makers to enhance ecosystem resilience. These include supporting an aligning landscape-scale management through partnerships laying the foundations for delivery, creating Resilient Ecological Networks, meeting the objectives of Sustainable Land Management and delivering Wales' biodiversity commitments and targets.

To understand how well Welsh ecosystems can handle change, we need to understand the landscape, its geology and soils and the pressures and threats it faces. These elements shape the ecosystems, habitats, and species present, and determine their ability to resist, recover from, and adapt to various pressures

Laying the foundations for delivery: Resilient Ecological Networks (RENs)

Resilient ecological networks are vital for nature recovery. They are networks of habitat in good ecological condition linking protected sites and other biodiversity hotspots across the wider landscape and providing maximum benefit for biodiversity and well-being. Such networks have existing or potential for healthy resilient ecosystems which provide a range of important ecosystem services as well as allowing the movement of species across landscapes in response to climate change.

Resilient Ecological Networks (RENs) are a policy priority for Welsh Government in addressing nature and climate emergencies. Maintaining and Enhancing Resilient Ecological Networks is 1 of 5 themes identified in the Nature Recovery Action Plan (NRAP) (targeted place-based spatial action to deliver benefits for biodiversity, species and habitats, reduce negative impacts and maximise our well-being) (Welsh Government, 2020a). Nature-based solutions to address both emergencies, should contribute wherever possible to maintaining and enhancing these nature networks.

The Resilient Ecological Networks approach (NRW, 2024c) is integrated into existing Welsh legislation, thematic and spatial strategies, and policy frameworks, providing long-term support to 30by30 framework (Welsh Government, 2025c) and the wider aspirations of the GBF (Convention on Biological Diversity, 2022).

The concept of Resilient Ecological Networks recognises that ecosystem processes occur at a landscape scale and often beyond the boundaries of individual sites. The resilience of ecosystems relies on these processes, such as pollination and seed dispersal, on being functionally and structurally connected.

Resilient Ecological Networks (RENs) offer an effective and transformative framework through which existing and new programmes and projects can be organised and prioritised to better maintain, and crucially build, ecosystem resilience at scale and pace.

RENs - *These networks should be diverse, of sufficient scale and extent, in good functional condition and part of connected mosaics, to enable species and habitats to adapt to disturbance and change'. They are intended outcomes i.e. functionally and structurally connected series of important sites for biodiversity that have existing, or the potential for healthy and resilient ecosystems, and provide benefits for biodiversity and wellbeing. RENs can be developed at any scale, from landscape-scale to very local. RENs feature core areas and an intervening land-use matrix and should be informed by co-design .* *See pages 11-13 of Terrestrial and freshwater Resilient Ecological Networks: a guide for practitioners in Wales*

SoNaRR 2025 highlights the need for connected, functional ecological networks to support resilience and explores Resilient Ecological Networks further in the SoNaRR 2025 Biodiversity Assessment. A key message from the SoNaRR 2025 marine ecosystem assessment is the priority focus for delivering resilient marine ecosystems in Wales is to ensure the effective management and favourable condition of the Marine Protected Area (MPA) Network which covers 69% of Welsh inshore waters (NRW, 2021d).

Resilient Ecological Networks (RENs) are essential for nature recovery and climate adaptation, connecting protected sites and biodiversity hotspots across the landscape.

Policy Levers and Enabling Conditions:

- Embed RENs into national, strategic and local development plans by using existing planning frameworks (e.g. Future Wales, TAN guidance) to identify and safeguard ecological corridors and connectivity.
- Use Area Statements to identify place-based opportunities for REN development, ensuring actions are spatially targeted and co-designed with stakeholders.
- Direct funding (e.g. Nature Networks Programme, SFS Collaborative actions) toward areas identified as REN priorities, especially where connectivity can be enhanced between protected sites and semi-natural habitats.
- Align RENs with 30by30 commitments recognition of Other Effective area based Conservation Measures and bringing protected sites under effective management.
- Integrate RENs in spatial planning, Nature Recovery Programmes and investment decisions.
- Extend REN principles to the marine environment by supporting ecologically coherent networks of Marine Protected Areas (MPAs) and integrating with marine spatial planning

Laying the foundations for delivery: Sustainable Land Management

Demand on our ecosystems for food and fibre sits alongside increasing policy ambitions for more renewable energy for the decarbonisation agenda, more organic materials for recovery to land, to supply housing for a growing population, to store and sequester carbon, to mitigate and adapt to climate change, maintain and restore habitats for biodiversity and improve resilience to extreme weather.

These are all likely to influence future land use and management change in Wales. Farmers and land managers have been vulnerable to global economic shocks caused by pandemics, war and extreme weather events. There is a risk of unsustainable land use and management changes (increased intensity or reduced management intensity) without appropriate policies and economic incentives (SoNaRR 2025: land use change)

The Sustainable Land Management Framework established in the Agricultural (Wales) Act 2023, sets out Welsh Government’s commitment to building on sustainable farming practices to deliver high animal health and welfare standards, respond to the challenges of the climate and nature emergency and support the sustainable production of food.

Sustainable Land Management recognises the key environmental, economic, cultural and social contribution of farmers in Wales (Welsh Government, 2023b).

Figure 3: Sustainable Land Management objectives in Wales.

© Welsh Government (Welsh Government, 2023b)

Sustainable Land Management (SLM) is built around four objectives which celebrate the key contributions our agricultural industry makes to Wales. The objectives capture the sustainable production of food and other goods while also addressing the declared climate and nature emergencies and recognising the key role farmers play in the environmental and cultural health of Wales

Placing the Sustainable Land Management duty on all Ministers, SLM is a key policy framework ensuring future agricultural support and regulation in Wales will be consistent with Welsh Government's obligations under the Well-being of Future Generations (Wales) Act 2015, helping to contribute to the well-being goals under section 4 of that Act, and the Environment (Wales) Act 2016 (Welsh Government, 2023b), embedding ecosystem resilience into agricultural policy and practice. To achieve the objective to Maintain and enhance the resilience of ecosystems and the benefits they provide: Welsh Government has committed to supporting the agricultural community to seek to maintain and enhance the diversity of plants and animals, support the agricultural industry in the careful management of our natural resources including soils, water, crops and habitats, making our landscape strong and flexible

Sustainable Land Management is central is central to delivering GBF target 7 and Target 10 (promoting sustainable agriculture and forestry) and complement the above targets.

Policy Levers and Enabling Conditions:

- Ensure SLM delivery contributes to statutory biodiversity targets and 30by30 commitments, using RENs and Area Statements to guide spatial prioritisation.

- Support collaborative delivery models (e.g. catchment groups, regional clusters) that enable land managers to work across boundaries to deliver ecosystem resilience
- Use the statutory SLM framework to guide agricultural support schemes, ensuring that payments reflect contributions to biodiversity, and complementary ecosystem services such as water quality, carbon storage, and cultural landscapes
- Development of indicators and targets to monitor progress complementing nature targets, aligning with 30x30 commitments, recognition of Other Effective area based Conservation Measures and bringing protected sites under effective management.
- Align SLM delivery with existing regulations (e.g. Control of Agricultural Pollution, EIA Agriculture) to ensure baseline protections are maintained while incentivising best practice
- Provide training, advice, and demonstration projects to build capacity among land managers to adopt nature-positive practices.
- Empower Ministers to support agriculture and ancillary activities that contribute to biodiversity, climate adaptation, and sustainable food production.

Laying the foundations for delivery: Nature Targets

The Welsh Government is taking significant steps to align national biodiversity policy with the Global Biodiversity Framework (GBF).

The Welsh Government has committed to an ambitious goal: *protecting 30% of our land, freshwater, and seas by 2030* (Welsh Government, 2025c). Despite these existing regulatory and policy frameworks, the pace and scale of action remain insufficient and Wales risks further ecological breakdown.

The Environment (Principles, Governance and Biodiversity Targets) (Wales) Bill responds to this challenge by embedding environmental principles into law and establishing a statutory framework for biodiversity targets. (Senedd Cymru, 2025).

The Bill proposes to enshrine key environmental principles, prevention, precaution, rectification at source, and polluter pays into Welsh law. These will guide all public policy affecting the environment.

Policy Levers and Enabling Conditions:

- Apply environmental principles (e.g. precautionary, polluter pays) in Strategic Environmental Assessments and project-level decision-making.
- Finalise and legislate biodiversity targets under the Environment (Wales) Bill, ensuring they are measurable, time-bound, and aligned with the Global Biodiversity Framework. Embed nature targets across agriculture, forestry, planning, and climate policy to ensure coherent delivery and avoid siloed implementation.
- Communicate progress toward targets clearly and accessibly, building public support and accountability. Use the SLM framework to deliver measurable contributions to GBF Targets 2,3, 4, 7, 10, and 21.

- Align monitoring frameworks (e.g. SoNaRR, SFS indicators) with nature targets to track progress and inform adaptive management

Laying the foundations for delivery: Landscape Scale Management and Less favoured Areas

The Agriculture (Wales) Act 2023 is designed to work in conjunction with the Environment (Wales) Act 2016, which introduced the concept of Sustainable Management of Natural Resources (SMNR) and mandated the creation of Area Statements by Natural Resources Wales.

The broad holistic objectives require land management at a landscape scale, rather than just individual farm boundaries to deliver meaningful outcomes for Nature Recovery and Ecosystem Resilience.

Area Statements identify priorities and opportunities for SMNR delivery within specific geographical areas across Wales. The SFS and the support mechanisms under the Agriculture (Wales) Act 2023 are intended to deliver on these area-specific priorities, thus promoting a more localised and area-based approach to land management and environmental delivery.

In Wales, the Agriculture (Wales) Act 2023 establishes Sustainable Land Management as the framework for future agricultural support and regulation within Wales. It’s a shift from production-focused subsidies to a system that rewards farmers for the public goods they provide, clean air, thriving wildlife, healthy soils, and vibrant communities. Sustainable Land Management recognises the key environmental, economic, cultural and social contribution of farmers in Wales (Welsh Government, 2023b), providing the legislative basis for the Sustainable Farming Scheme (SFS).

Aligned with the Environment (Wales) Act 2016, which enshrines the Sustainable Management of Natural Resources (SMNR), this new framework encourages land management that works with nature, not against it, managing landscapes, not just as individual parcels. The Sustainable Farming Scheme, as the principal delivery mechanism for the Act, will support farmers in the ongoing sustainable production of food, at the same time as addressing the climate and nature emergency (Welsh Government, 2025d).

90% of the land area of Wales is given over to farming (Welsh Government, 2024b). Land used for agricultural production generally comprises enclosed farmland, semi-natural grassland, coastal margins and mountain, moorland and heath ecosystems (SoNaRR 2025 Soil assessment).

Of the total land area of Wales, 60% is more than 150 m above sea level, and 27% is more than 300 m above sea level (Russell et al., 2011), which will limit the potential for agricultural crop production (ADAS, 2019). The optimal zones for agricultural production are related to both climatic and soil conditions.

High altitudes, acid soils and impeded drainage have limited arable cropping and grassland intensification over parts of Wales.

Wales’ uplands and marginal lands have been seen through a lens of limitation. This lower-grade agricultural land made up of thin soils, harsh climates, and steep gradients have constrained agricultural productivity and economic returns (Armstrong, 2016; Rollett and Williams, 2022b).

Land use is dominated by grassland pasture which accounts for 75% of land use in Wales, 80% of which is LFA land (Armstrong, 2016). LFAs were introduced in 1975 under the European Directive (75/268) on mountain and hill farming in certain areas. The original objective of LFA policy was to “ensure the continuation of farming, thereby maintaining a minimum population level or conserving the countryside (Natural England, 2001). In Wales the LFA system depends on the presence of land where agricultural productivity is low, economic results are lower than the national average, and there is a low or dwindling population reliant on agriculture (Natural England, 2001) For the purposes of UK legislation, there are two types of LFA, according to the severity of the handicaps of agricultural production. These are designated as the ‘Severely Disadvantaged Areas’ (SDA) and ‘Disadvantaged Areas’ (DA) (Natural England, 2001) (Figure 4). In both types, agricultural production is either severely restricted or restricted in its range by virtue of the adverse soil, relief, aspect or climate, or by a combination of these. This reflects the upland terrain and wet climate of the country LFAs cover around 80% of the agricultural land in Wales Less Favoured Area (LFA) Directive (EU Directive 75/268/EEC of 28 April 1975) (ADAS, 2019).

These landscapes are ecologically and culturally significant. Holding extraordinary potential for delivering the environmental, social, and cultural outcomes that Wales now prioritises. They hold significant proportions of semi-natural habitats and protected sites critical for biodiversity and ecosystem resilience, they provide climate mitigation and adaptation through carbon storage and water regulation in peatlands and grasslands etc. They shape cultural identity through language, heritage, and landscape, offering recreational and educational value to wider society.

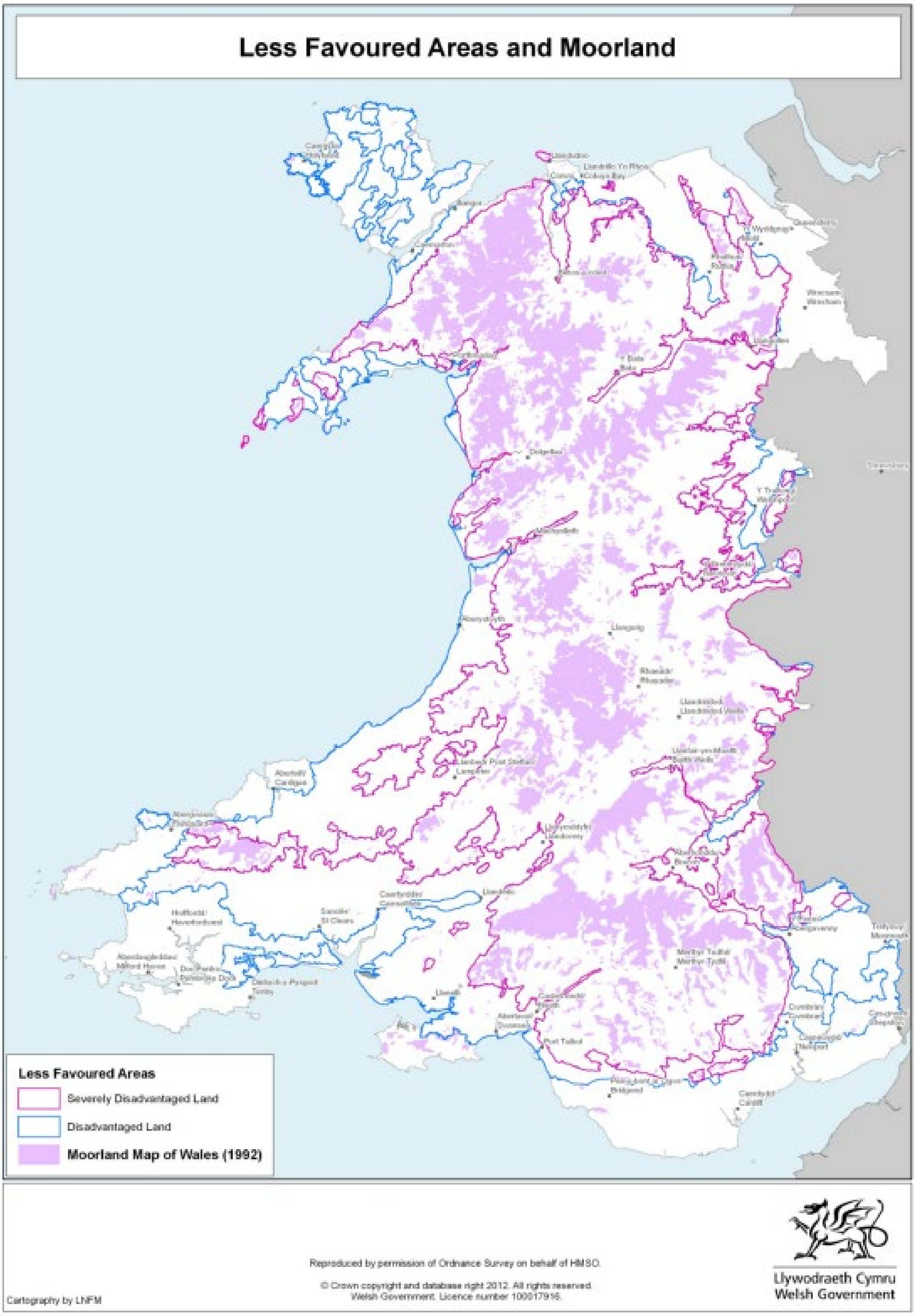

Figure 4 Map showing less favoured areas and upland zones in Wales © Welsh Government (Welsh Government, 2014)

Policy Levers and Enabling Conditions:

Farmers and land managers are not just producers, they are stewards of ecosystems, guardians of heritage, and partners in climate action. In Less Favoured Areas, recognising and rewarding what is already done and support to do more of what Wales needs to help these landscapes meet their significant potential for nature recovery whilst maintaining and supporting these cultural landscapes. Turning the historic challenges of LFAs into a national opportunity for renewal.

- Prioritise funding and support for LFAs where semi-natural habitats, protected sites, and cultural landscapes overlap, recognising their strategic value.
- Embed the value of public goods (e.g. clean water, carbon sequestration, flood regulation) into agricultural support mechanisms, enabling fair reward for ecosystem stewardship, facilitate multi-stakeholder partnerships to co-design and deliver landscape-scale interventions, ensuring local knowledge and cultural values are respected.
- Use Area Statements to identify landscape-scale opportunities for effective management and ecosystem restoration, cultural stewardship, and climate adaptation in LFAs.
- Develop spatially explicit indicators to track ecological condition, cultural value, and delivery outcomes in LFAs
- Ensure that land use decisions in LFAs are informed by soil capability, climate resilience, and biodiversity priorities, avoiding over-promising of land for competing policy goals

Opportunities for Action: halting and reversing the decline in biodiversity

This chapter marks a deliberate shift in focus, from assessing the current state of ecosystem resilience, opportunities that exist within current policies and legislation, to identifying the strategic opportunities for action that will shape Wales' ecological future. It is included within Aim 2 of SoNaRR to provide a forward-looking lens, recognising that resilience is not only about withstanding pressures, but about actively restoring the capacity of ecosystems to thrive.

The urgency of the Nature Emergency, combined with Wales' commitment to the Kunming-Montreal Global Biodiversity Framework and the 30by30 target, demands a step-change in delivery. These commitments are not just aspirational, they are time-bound, measurable, and transformative. They require coordinated action across sectors, guided by evidence and aligned with the proposed statutory nature targets under the forthcoming Environment (Principles, Governance and Biodiversity Targets) (Wales) Bill.

SoNaRR 2025 provides the evidence base to support this transformation. By identifying where pressures are greatest, and where opportunities for recovery are most viable, it enables policy makers to move from ambition to delivery. This chapter sets the stage for the next SoNaRR to become more than a report, it must be a record of progress, demonstrating how Wales has used its policy frameworks, funding mechanisms, and place-based tools to halt biodiversity loss and restore ecosystem function.

For policy makers, this chapter offers a strategic guide: not prescribing what to do but showing how it could be done. It highlights the enabling conditions, partnerships, and mechanisms that can support delivery, ensuring that Wales' ecosystems are not only protected, but resilient, adaptive, and flourishing by 2050.

Framing SoNaRR 2030 Opportunities Around Future Nature Targets

In recent years, the number of nature-related targets and legislative commitments in Wales has proliferated. The target-based commitments include the SLM indicators and related targets required under the Agriculture (Wales) Act 2023, the air quality targets introduced under the Environment (Air Quality and Soundscapes) (Wales) Act 2024 and the biodiversity targets under the Environment (Principles, Governance, and Biodiversity Targets) (Wales) Bill. In addition to the target type commitments, there is also the Section 6 duty under by the Environment (Wales) Act 2016. It is important to understand how these targets and commitments are contributing, in aggregate, to the effective management of our natural resources and our efforts to enhance our ecosystems.

SoNaRR, with its wide remit, is well-placed to provide such an overarching assessment. This assessment could fulfil a similar function as the significant improvement test introduced by the Environment Act 2021. Such an assessment would provide the Welsh Ministers, and policy makers, with a holistic understanding of the impacts of current commitments and identify areas that may benefit from the additional focus and ambition that statutory targets impart.

However, to do this effectively, such an assessment would benefit from a consolidation of reporting timelines and formats. As it currently stands, each suite of targets are being reported disparately and on different timescales. For example, the Welsh Minister's reporting for the new biodiversity targets will be tied to the Section 6 reporting cycle, which reports every three years. The cycle of reporting for the SLM indicators and targets is required every five years. These two examples are again different than the reporting cycle of SoNaRR which will be shifting to a four year reporting cycle. By bringing together the different reporting timelines officials could help improve their understanding of the interconnected impacts of the different target areas through the comprehensive assessment provided by SoNaRRs. This assessment, in turn, could better facilitate the strategic overarching strategy that the Natural Resources Policy was intended to provide.

To ensure future SoNaRRs on what has been achieved, not just what is known, this section identifies four strategic opportunity areas where evidence-informed delivery could support the development and implementation of Wales' future statutory biodiversity targets.

While the proposed statutory biodiversity targets provide a vital framework for nature recovery, they do not exist in isolation. Wales' broader legislative landscape, including the Agriculture (Wales) Act 2023, the Clean Air Act (Wales) 2024, and the Well-being of

Future Generations (Wales) Act 2015, contain overlapping targets and duties that directly influence biodiversity outcomes. Future SoNaRRs must reflect this interconnectedness, drawing together these legislative strands to provide a holistic picture of delivery and impact.

These opportunity areas are directly aligned with the proposed priority areas set out in the Environment (Principles, Governance and Biodiversity Targets) (Wales) Bill (Senedd Cymru, 2025), which include:

1. Reducing the risk of the extinction of native species
2. The effective management of ecosystems
3. Reducing pollution
4. the quality of evidence to inform decisions relating to biodiversity, access to that evidence and its use and application.

These targets areas reflect Wales' commitment to halt and reverse biodiversity decline, enhance ecosystem resilience, and increase the abundance and genetic diversity of native species. They are being embedded alongside a broader legislative framework that includes environmental principles of prevention, precaution, rectification at source, and polluter pays, all of which must be applied by Welsh Ministers and NRW when making policy affecting the environment.

This chapter is included in SoNaRR Aim 2 to help shift the narrative from diagnosis to delivery. It recognises that the next five years are critical for reversing biodiversity decline and restoring ecosystem function. SoNaRR 2025 provides the evidence base; SoNaRR 2030 must demonstrate how that evidence has been used to guide investment, shape policy, and enable change.

By focusing on these four opportunity areas; species recovery, effective ecosystem management, pollution reduction, and evidence availability, SoNaRR 2030 can become a strategic milestone in Wales' journey toward nature recovery. It can help ensure that future targets are not just aspirational, but achievable, by identifying the enabling conditions, partnerships, and mechanisms that support delivery.

This is a call to policy makers to look ahead, to use SoNaRR not only as a mirror reflecting the state of nature, but as a compass for navigating the path to recovery.

To support this shift, future SoNaRRs could focus on the following opportunity areas, aligned with Wales' Nature Recovery Action Plan priorities and the Kunming-Montreal Global Biodiversity Framework: Ensuring future SoNaRRs become a report on what has been achieved, not just what is known. This transition supports the delivery of SMNR, enhances ecosystem resilience, and ensures that Wales is on track to meet its global biodiversity commitments.

1. Wales Species Recovery Framework:
2. Effective Management of Ecosystems: RENs, Protected Sites and OECMs
3. Reducing Pollution
4. Evidence Availability and Place-Based Delivery

1. Wales Species Recovery Framework:

The Welsh Government's proposal to establish statutory nature targets includes a specific category focused on reducing the risk of extinction of native species. This presents a timely opportunity to develop a Wales Species Recovery Framework. This framework would provide a structured, evidence-led approach to reversing species decline and enhancing ecosystem resilience.

Evidence from SoNaRR 2025 and NRW's species assessments highlights the scale and urgency of the challenge. Recent analysis by NRW species specialists indicates that at least 2,955 terrestrial and freshwater species in Wales are restricted to five or fewer localities, with 1,262 known from just one site (Bosanquet et al., in press Terrestrial & Freshwater Species in Peril – NRW Report No. 818.). Since the 1950s, 114 species have become extinct in Wales, including 11 since 2000. The State of Nature Wales 2023 (Smith et al., 2023) report shows a 20% decline in average of monitored species abundance since 1994, with many species now absent from large parts of their former range. These trends reflect long-term pressures including habitat loss, pollution, climate change, and agricultural intensification pressures consistently identified across NRW ecosystem assessments and the ERAMMP Report 105 (Emmett et al., 2025). Highlighting the urgent need for targeted, coordinated action to prevent further loss and support recovery.

A Welsh Species Recovery Framework could:

- Translate policy ambition into delivery, ensuring statutory targets are met through coordinated, place-based action.
- Embed species recovery within wider land-use and biodiversity frameworks, including Resilient Ecological Networks (RENs), Protected Sites, and OECMs.
- Support delivery through the Sustainable Farming Scheme (SFS), which provides universal and tailored interventions for land managers to contribute to species recovery.
- Enable monitoring and reporting through SoNaRR, tracking progress against statutory targets and informing adaptive management.

This framework would directly support the statutory target category to reduce the risk of the extinction of native species and contribute to broader goals under the Global Biodiversity Framework, including Target 4 (conservation of threatened species) and Target 2 (restoration of degraded ecosystems).

2. Effective Management of Ecosystems

The proposed statutory nature target category the effective management of ecosystems is central to reversing biodiversity decline and building long-term ecological resilience in Wales. SoNaRR 2025 confirms that most ecosystems currently show low overall resilience, with semi-natural habitats particularly vulnerable to fragmentation, pollution, and land use change.

This opportunity area focuses on three key delivery mechanisms:

Protected Sites: A Critical Opportunity for Nature Recovery

Wales' protected site network, including over 1,000 Sites of Special Scientific Interest (SSSIs), Special Areas of Conservation (SACs), and Special Protection Areas (SPAs), covers around 12% of the country and represents the backbone of biodiversity protection. However, the 2020 Baseline Assessment (NRW, 2023b) found that only 20% of assessed site features were in favourable condition, 30% were in unfavourable condition, and for the remaining 50%, there was insufficient evidence to assess their state.

This baseline highlights the urgent need for improved management, monitoring, and coordinated restoration efforts. The Terrestrial & Freshwater Species in Peril report (Bosanquet et al., 2025) identifies protected sites as anchors of diversity and resilience, but their effectiveness depends on being bigger, better, and more connected. The 30 by 30 commitment also brings renewed focus to these sites, positioning them as priority areas for investment and action.

Most SSSIs are in private ownership, meaning that large-scale nature recovery will depend on engaging landowners through mechanisms like the Sustainable Farming Scheme (SFS). These sites must be actively managed to support ecosystem resilience, ensuring habitats are functioning, species populations are stable, and natural processes like carbon storage and water regulation are maintained.

At sea, the Marine Protected Area network has been designed to support ecological coherence and is a key tool for delivering resilient marine ecosystems. However, many features remain in poor condition across the network and addressing this will be critical. Part of the answer lies in recognising the importance of, and using, both marine and terrestrial policy levers such as the Welsh National Marine Plan, SFS, Local Development Plans and Shoreline Management Plans to manage pressures on the marine environment and the coastal interface. Collaborative and strategic approaches across multiple land and sea users, which recognise the needs of local communities, will be fundamental to restoring the condition of the MPA Network.

If all Protected Sites were in favourable condition, Wales would have a stronger foundation for resilient ecosystems capable of adapting to climate change and other pressures. This would also support better outcomes for farming, flood mitigation, and public health, while enabling future payments for ecosystem services, provided we can evidence what these sites deliver. For example, the Sustainable Farming Scheme (SFS) provides a mechanism to engage landowners in active site management.

Looking ahead to SoNaRR 2030 and future reporting, we must focus on closing evidence gaps, improving condition assessments, and developing frameworks to value and invest in the public goods provided by protected sites. Understanding what these sites do for us is the first step toward paying for what they provide.

Other Effective Area-based Conservation Measures (OECMs): Expanding the Conservation Toolkit

The identification and recognition of Other Effective Area-based Conservation Measures (OECMs) presents a flexible and inclusive opportunity to expand Wales' conservation footprint beyond formally designated protected sites. As outlined in the Welsh Government's 30by30 framework, OECMs are essential to achieving the commitment to protect 30% of land, freshwater, and sea for nature by 2030. They recognise areas that deliver long-term biodiversity outcomes through existing governance and management, without requiring formal designation or new regulation.

Wales has adopted the staged approach to OECM recognition, beginning with potential OECMs, areas likely to support biodiversity, progressing to candidate OECMs where assessment has been agreed, and culminating in recognised OECMs that meet the criteria for sustained conservation ("PATRS-003-En.pdf," n.d.). This process is voluntary and based on informed consent, enabling landowners, communities, and organisations to showcase and support biodiversity stewardship.

OECMs complement the protected site network by capturing conservation value in areas not currently designated, helping to build a more ecologically representative and connected network. They also offer a pathway to engage new partners, align with schemes like the Sustainable Farming Scheme, and potentially unlock payments for ecosystem services where biodiversity outcomes can be evidenced.

As part of the 30by30 commitment, recognising and supporting OECMs will be critical to delivering nature recovery at scale, highlighting their role in building ecologically representative and connected networks.

Resilient Ecological Networks: supported by area and landscape partnerships.

Resilient Ecological Networks (RENs) offer a strategic and transformative framework for restoring and connecting ecosystems across Wales. Through which, existing and new programmes and projects can be organised and prioritised to better maintain, and crucially build, ecosystem resilience at scale and pace.

RENs represent the landscape and the views of legitimate stakeholders, working in partnership to identify where is desirable, feasible and viable to deliver 'nature networks'.

They are identified in the Nature Recovery Action Plan as a key delivery mechanism, supported by Area Statements, safeguarded in spatial planning tools and are central to achieving the 30by30 target and the ecosystem restoration statutory target.

Together protected Sites, Other Effective Area-based Conservation Measures (OECMs), and Resilient Ecological Networks (RENs) form the ecological backbone of Wales' nature recovery strategy. Their effective management and restoration are essential to delivering statutory targets (30by30) and ensuring that ecosystems are resilient, adaptive, and capable of supporting biodiversity and human wellbeing.

3. Reducing Pollution

The proposed statutory nature target to reduce pollution and its impact on biodiversity is essential for restoring ecosystem function and resilience. Despite a long-term decline in several atmospheric pollutants, ammonia (NH_3) emissions from agriculture remain persistently high and are increasing in Wales, according to the National Atmospheric Emissions Inventory (NAEI). Agriculture contributes over 85% of total ammonia emissions, which pose significant risks to both human health and the natural environment (Welsh Government, 2020b).

Ammonia contributes to the formation of fine particulate matter (PM2.5), linked to respiratory and cardiovascular diseases. When deposited, it leads to acidification and eutrophication of soils, freshwater systems, and sensitive habitats, undermining ecosystem resilience and biodiversity.

Evidence provided by all the 2025 Natural Resource Assessments identifies nutrient pollution from organic manures and fertilisers in particular as critical pressures on Welsh ecosystems.

Pollution is a key barrier to achieving SoNaRR Aim 2, which assesses whether ecosystems are resilient to expected and unforeseen changes. Around 50% of Welsh Marine Protected Areas (MPAs) are in unfavourable condition, with pollution identified as a primary cause.

There is a recognised need for Wales to strengthen its controls to prevent such pollution from impacting on semi-natural habitats, reaching watercourses and, ultimately, the sea, farming based solutions are identified in The Clean Air Plan for Wales . Aim 4 highlights the Dasgupta (2021) review and explores further measures of economic productivity should account for the environmental pressures they create, as well as the contribution (or use) of nature in production activities.

Support to reduce pollution
Welsh Governments Sustainable Farming Scheme (SFS) provides a structured and strategic opportunity to support land managers in Wales to reduce harmful pollution through:

- Targeted nutrient management planning, including responsible use of organic manures and fertilisers.
- Adoption of low-emission technologies and innovative (precision) farming practices to reduce ammonia emissions and nutrient runoff.
- Implementation of nature-based solutions such as buffer strips, cover crops, and wetland restoration to intercept pollutants and improve soil and water health.

These actions are embedded within the Universal, Optional, and Collaborative stages of the SFS, offering flexibility and tailored support to farmers based on their land, business model, and local environmental context.

Role of regulation

Where these voluntary measures are not taken up or prove insufficient to address pollution risks, particularly in high-pressure landscapes or near sensitive receptors, regulation has a critical role to play to ensure baseline protections. This includes:

- Strengthening the Control of Agricultural Pollution Regulations.
- Enhancing Environmental Impact Assessment (Agriculture and Forestry) Regulations.
- Improving development planning guidance to ensure intensive livestock units are sited appropriately.
- Embedding Sustainable Management of Natural Resources (SMNR) principles into permitting and compliance frameworks.

This dual approach, incentivising best practice through for example the SFS, while ensuring baseline standards through regulation are essential to align with Wales' commitment to 30by30 and the Kunming-Montreal Global Biodiversity Framework, including those set out in the Agriculture (Wales) Act 2023, the Clean Air Plan for Wales, and the Environment (Air Quality and Soundscapes) (Wales) Act 2024.

4. Evidence Availability and Place-Based Delivery

The proposed statutory nature target to improve the availability, access, and use of biodiversity evidence is foundational to delivering all other targets. Without robust, accessible, and spatially relevant data, Wales cannot effectively monitor progress, guide investment, or adapt delivery to local needs.

SoNaRR 2025 highlights several critical evidence gaps that limit the ability to assess ecosystem resilience and biodiversity status. These gaps hinder the ability to track delivery against statutory targets and the Global Biodiversity Framework, particularly Targets 1 (spatial planning), 21 (knowledge sharing), and 23 (monitoring). See SoNaRR evidence gaps pages for more information.

Wales must also strengthen its place-based delivery frameworks, such as Area Statements and Resilient Ecological Networks (RENs), which help prioritise areas for investment, restoration, and connectivity. These mechanisms ensure that evidence is not only available, but usable, enabling policy makers and practitioners to make informed decisions that reflect local ecological and social contexts maximising opportunities for action. .

Evidence Needs

Comprehensive, up-to-date, and repeatable habitat and land-cover mapping is a critical evidence requirement for Wales. It provides the foundational understanding of "what we have, where it is, and how it's changing" essential for delivering nature recovery, climate adaptation, and sustainable land management.

The current habitat data, largely derived from historic Phase I surveys, is increasingly outdated (often 30–40 years old), static, and unable to support dynamic monitoring or policy delivery. This limits our ability to assess ecosystem resilience, track biodiversity recovery, and guide interventions such as woodland creation, nutrient management, and spatial planning.

SoNaRR 2025 highlights persistent evidence gaps that hinder delivery:

- Lack of condition data for protected sites.
- Incomplete spatial data on semi-natural habitats and ecosystem services.
- Insufficient monitoring of agricultural pollution and land-use change.

A renewed mapping programme should:

- Combine Earth Observation for broad-scale coverage with targeted field survey to distinguish habitats and inform key policy needs.
- Be designed to support statutory nature targets, including 30by30, RENs, and SFS delivery.
- Enable repeatable monitoring to assess change over time.
- Integrate with existing data frameworks and potentially citizen science.

Resilient Ecological Networks (RENs) are a key delivery mechanism for ecosystem resilience. They are a core evidence need because they provide the spatial framework for prioritising action, linking protected sites, semi-natural habitats, and areas of opportunity to build ecological connectivity and resilience across the landscape. RENs help identify where interventions will be most effective in restoring biodiversity, supporting species movement, and enabling ecosystems to adapt to pressures such as climate change and land-use change.

While ecological modelling helps identify areas of high biodiversity value, RENs are not solely technical constructs, they are shaped by people. Their success depends on being desirable, viable, and feasible, reflecting local priorities, land-use realities, and community aspirations. As outlined in NRW's Practitioners' guide to Resilient Ecological Networks, RENs must be co-designed with stakeholders to ensure they are ecologically effective and socially supported.

Importantly, the identification and mapping of RENs is essential to any future land-use strategy. They provide the evidence base to align spatial planning and policy objectives with the delivery of SMNR Aim 2, ensuring ecosystems are resilient to expected and unforeseen change. RENs offer a practical mechanism to integrate biodiversity, climate adaptation, and sustainable land management into decision-making across sectors, helping Wales meet its statutory nature targets and commitments such as 30by30.

This mapping is not just a technical exercise, it is a strategic enabler of ecosystem resilience, biodiversity recovery, and evidence-informed decision-making across Wales.

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Aim 2 Appendix 1: Key Pressures from aims and ecosystem assessments

Table 16 Effects of anthropogenic land use, Built development and infrastructure pressure, on semi-natural habitats

Ecosystem	Description of pressure from aims and ecosystem assessments
Freshwater	Pressures associated with construction in urban areas, transport and waste water treatment are identified as economic activities affecting the quality of water
Freshwater	Built development and infrastructure are a pressure of concern leading to an increase in the risk of flooding and pollution, along with loss of habitats, species and connectivity between rivers and flood plains, and between rivers and ponds/lakes
Freshwater	Historically (1970 to 2025) built development and infrastructure has led to deterioration of freshwater ecosystems. Between 2021 and 2024, 805m of watercourses were reported as having been modified as part of consented road schemes across Wales, including bank protection and culverts (NRW, 2024a). The future outlook to 2050 is deteriorating. In some areas, the pressure for redevelopment and the need to increase housing stock has led to development taking place within floodplains. The concern is an increase in the risk of flooding and pollution, along with loss of habitats, species and connectivity between rivers and flood plains, and between rivers and ponds/lakes

Ecosystem	Description of pressure from aims and ecosystem assessments
Coastal margins	Built development, infrastructure and physical modifications (e.g., for coastal flood protection) has led to loss and fragmentation of coastal margin ecosystems which will get more severe into the future as coastal squeeze increase with sea level rise. This also affects the habitat available for animals, plants and other organisms in some areas Built development and infrastructure, including those associated with leisure and tourism, have historically led to loss and fragmentation of coastal margin ecosystems, and also created barriers for habitats to roll back in to as coastlines erode. It is estimated that approximately 30% of sand dunes in Wales have been lost to development and erosion since 1900 (Pye, Blott and Guthrie, 2017). There is limited evidence and quantitative data on the long and short-term trends in this pressure. However, aerial imagery identifies substantial urban areas, caravans / holiday parks along Wales coastline. The future outlook (from 2025) is mixed, with planned increase for offshore renewable energy infrastructure such as cabling where it makes land fall, the requirement for upgraded flood defences dure to sea level rise and for tourism are likely to increase
Semi-natural grassland	Built development and infrastructure for renewable energy infrastructure house building in particular, have resulted in loss and fragmentation of semi-natural grassland habitats in Wales
Semi-natural grassland	New roads, quarrying, housing and power generation infrastructure has negatively affected semi-grassland habitats over at least the last 13 years. Installation of wind and solar renewable energy infrastructure has increased substantially, with over 2,000 GWh being produced by this infrastructure in 2022 (Office for National Statistics, 2023)* House building rates in Wales remained fairly static between 2014/15 and 2019/20 (at around 6000 to 7000 new dwellings per year) and have slowed thereafter (StatsWales data). This mostly affects semi-natural grassland in the south and south-eastern part of Wales, where most of the country's house building takes place. The future outlook is mixed, although increases in onshore wind/solar and house building can be expected in response to renewable energy and housing targets.

Ecosystem	Description of pressure from aims and ecosystem assessments
Woodland	There is currently no data or evidence for Wales that reliably captures woodland loss (numerically or spatially) linked to built development and infrastructure As Wales transitions to a low carbon economy, onshore wind farms and bult development and infrastructure outlined in the Welsh Government's National Plan 2040 will likely impact on woodlands
Freshwater	The greatest volume of licensed water abstractions is associated with the energy sector, comprising 9,629,231 ML in 2024 (approximately 81% of total licensed abstraction in Wales). This includes non-consumptive abstractions for hydropower generation. In 2022 the estimated hydropower generation in Wales was 350 GWh across 379 projects. 95% of this hydropower generation is from North and Mid Wales, where mountains and hills support hydropower resources (NRW, 2025b; Welsh Government, 2023c)

Ecosystem	Description of pressure from aims and ecosystem assessments
Freshwater	Historically the effects of built development and infrastructure on water show a mixed – improving trend in Wales (1970 – 2020). The future outlook is also mixed (to 2050). Construction of new homes (a necessary policy objective), Housing, transportation and other urban land-uses are identified reasons for not achieving good status in a 14% of waterbodies. As highlighted in Aim 1, source apportionment modelling identifies wastewater treatment (3 out of 10) the main sources of phosphorus pollution in SAC river catchments Historically water abstraction and demand has decreased in Wales (1995 to 2020). The future outlook is mixed, due to projected decreases in summer rainfall reducing supply (to 2050). Over the last 25 years, Dŵr Cymru report a reduction from 1000 megalitres per day (Ml/d) to 850 Ml/d. This has been due to a reduction in both industry demand and a reduction in leakage from distribution systems. However, there remain concerns to meeting this demand during to spatial and temporal variations in the availability of water resources in Wales. Of the 27 Water Resource Zones in Wales, 3 of these are anticipated to go into deficit by 2050 (SEWCUS and Tywi Gower associated with the urban south and Lleyn/Harlech/Barmouth in the north west). In these zones direct exploitation of water by the economy (including public supply) will be an acute concern. This will be linked with the pressure of Non-efficient use of water Modelled data from Flood Risk Assessment Wales indicates that around 170 km of rail and 3,400 km of road infrastructures is at risk of flooding from rivers, 160 km rail and 2,000 km road from sea and 190 km rail and 4,800 km road from surface waters and small watercourse. This is predicted to increase to approximately 220 km of rail and 4,100 km of roads at risk of flooding from rivers, 270 km rail and 2,800 km road from sea and 230 km rail and 6,300 km road from surface waters and small watercourse under predicted climate change.

Ecosystem	Description of pressure from aims and ecosystem assessments
Marine	Built development and infrastructure associated with marine renewable energy generation has become an increasing pressure on marine ecosystems since the commissioning of the UK's first commercial scale offshore windfarm (North Hoyle) off the North Wales coast in 2003. The overall marine footprints of an Offshore Wind Farm (OWF) can be considerable. Gwynt y Mor OWF, further off the North Wales, coast has a footprint of around. 124 km^2 ,in total including the export cable corridor. These developments can also change physical processes (e.g., currents), create collision hazards and other forms of disturbance (e.g., noise as highlighted in Aim 1). (Marine Energy Wales, 2023)
Marine	Whilst the pressure of infrastructure development is stable over the short-term (2020 to 2025). the UK government's commitment to achieving 50 GW of offshore wind generating capacity by 2030 means off shore renewable development is likely to progress at a rapid pace over the next five years at least, Beyond this the Crown Estate are looking at a range of scenarios with a maximum generating capacity of 140GW from offshore wind by 2050 (Department for energy, security and net zero, 2023).

Table 17 Effects of anthropogenic land use, agricultural intensification, on semi-natural habitats

Ecosystem	**Description of pressure** from aims and ecosystem assessments
Peatland	Historically **drainage** of soils for different land uses has affected soil quality in Wales (1900 to 2020). Post World War II saw a major agricultural expansion and during 1971-1980 10% of farmland in the UK was drained. An estimated 80% of the peatlands is estimated to be in a "damaged and deteriorating state" due to drainage of soils for various uses**.**
Freshwater	Agricultural Intensification is identified as a concern with respect to the management of land used for farming, particularly in relation to the affects it has on land drainage, soil compaction, loss of riparian corridor habitat, erosion and pollution to watercourses

Ecosystem	Description of pressure from aims and ecosystem assessments
Freshwater	**Agricultural intensification** pressures from agriculture is also identified as a sub sector of the economy in rural areas are also identified economic activities affecting the quality of water
Freshwater	Historically the effects of **agricultural intensification** on water show a mixed trend in Wales (1946 – 2024). The future outlook is also mixed (to 2050). As Aim 1 highlighted, the reasons for many waterbodies not achieving good status remain linked to rural land uses. The agricultural and forestry sub-sectors and associated land uses in rural areas are also generating pollution pressures, including phosphorus pollution of water.
Freshwater	Historically (1970 – 2025) **Agricultural Intensification** has negatively affected animals, plants and other organisms in freshwater ecosystems, particularly in areas of intensive dairy farming (for example in West Wales and the lower Dee catchment) (Pharaoh *et al.*, 2024). Over the shorter term (2020 to 2025) numbers of cattle, calves, sheep and pigs have decreased and numbers of poultry have increased. Pollution from agriculture and land management are amongst the top pressures in Wales in terms of impact and likely future development
Coastal Habitats	Agriculture is an established practice in many coastal margin ecosystems, including cliff-top areas, heathlands and saltmarshes. However, a careful balance on the intensity of this activity is needed. Over grazing in some areas is negatively affecting the condition and diversity of animals, plants and other organisms in some areas. At the same time, abandonment and reduced grazing intensity in other areas is affecting condition and diversity as dense, coarse vegetation builds up and out competes established plant species
Coastal Habitats	**Agricultural intensification** (and extensification**)** can lead to habitat loss, fragmentation and declines in biodiversity. At the same time, appropriate levels of gazing are often needed to maintain ecosystem condition (NRW, 2021). The long-term (2000 to 2024) and short term (2020 to 2025) trends indicate grazing levels have intensified on cliff top grasslands and heathlands in some locations. Overgrazing on saltmarshes is also affecting the condition and diversity of these coastal margin habitats. The future outlook (2025 to 2035) for this pressure is mixed, there is potential that the sustainable farming scheme will help address these pressures (and their trends) on coastal ecosystems

Ecosystem	**Description of pressure** from aims and ecosystem assessments
Semi-Natural Habitat	Agricultural intensification has been the major factor in the decline of semi-natural grasslands in the UK, including in Wales, where over 90% of this habitat has been lost (NRW, 2020), over the last 70 years This intensification, along with climate change, has significantly impacted species populations since the 1970s (Burns et al., 2023) . Semi-natural grasslands are highly sensitive to elevated soil nutrient levels from fertiliser application and are also destroyed by ploughing and herbicide use. This leads to increased soil compaction, reduced water retention, higher flood risk, depletion of pollinator resources, and habitat fragmentation
Semi-Natural Habitat	ERAMMP results (Emmett et al., 2025) suggest that issues of concern over condition of all forms of SNG over the short term (2013-16 to 2021-23) might be due to high management intensity. The future outlook (to 2035) for this pressure is mixed picture, reflecting continuing losses but perhaps also some positive impacts from the Sustainable Farming Scheme
Semi-Natural Habitat	Over the past 50 years, the decline in semi-natural grasslands has continued, although the rate of loss is thought to have slowed since the 1980s. Recent evidence suggests that agricultural intensification remains a significant threat, with ongoing habitat losses and high enforcement cases related to agricultural practices. Despite some statutory site protections, only a relatively small percentage of grassland habitats are protected, leaving the ecosystem vulnerable. There is hope that sustainable agriculture initiatives may improve the situation, but the future outlook remains uncertain (. Reduced land use / management intensity on sites has negatively affected semi-natural grasslands for at least the last 30 years. Over the last five years this trend has continued, with undermanagement being the principal cause of poor condition assessments. The outlook to 2050 is poor given current trajectory of the drivers for reduced management, but the importance of appropriate management has been recognised by the Welsh Government's Biodiversity Deep Dive recommendations. (Burns *et al.*, 2023) (alongside climate change). Undermanaged and/or suffering from associated scrub expansion is identified as the principal cause of semi-natural grassland SSSIs being in unfavourable condition. Under grazing is found to be a key causal factor in England (Hewins et al., 2005), and likely to be significant in Wales. Under-grazing has been listed as a 'high pressure' for four out of seven grassland habitats reported on during reporting under Regulation 9A of The Conservation of Habitats and Species Regulations (2017)

Ecosystem	**Description of pressure** from aims and ecosystem assessments
Semi-Natural Habitat	The future outlook (to 2050) is continuing deterioration due to this pressure given current trajectory of the indirect drivers (e.g., economic) linked to reduced management. However, the importance of appropriate management has been recognised by the Welsh Government's Biodiversity Deep Dive recommendations. In coming years, the Sustainable Farming Scheme (SFS) is also expected to be a key part of delivering better semi-natural grassland condition.
Enclosed Farmland	SoNaRR2020 Enclosed Farmland Chapter reported the weight of pesticide active ingredients applied to land had decreased over the past 25 years, whilst the number of hectares treated with pesticides, along with the frequency of treatments, had increased, impacting soil biodiversity (NRW, 2021b). On grassland and forage land across the UK, there was an increase in the pesticide-treated area of 25% since 2017, and 43% since 2009 corresponding to an increase in the area of fodder crops grown (turnips and swedes, fodder beet, maize and other crops for stock feeding). The weight of pesticides applied increased by 14% since 2017 and by 48% since 2009 (Ridley et al., 2021)

Aim 2 Appendix 2: Area Statements SMNR overview

Across Wales, there's a clear consensus among all Area Statements that reversing biodiversity decline and enhancing natural habitats is a critical priority to enhance ecosystem resilience and provide the benefits that are needed. A major challenge lies in restoring and connecting vulnerable protected areas to ensure they are resilient and able to deliver broader social and economic advantages.

South Central Wales is the most densely populated area, with the urban ecosystem making up close to 18% of the total area (Wales average is 6%). This is reflected in the statement which highlights the close relationship between urban and natural environments. It highlights the importance of building ecosystem resilience to help address some of the biggest challenges to local communities around air quality, health and water quality and regulation.

It is in this area where opportunities exist for natural flood management on the steep valley sides that can mitigate Flood events in valley towns and Cardiff City. Semi-natural habitats in and around urban areas provide essential health and well-being benefits such as recreation and improved air quality.

To avoid unintended consequences of nature-based solutions having a negative impact on ecosystem resilience, through the development of ecosystem profiles and identification of resilient ecological networks they have worked with partners, to better understand where to focus efforts to build resilience within ecosystems, making them more resilient, but also deliver ecosystem services so they are valued and beneficial to our communities ("Natural Resources Wales, Building resilient ecosystems).

South West Area Statement, underscores the integral role of land management in tackling this issue, emphasizing that without the active participation of land managers, the ongoing loss of biodiversity cannot be halted. Given that enclosed farmland constitutes a significant portion of South West Wales' predominantly rural landscape (56% compared to 51% across Wales), the sectors reliant on this land, agriculture, forestry, and fisheries are vital for livelihoods and communities, as well as for sustaining the natural resources upon which we depend. The management of this land profoundly impacts both local and wider environments, making it crucial to transition towards more sustainable practices. For South West Wales, the goal is for the rural sector to flourish, supporting a high-quality environment while also delivering premium goods and services.

Farmers, in particular, hold a pivotal role in this endeavour. While intensive farming can be detrimental, their practices can also significantly benefit biodiversity by creating new habitats. They are essential not only for food production but also for enriching and preserving biodiversity. Encouragingly, evidence suggests that conservation efforts have helped mitigate the decline in farmland bird populations, and many environmentally conscious agricultural schemes have proven advantageous for wildlife.

However, water quality remains a significant concern, directly impacting the area's biodiversity and economy. Agricultural pollution has increasingly become a prominent issue, and there's a recognised need for Wales to strengthen its controls to prevent such pollution from reaching watercourses and, ultimately, the sea. Ultimately, embedding biodiversity and ecosystem resilience within food and fibre production is paramount, with the understanding that land managers are best equipped to determine the most effective ways to achieve these goals.

Mid Wales is a diverse and historic landscape, stretching from the Brecon Beacons National Park in the south through the central Cambrian Mountains to the Berwyn uplands in the north.

This region is sustained by a vibrant community, with people living and working in its rural market towns, dynamic universities, close-knit villages, and traditional seaside resorts. It is a stronghold of Welsh language and culture, with Ceredigion notably having one of the highest proportions of Welsh speakers in Wales.

The area is also recognised for its ecological importance, hosting numerous national and international wildlife designations. Economically, agriculture and forestry form a substantial part of the rural landscape, with farming primarily focused on sheep, dairy, beef, and a growing number of poultry units. The long-term health of Mid Wales' protected sites and biodiversity is intrinsically linked to how the broader landscape is managed, including farmlands, water bodies, river catchments, forests, and uplands.

Farmers, in particular, are central to the culture and very fabric of Mid Wales. However, the prevalence of intensive agriculture in the region poses a significant challenge, with the potential for environmental incidents, especially those related to slurry pollution.

Much of this landscape, often classified as 'agriculturally less favoured,' has historically been underestimated for its crucial role in providing vital ecosystem services such as biodiversity, water and carbon storage, and opportunities for recreation.

North West Wales presents a diverse landscape encompassing vast uplands, extensive coastal areas, and intervening lowlands and settlements. The majestic mountains of Snowdonia National Park, known as 'Eryri', form the central upland spine, complemented by additional moorland to the east in Conwy. The coastal stretches include the scenic Llŷn Peninsula and the Isle of Anglesey; both largely protected within their respective Areas of Outstanding Natural Beauty (AONB). This contrasts sharply with the developed northern coast, which hosts significant transport infrastructure, while rural lowlands can be found in areas like Arfon, Anglesey, Dwyfor, and inland Conwy.

Despite the considerable portion of this area benefiting from protected area designations, the North West Wales Area Statement acknowledges numerous threats to its habitats, plant life, and animal populations. Consequently, the statement emphasises the crucial need for collaborative partnerships. These partnerships aim to foster improved relationships and deepen the understanding of how the environment, agriculture, and other industries collectively underpin the region's economy. This localised, place-based approach is central to implementing the Natural Resources Policy, encouraging communities to take the lead in shaping local priorities and opportunities. By connecting with national objectives, communities can devise practical solutions that maximise benefits for local residents, ensuring they fully gain from the natural resources within their area.

North East Wales is characterized by a landscape predominantly shaped by agriculture, with enclosed farmland making up nearly 60% of its area. Beyond this, woodlands cover 15%, while mountains, moorland, heath, and urban areas contribute to the remaining diverse habitats. The region, though containing significant urban areas and industrial zones, retains a rich mosaic of historical elements, including small villages, traditional farm buildings, and ancient monuments. This cultural and natural heritage, particularly in its designated areas of natural beauty, significantly boosts tourism, contributing substantially to the local economy.

The area exhibits a contrast between its more urbanised and industrialised parts, which also face social challenges, and tranquil rural areas where traditional ways of life and strong cultural identities persist. These diverse landscapes support a range of valuable wildlife havens, some surprisingly located within industrial settings, alongside well-established nature reserves.

Economically, while agriculture remains a backbone, tourism plays a vital role, especially in areas stretching from coastal towns to picturesque inland communities. Forests in the region are not only critical for wildlife and recreation but also contribute to energy production and generate income through sustainable timber harvesting.

Water resources are dominated by two main river catchments, both crucial for public water supply, with one being exceptionally protected due to its strategic importance. Despite their vital role, many freshwater bodies in the region struggle to meet good ecological status, often due to agricultural influences, highlighting ongoing environmental challenges. There's a strong consensus among stakeholders that integrating environmental considerations into farming practices is essential for sustainable food production, thriving wildlife, and improved access to natural landscapes, though the path to achieving this remains a work in progress.

The **Marine Area Statement covers** Welsh inshore waters (out to 12 nautical miles), representing around 43% of Wales' territory. These waters support communities and the economy through resources such as seafood, aggregates, energy, and tourism. Developed under the Environment (Wales) Act 2016, the statement aims to build resilience in marine ecosystems, enable nature-based solutions for coastal adaptation, and make the most of marine planning.

Welsh seas host iconic species including bottlenose dolphins, Manx shearwaters, northern gannets, and common scoters, alongside habitats such as seagrass, kelp, saltmarshes, and shellfish beds that provide vital services like carbon storage, coastal protection, and water filtration. However, these ecosystems face pressures from climate change, pollution, invasive species and marine litter. Marine Protected Areas cover about 70% of inshore waters, yet many features remain in unfavourable condition, highlighting the need for targeted evidence, coordinated management, and shared responsibility among stakeholders. Improving knowledge of resilience and climate impacts are key priorities.

Coastal communities, home to around 60% of Wales' population, are increasingly vulnerable to sea-level rise and storm events. Traditional hard defences may become unsustainable, so Shoreline Management Plans guide future approaches such as holding the line, managed realignment, or no active intervention. Nature-based solutions like saltmarsh restoration and beach nourishment offer ecological, recreational, and carbon benefits, but face barriers including low public awareness, legislative complexity, and funding gaps.

Marine planning is essential to balance diverse uses such as renewable energy, aggregates, aquaculture, fisheries, transport, and recreation. The Welsh National Marine Plan provides strategic oversight beyond case-by-case decisions, aiming for evidence-based management, integration of nature recovery, and support for sustainable offshore renewables. Cross-boundary coordination with terrestrial planning and improved data sharing are critical next steps. Collaborative research, guidance on environmental enhancement, and streamlined consenting processes will help deliver a resilient, well-managed marine environment that supports both biodiversity and sustainable development.

Include a simple table with DECCA assessment across each ecosystem – refer to DPSIR portal for more detail

Aim 3 assessment: Wales has healthy places for people, protected from environmental risks

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Executive Summary

Wales' natural resources deliver immense health, wellbeing and cultural value, yet exposure to hazards and access to nature remain unequally shared and unevenly distributed. The sustainable management of natural resources (SMNR) approach emphasises integrated solutions that advance public health and cultural well-being, protect biodiversity, restore ecosystem resilience and underpin regenerative economic activity.

Since the SoNaRR 2020 assessment, Wales has taken important steps to strengthen protections and improve its management of natural resources to support healthy places. These include the Environment (Air Quality and Soundscapes) Act 2024, which addresses air pollution, and the Agriculture (Wales) Act 2023, which promotes nature-based solutions for farmers.

The nation has committed to the global '30 by 30' biodiversity target and invested in local flood-resilience projects under the National Strategy for Flood and Coastal Risk Management (2020). Natural Resources Wales has also directly contributed through targeted grant programmes, co-productive work with Public Services Boards, and initiatives such as Natur am Byth.

Despite this progress, Wales still faces significant challenges in creating "*Healthy places for people, protected from environmental risks*."

These include:

- **Poor health outcomes: linked to the environment**, with chronic diseases made worse by air pollution, low physical activity and limited access to nature.
- **Climate and nature emergencies: that affect health**, where flooding, biodiversity loss and degraded ecosystems undermine our nation's resilience and well-being.
- **Persistent inequities**: deprived and marginalised communities facing higher exposure to hazards, poorer physical and mental health with fewer opportunities to benefit from green and blue spaces.

This 2025 assessment builds on the foundation of the 2020 report and adopts a One Health approach: “*a holistic framework recognising the interconnectedness of human, animal, and ecosystem health.*”

This approach aligns with the mission-based priorities set out in the ***Future Generations Report 2025***.

Nature already protects us:

- In Wales, it is estimated that between **1,000 and 1,400 deaths** per year are attributable to air pollution. Woodlands filtered **35 million kg** of air pollutants in 2020 and helped moderate extreme heat event(s).
- Approximately **275,000 properties** in Wales face medium to severe flood risk (around 1 in 7).
- Green Infrastructure already delivers multifunctional benefits by acting as a natural buffer against environmental risks. It not only manages flood risk and filters pollutants but also improves air quality, regulates local temperatures, and creates interconnected habitats that boost amenity and biodiversity.
- Nature can play a critical role in shielding us from the environmental risks people in Wales face from climate change.

Health improvement gains on tap:

- The Office for National Statistics (ONS) reported the value of health benefits associated with outdoor recreation (estimated through saved healthcare costs) within the UK was between **£6.2 billion** and **£8.4 billion in 2020**.
- **Wales in 2022**: total ecosystem-service flows amounted to **£2 billion**, of which health benefits from recreation & tourism was the single largest contributor at **£320 million** (Office for National Statistics, 2022).
- **247 million visits** to natural and green spaces in Wales were made in the 2021/2022 financial year (PaNS Wales, 2025), with **94% of visitors** reporting **mental health benefits** and **96%** reporting **physical health benefits.**

Contributions to cultural well-being:

- Ecosystems are important cultural assets that contribute to our culture and heritage, our sense of place, identity and quality of life. They contribute to place-making, community cohesion and well-being, yet these values are often overlooked in decision making.

Equity gap to close:

- **High hazard burden**: Exposure to environmental risks like flooding and poor air quality is worse in the most deprived communities (WIMD, 2019).

- **Unequal access**: Low-income, minority and mobility-limited groups visit nature 20% to 30% less often than the total population; 20% of non-visitors cite poor physical health, 11% poor mental health (PaNS Wales, 2025).
- **Rising demand**: In 2021/22 People & Nature Survey Wales showed that 85% feel more connected to nature since the pandemic, and 91% want to keep spending time outdoors (PaNS Wales, 2025).

These headlines underscore why scaling **Nature-based Solutions (NbS)** and ensuring equitable, fair access should be at the forefront of Wales' Well-being ambitions.

Vision for Aim 3

That every person in Wales lives in an environment that nurtures their health, every community is resilient to environmental risk, and natural resources are managed so future generations inherit ecosystems that are healthier, more biodiverse and more valued than today. This can be achieved through:

1. Health protection: Reduce air, water and soil-borne hazards, and impacts of climate change. Prioritising communities where risk and deprivation coincide.
2. Health improvement: Promote daily access to green and blue space, mainstream green social-prescribing, access to nature and active-travel for health benefits.
3. Cultural benefits & equity: co-design, interpret and fund nature projects as part of 'place-making' so every community feels welcome and represented.

Delivering these actions advances all seven Well-being of Future Generations goals and contributes to progress against the National Indicators for healthy life expectancy (*Indicator 2*), air quality (*Indicator 4*), dwelling safety (*Indicator 31*), flood risk (*Indicator 32*), mental well-being (*Indicator 29*), greenhouse-gas emissions (*Indicator 41*) and ecosystem health (*Indicator 43*).

We describe technical ecosystem-resilience metrics in Aims 1 & 2. Green-economy levers and job pathways are developed further in Aim 4.

Key Messages

1. With the appropriate management, Wales' ecosystems can protect us from many environmental risks such as flooding, heat stress and pollution. These nature-based solutions (NbS) can deliver multiple benefits simultaneously by building climate resilience, restoring habitats and ecological corridors to support nature recovery, and cutting pollution, all while proving more adaptable to climate change than grey infrastructure.
2. Across the UK, green and blue spaces help avoid an estimated £6-8 billion in NHS costs every year through the health benefits of outdoor recreation and physical activity. In Wales alone, health gains from recreation and tourism in nature are valued at over £320 million annually, highlighting the critical role of nature in supporting well-being and reducing pressures on health services.

3. Biodiversity and ecosystem resilience are the engines of this system. Wildflower grassland, saltmarsh and broadleaf woodland all multiply pollinators, boosts soil life and strengthen our resilience to climate shocks as well as improving our health and well-being. This integrated approach means that restoring habitats not only slows the biodiversity crisis but simultaneously creates green jobs, improves air quality, and builds the ecological corridors that underpin ecosystem resilience.
4. Welsh landscapes are more than simple ecosystem goods and services factories; they are touchstones of our identity. National Parks are officially recognised as part of Wales' cultural fabric and laboratories for sustainable living. Dark sky reserves now attract visitors to stargaze in the same hills that nurture the Welsh language and folklore, turning environmental quality into cultural and economic value(s). Protecting nature therefore also protects stories, language, and sense of place.
5. At the same time, our ecosystems operate as a nationwide life-support system, locking away million tonnes of carbon, filtering air pollutants and trapping agricultural run-off pollution every year.
6. Well-designed nature-based solutions amplify these benefits: restored peatlands and floodplain wetlands sequester CO_2 while flattening flood peaks, native woodlands shade urban heat while intercepting particulates and ammonia, and vegetated swales trap micro-plastics before they reach our rivers and coasts.
7. Protecting and enhancing natural capital is therefore not only a cultural duty, but also preventive medicine, climate insurance and economic common sense rolled into one.

Introduction: Healthy places for people, protected from environmental risks"

Since our last State of Natural Resources Report in 2020, Wales has faced a global pandemic, a cost-of-living squeeze, geopolitical upheaval and ever-faster, more visible climate change impacts.

These systemic shocks have deepened health and income inequalities. Aim 3 sets the lens through which public bodies should view this challenge: every policy and project should contribute to environments that shield people from hazards, support daily well-being and sustain cultural life.

An unprecedented warning from more than 200 medical journals in 2021 called climate change and biodiversity loss "catastrophic" for public health, and one of the greatest challenges humanity faces (Wise, 2021). This is further reinforced at the Welsh scale in Public Health Wales' Climate Change Health Impact Assessment, stating "The assessment recognises that climate change is the greatest threat to health and wellbeing that Wales will face this century" (Edmonds and Green, 2023).

The recent Future Generations Report (2025) also highlights these challenges are further compounded by rising obesity rates and structural inequalities in Wales. The report calls for more preventive actions to address the social, cultural, economic, and environmental factors that impact people's health and well-being in Wales. Box 1 below provides an overview of the state and trends of people and their well-being in Wales.

There is substantial evidence that environmental hazards negatively affect health and wellbeing, with impacts varying by sociodemographic and geographic factors. Vulnerable groups, such as older adults, people living in relative poverty, the unemployed, the inactive, and those exposed to flooding, poor air quality or high levels of environmental noise, are at greater risk of increased health burdens and reduced healthy life expectancy due to known and avoidable environmental hazards (UK Health Security Agency, 2024)

Wales, already owns the many of legislative tools to respond to these challenges e.g., the **Well-being of Future Generations Act 2015**, the **Environment (Wales) Act 2016** and the **Public Health (Wales) Act 2017**.

However, their power to deliver equitable benefits depends on them being used to transform things like the food, energy and transport systems responsible for the majority of environmental problems (NRW, 2020).

Box 1: People in Wales: A Snapshot of Health, Ageing, and Inequality.

The population in Wales is the largest ever recorded. As of mid-2023, the population was estimated to be 3.14 million. Based on the latest projections, it is expected to increase by 2.1% to 3.23 million by 2043 (Welsh Government, 2025).

Our population is ageing. In mid-2023, approximately 21.5% of the population of Wales was over 65 years old, and this group is projected to increase by over 25% by 2043 (Welsh Government, 2025) .

Life expectancy is an important indicator of the overall health of a population. Whilst this is increasing in Wales, healthy life expectancy is lower than the UK average. At birth, average life expectancy for men in Wales is 78, but healthy life expectancy is 61 - a difference of 17 years (ONS, 2023). For women, life expectancy is 82, but healthy life expectancy is 62 - a difference of 20 years (Public Health Wales, 2022).

The gap in healthy life expectancy between the least and most deprived populations in Wales has been increasing in recent years, which suggests a growing inequality (Older People’s Commissioner Wales, 2023).

The People and Nature Survey for Wales reveals that 61% of people in Wales say they are in good or very good general health. However, 45% have a long-term condition, and 83% of them experience daily life impacts. Mental health (42%) and mobility (38%) are the commonly reported issues in this group (2021/22 data cited in PaNS Wales, 2025 Health & Wellbeing Report).

Around one in four adults aged 16 and over are living with obesity. Wales has the highest percentage of people living with diabetes in the UK. Currently, 220,000 people have diabetes. 10% of NHS funding is already spent on diabetes, yet most Type 2 diabetes cases are preventable (Future Generations Commissioner for Wales, 2025).

The prize and the gap

- Approximately **247 million visits** (Owen, Rhydderch and Williams, 2025)to natural and green spaces in Wales in 2021-22 generated **£320 million in Welsh health benefits** from recreation and tourism (out of Wales' £2 billion total ecosystem-service flows in 2022) (Office for National Statistics, 2024a)
- These benefits help underpin the UK's **£6.2-8.4 billion** saving in avoided healthcare costs in 2020, yet low-income, minority-ethnic and mobility-limited groups who have the most to gain, **visit nature 20% to 30% less often.**
- Welsh woodlands removed **35 million kg** of air pollutants in 2020, but fine particles still shorten thousands of lives each year and the worst air quality lies in Cardiff, Newport and parts of the South Wales Valleys.
- Only 40% of water bodies achieve good overall status, and **275,000 homes** already sit in medium or high-flood-risk zones, mostly in the same deprived communities. Widespread **access to nature** helps people across Wales live happy and healthy lives (NRW, 2023).

Nature-based solutions offer multiple benefits: catchment woodlands and reconnected floodplains mitigate flood peaks and capture pollutants; sustainable drainage schemes (SuDS) and street trees filter particulates and provide shade, dampen urban noise; and constructed wetlands could help treat and attenuate water discharges.

At the same time, Wales is investing in the people who will deliver and steward those places. *Y Gwasanaeth Natur / The Nature Service* , a new national initiative, will knit together nature-based learning, volunteering, training and employment so that more citizens gain the skills and eco-literacy needed for a nature-positive economy .

Wales' landscapes also shape identity and culture. The People & Nature Survey shows that in 2021/22 **85%** of adults felt closer to nature since the coronavirus (COVID-19) pandemic and **91%** wanted to keep spending time outdoors (Owen, Rhydderch and Williams, 2025). The fundamental connection between nature, economic prosperity and human health and well-being became increasingly evident during the pandemic, which probably had its origins in nature's over-exploitation and degradation (Brotherton *et al.*, 2021).

This points to a simple truth: human, animal and ecosystem health are inextricably woven together. Aim 3's One Health perspective provides the framework to turn that insight into coordinated action and at a systems level which can transform things like transport and the built environment. Scaling this full menu of nature-based solutions (NbS) and ensuring every community enjoys easy access to high-quality green and blue space will be key to success.

Objectives of this assessment

- Analyse and report on current environmental risks to health and well-being and demonstrate how sustainable management of natural resources protects health.
- Analyse and report on the contributions of nature to improved health outcomes.
- Capture the cultural benefits nature provides in Wales.

- Recommend priority nature-based solutions (NbS) that deliver health protection, improvement and cultural well-being.

Why Aim 3 matters to well-being in Wales

Table 18: Why Aim 3 matters to well-being in Wales

Contribution of SMNR	Linked National Wellbeing Indicator*
Protect health & wellbeing - reduce air, water and soil hazards, and manage flooding and heat effects	**Indicator 4** Levels of nitrogen dioxide (NO2) pollution in the air **Indicator 31** Percentage of dwellings which are free from hazards **Indicator 32** Number of properties (homes and businesses) at medium or high risk of flooding from rivers and the sea **Indicator 41** Emissions of greenhouse gases within Wales
Improve health & wellbeing, ensure daily access to green and blue space, promote active travel and green prescribing	**Indicator 2** Healthy life expectancy at birth including the gap between the least and most deprived **Indicator 29**Mean mental well-being score for people **Indicator 48** (Percentage of journeys by walking, cycling or public transport)
Cultural and equity benefits, ensure every community feels welcome, represented and involved	**Indicator 28** Percentage of people who volunteer **Indicator 29** Mean mental well-being score for people **Indicator 43** Areas of healthy ecosystems in Wales **Indicator 8** Percentage of adults with qualifications at the different levels of the National Qualifications Framework

Aim 3, “Healthy places for people, protected from environmental risks” turns healthy, hazard-free environments into a delivery mechanism for all seven Well-being Goals:

- It safeguards health (*A Healthier Wales*),
- Cuts inequality in exposure to risk and access to nature (*A More Equal Wales*),
- Creates green-economy jobs and lowers costs (*A Prosperous Wales*),
- Restores ecosystems for climate resilience (*A Resilient Wales*),
- Empowers locally led greening and place-making (*Cohesive Communities*),
- Celebrates place-based heritage (Vibrant Culture & Thriving Welsh Language),
- Locks in global carbon and biodiversity benefits (*A Globally Responsible Wales*).

Structure of this report

Evidence is organised under three interconnected dimensions:

- **Health protection**: regulating services that buffer environmental hazards such as air filtration, local climate regulation, extreme weather events, noise attenuation, water flow regulation and water purification.
- **Health improvement**: physical and mental-health gains from safe, accessible green and blue spaces.
- **Cultural benefits and equity**: identity, cohesion, inspiration, education and fair distribution of nature’s benefits.

Across all three sections we highlight socio-economic gradients, map hotspots where risks and deficits coincide, and flag nature-based solutions (NbS) such as riparian tree belts, restored wetlands, urban street trees and salt-marsh buffers together with the investment areas needed for inclusive access and community-led culture.

Aligning sustainable natural resource management with Aim 3 will cut avoidable disease, narrow health inequalities, strengthen community resilience and create green economy jobs, while restoring the ecosystems that future generations depend upon.

Natural England's 2024 report, ‘A Narrative Review of Reviews of Nature Exposure and Human Health and Well-being in the UK’, synthesises findings from 104 evidence reviews and shows that contact with natural environments, whether through simple proximity or active engagement, benefits physical and mental health - whereas exposure to polluted or degraded nature can undermine it (Lamont and Hinson, 2024).

Key findings from the review were:

- **General nature exposure is good for well-being**: Proximity to green or blue spaces e.g., parks, fields, woodlands, mountains, rivers, or coastlines, is associated with improved mental health, reduced stress, and lower risks of conditions like cardiovascular disease.
- **Active engagement with nature can improve health**: Activities like walking, gardening, or participating in organized nature-based interventions (e.g., outdoor education or conservation projects) can enhance physical health, alleviate anxiety and depression, and foster social connections.

- **Exposure to environmental risks is affecting well-being**: Interacting with polluted or degraded natural environments e.g., due to factors like poor air or water quality etc, can negatively impact health, highlighting the importance of environmental quality.
- **Nature improvement activities**: Engaging in or witnessing efforts to restore or enhance natural spaces can yield psychological benefits, including increased feelings of well-being and community cohesion.

Health protection

Healthy places begin with protecting people from avoidable environmental harm. In Wales, the most significant environmental hazards include air pollution, floodwaters, chemically contaminated water bodies, soil erosion, noise, and extreme weather events.

These hazards are most acutely felt in lower-income urban and rural communities, that often have the least access to high-quality green and blue spaces. They also contribute to reduced healthy life expectancy, heightened anxiety, deepening inequalities, and weakened economic security.

Table 19: Health protection key issues (from SoNaRR 2025 ecosystem and natural-resource assessments unless stated)

Natural resource	Principal risk themes for Aim 3
Air	Long-term exposure to PM2.5 and NO_2 shortens many Welsh lives each year (estimated 1000-1400 deaths per yr[2]) and concentrates in Cardiff, Newport and industrial valleys. Odour and ammonia emissions from solid-waste management sites exacerbate urban risks Noise and light pollution add mental-health burdens. In 2021/22, 28% of urban residents in Wales reported being regularly bothered by noise from outside their homes, compared to 21% in rural areas (Owen, Williams and Rhydderch, 2025). 46% of Wales experienced negligible night-time light pollution, although artificial light emissions around the edges of built-up areas are rising and affect both wildlife and people. Together, these stressors disrupt sleep, exacerbate stress and add impact mental health negatively. Climate projections suggest increasingly frequent and intense summer heatwaves in Wales. By 2050, around 14% of Welsh homes are expected to overheat in a typical summer, elevating risks of heat exhaustion, strokes and worsening cardiovascular and respiratory conditions. This will disproportionally affect the very young, elderly and those in poorly insulated housing.

2

Natural resource	Principal risk themes for Aim 3
Soil	9,330 potential contaminated-land sites (414 of which are considered to be high-priority for inspection) may expose people to risks. Peat and agricultural soils are losing carbon and increasing runoff, amplifying flood hazards. Increase in the frequency of extreme weather events increases erosion risk of soils into the wider environment, reducing the soils capacity for providing benefits for people. Excessive nutrient application, particularly nitrogen and phosphorus, can disrupt soil health by altering microbial communities, acidifying the soil, and degrading its structure. Surplus nutrients often leach into groundwater or run off into nearby water bodies, contributing to pollution and eutrophication. This imbalance can also lead to greenhouse gas emissions, reduce flora resilience, and cause long-term nutrient accumulation, creating persistent environmental risks even after inputs are reduced. Emerging contaminants are at risk of affecting the public by increasing exposure to pollutants, including per- and polyfluoroalkyl substances (PFAS) and micro and nano-plastics. One source of is contaminated floodwaters, which may leave contaminants behind in the soil and increase exposure to the public.

Natural resource	Principal risk themes for Aim 3
Water	Coastal communities face escalating challenges from sea-level rise, erosion, and storm surges. 275,000 properties already lie in medium or high-flood-risk zones; the figure could exceed 320,000 by 2120. 40% of Welsh river waterbodies meet good Water Framework Directive regulations status. Agriculture impacts on 21% water bodies, while urban areas and wastewater impact on a further 27%. Overall, in 2024 only 42.7% of rivers, 24.6% of lakes, 62.5% of canals, 30.4% of coastal waters and 15.6% of transitional waters achieve good or high status. Climate change predictions indicate that Wales can expect Increasingly severe summer droughts which could threaten drinking-water security and private supplies. Phosphorous is one of the main pressures in SAC River catchments in Wales. Out of the 9 SAC rivers, 7 fail to meet the phosphorous targets. Source apportionment modelling by DCWW shows the dominant sources are from rural land use and waste water. Historic metal-mine drainage still pollutes some 700 km of Welsh rivers, 41 river waterbodies, 2 lakes and 5 transitional waters now exceed environmental quality standards for zinc, cadmium or lead. Microplastics are now ubiquitous in the Welsh aquatic environment, and persistent organic pollutants (PBDEs, PCBs) show no decline. Meanwhile, 265 of Wales' 1,632 authorised or historic landfill sites lie on the coast (Robbins *et al.*, 2023). posing growing risks of direct marine contamination as sea levels rise and storms intensify.

[1]Lifespan adjusted-e.g., this figure doesn't represent direct, actual deaths from air pollution but reflects the overall reduction in life expectancy, averaging 6-8 months, (though it can range from days to years) across the population

Health protection: nature-based solutions to key issues

Table 20: Health protection nature-based solutions to key issues (from SoNaRR 2025 ecosystem assessments)

Ecosystem Type	Nature-based Solution
Coastal margins & Marine	Adaptation strategies, including restoring saltmarsh, re-aligning defences, and community engagement via Shoreline Management Plans. Saltmarshes and seagrass attenuate waves (up to 72% wave-height reduction) and store blue-carbon (7,726 t C yr^{-1}). Saltmarshes provide a waste-remediation service, trapping faecal bacteria and heavy metals.
Enclosed farmland & semi-natural grasslands	Vegetation removed ≈ 850t of airborne pollutants in 2022, preventing ~19 life-years lost. The UK government have recognised that farmland should play a role in storing flood water in some places (House of Commons: Environment, Food and Rural Affairs Committee, 2016; DEFRA *et al.*, 2025) (House of Commons, 2016; Pearson *et al.*, 2025). The Environment Agency (2025) provides an evidence directory of the likely effectiveness of natural processes, including in farmland, in mitigating flood risks. Deep, uncompacted swards also store water and reduce run-off (Office for National Statistics, 2023)(ONS Natural Capital Accounts, 2023).
Freshwater	River-floodplain restoration proven to slow flows and retain 173 t N yr^{-1} in-stream.
Urban green infrastructure	Sustainable Urban Drainage (SuDS), the accessible natural greenspace standard (ANGST), street trees and 20 mph policy package jointly target heat stress, air-pollution and surface-water flood risks, showing the benefits of transforming our transport and construction systems.

Ecosystem Type	Nature-based Solution
Woodlands	Welsh Woodlands draw-down, and lock in greenhouse gases mitigating climate change impacts on people around the world (1.54 Mt CO_2 yr^{-1}). ONS (2024b) (2024) Natural Capital Accounts: Welsh woodlands removed 35.4 million kg of air-borne pollutants in 2020. Woodlands also slow peak water flows and mitigate flood and heat risks. This can contribute to the protection of local communities.

Woodlands are positively contributing to Wales' commitment to achieve Net Zero by 2050, helping to mitigate the impacts of climate change on people around the world. The 2022 Greenhouse Gas Inventory for the Land Use, Land-Use Change and Forestry sector also highlights that grasslands (including pastures) contributed to this ambition, drawing in and locking down 0.65 Mt CO_2 yr^{-1}. However, other parts of the landscape are net emitters of carbon, with croplands emitting 0.66 Mt CO_2 yr^{-1}, degraded peatlands 0.28 Mt CO_2 yr^{-1} and settlements (built-up areas) 0.31 Mt CO_2 yr^{-1} (BEIS, 2024).

Table 21: Headline gaps to close for Aim 3 – Health protection (from the SoNaRR 2025 ecosystem and resource assessments)

Risk theme	Critical shortfall today	Nature-based priority
Air quality	4 local air quality management areas still breach annual NO_2 limits.	Double canopy cover on main distributor roads and around schools; target 25% by 2030.
Chemical water status	Phosphate exceeds target in 7 of 9 SAC rivers; presence of rates of uPBT (ubiquitous Persistent Bio accumulative and Toxic) substances.	Roll out riparian buffers and constructed wetlands; pilot plastic-capture litter traps.
Contaminated land	Only 18% of high-priority sites have secured funding for remediation.	Align brownfield clean-up with local development & housing grants; phytoremediation where feasible.

Risk theme	Critical shortfall today	Nature-based priority
Flood water	Approximately 275,000 properties are currently at risk from flooding in Wales.	Planting catchment woodland, floodplain restoration, and urban Sustainable Drainage Systems - SuDS reconnect floodplains in high-risk hydrological zones. Target natural flood management to lower risk (smaller) catchment areas.
Heat & noise	Lowest-income wards have <8% tree cover, highest noise scores.	Pocket parks, street trees, green roofs and quiet ways in urban heat islands and along busy corridors.

Cross-cutting challenges and opportunities

- **Resource constraint**: Capital spend is still dominated by hard defences; redirecting even 10% to nature-based solutions (NbS) would unlock co-benefits at lower life-cycle cost.
- **Data & early warning**: Real-time air-quality, water quality and river-height feeds now exist linking them to public apps and health advice nudges may help reduce exposure on high-risk days.
- **People and Nature equity insight**: The findings underline the broad health value of green and natural space. Prioritising NbS where persistent health inequalities and environment risk overlap, maximises public health return.
- **Circular economy**: Wales already leads UK recycling rates; extending producer-responsibility to micro-plastics and e-waste closes the loop between waste, pollution and health-risk. Aim 4 further assess Wales' progress towards a circular economy.
- **Evidence limitations**: While nature based (NbS) are often more effective in lower-risk or small catchments, current Flood and Coastal Erosion Risk Management (FCERM) funding is prioritised toward high-risk communities where NbS alone may not reduce risk to acceptable levels. This, coupled with challenges in evidencing outcomes, means many lower-risk but NbS-suitable areas lack investment. Addressing this misalignment could unlock multiple co-benefits.

A focussed programme that deploys these nature-based measures in the places of highest combined environmental risk and social deprivation will deliver the greatest health-protection gain for Wales, while simultaneously advancing Aim 4's regenerative-economy vision.

Health improvement

How nature boosts everyday well-being

Landscapes are the settings in which we live, work and experience life. They reflect the interrelationships between natural resources, culture and economy. Aim 3’s second lens is health improvement: making daily contact with thriving green and blue spaces part of normal life.

According to the PaNS Wales survey data from 2021/22, “*Three-quarters of Welsh adults already get out at least once a week and one in five go every day*.” Regular time in nature rich, well-kept environments gets people moving, reduces anxiety, eases stress, forges social ties and measurably cuts the burden of non-communicable diseases (NCDs).

Table 22: How much nature benefits Wales.

Annual recreation visits, 2021-22 (Owen, Rhydderch and Williams, 2025)

UK NEA ecosystem type	Total Number of Visits 2021-22
Coastal margins	21,922,081
Enclosed farmland	25,257,483
Freshwaters	28,014,904
Marine	19,927,591
Mountains, moorlands & heath	17,437,539
Semi-natural grasslands	23,262,992
Total Visits	246,746,599
Urban green infrastructure	72,057,886
Woodlands	38,884,122

Recreation-related ecosystem services are enjoyed in combination with the visual and sensory amenity services that nature supplies. **More than half of Wales is rated Outstanding or High for visual and sensory character and scenic quality**, providing a nationally important backdrop for everyday life. Tranquillity is similarly widespread: 81% of the land area falls within the top three most visually-tranquil categories, where natural sounds, dark skies and limited human influence dominate, although this falls to just 10% in urban areas (NRW and Land Use Consultants, 2025).

Across Wales, **around 540,000ha, or 25% of the country, is national park or area of outstanding natural beauty** (Nolan et al., 2020). These landscapes are designated to conserve and enhance natural beauty and promote opportunities for enjoying their special quantities.

Light-pollution remains largely confined to built-up zones, and **over two-thirds of Wales enjoys the darkest sky class**. Soundscape mapping shows **86% of the country in the five best categories for natural sounds** (Green et al., 2025). These qualities translate into direct nature experiences: recent survey data from 2021/22 indicate that one in five adults visit green or natural spaces every day, enriching well-being and sense of place (Owen, Rhydderch and Williams, 2025).

Visits have changed since the last assessment. Based on 2021/22 survey data, walking remains the primary activity, chosen as the main purpose on 60% of visits (Owen, Rhydderch and Williams, 2025) . Woodlands alone saw about 70,000 additional people reporting measurable health benefit between 2019 and 2022 and Freshwater visits increased 12% in the same period .

The People & Nature Survey Wales shows that **94%** of recent visitors report mental-health benefits and **96%** physical-health benefits as a direct result of spending time in green and natural space (Owen, Williams and Rhydderch, 2025).

Chief Medical Officers in the UK recommend that adults have 150 minutes of moderate-intensity, or 75 minutes of vigorous-intensity physical activity, or equivalent, per week. Physical activities undertaken in green and natural spaces are understood to be more beneficial for health and wellbeing than similar types and levels of activity in other settings (Wicks et al., 2022). Investing in nature based solutions can be a cost-effective way to improve public health and reduce or optimise healthcare spending.

Recent data from the Welsh Council for Voluntary Action highlights the important contribution of community engagement through Local Nature Partnerships (LNPs). Of the approximately **2,350 volunteers involved in nature-based projects, over a quarter reported improvements in personal well-being**, collectively contributing around 16,000 hours of time.

Who is still missing out?

- Adults in the lowest-income quintile, minority-ethnic groups and people with limiting illness make **20–30% fewer** nature visits than average.
- Most trips are hyper-local (69% within two miles), so neighbourhood quality is paramount
- The average urban Welsh household is **1147m** from a public park, compared with the Great-Britain average of 881m.

- Among non-visitors, **20%** cite poor physical health and **11%** poor mental health as their main barrier (Headline report PaNS Wales, 2021/22).

Table 23 Headline gaps to close for Aim 3 - Health Improvement (from the SoNaRR 2025 ecosystem and resource assessments)

Gap to close	Proven Nature-based solution	Main delivery lever
Unequal daily access	Urban parks, street trees and greenways within 300 m of every home.	Local Development Plans, Future Wales tree-canopy targets, Active-Travel Act.
Low physical activity & rising NCDs	Green social prescribing linked to high-quality natural or green/blue spaces.	Health Boards, Sport Wales, NRW, and other NGO partners.
Urban heat & noise stress	Integrated urban GI packages (SuDS plus canopy plus 20 mph limits).	Active-Travel Act, Clean Air Plan.
Inclusive design	Co-designed paths, benches, toilets, lighting.	Access-for-All standards.
Under-used blue space	River baths, safe-bathing stretches, paddle trails.	Flood-risk plans, water-industry & land-scale scale partnerships.

Cross-cutting challenges and opportunities

- With supportive infrastructure, clear leadership and inclusive policies in place, both formal and informal volunteering can flourish across all sectors, ensuring participation is safe, well supported and sustainable.
- Green infrastructure that favours walking and cycling reduce greenhouse-gas emissions within Wales (National Indicator 41) and raise the percentage of journeys by walking, cycling or public transport (Indicator 48).
- Community volunteering in nature increases life-satisfaction scores and deepens place attachment, supporting the Vibrant Culture & Thriving Welsh Language goal and directly contributing to **Cohesive Communities**.

Cultural benefits: Enhancing identities, experiences, and capabilities through nature

Ecosystems provide our iconic landscapes and species, contributing to our culture and heritage (Welsh Government, 2018). Their characteristics and qualities deliver multiple benefits that contribute to cultural well-being, a sense of place, identity and quality of life. As such, ecosystems are more than just settings for leisure; they also enable livelihoods and carry the stories, symbols and shared experiences that knit Welsh society together.

(Further evidence in Annex 4: Aim 3 Cultural well-being evidence)

The UK National Ecosystem Assessment (UKNEA) follow-on proposed that these cultural ecosystem benefits operate through **three, overlapping value lenses** (Church *et al.*, 2014):

- **Physical and Psychological Experiences****: This covers direct encounters with nature, such as visits and nature watching, which promote recreation, relaxation and states such as peace and tranquillity, boosting mental and physical health.
- **Supporting Identities:** Shaping peoples identities such as sense of place, belonging, rootedness and spirituality.
- **Capabilities:** Equipping people with a range of skills and capabilities around education, research and knowledge for better decision making.

**Physical and psychological experiences have been addressed in the previous Health-Improvement section above.

The Millennium Ecosystem Assessment classed spiritual, aesthetic and inspirational experiences as core "*cultural ecosystem services,"* stressing that people draw meaning, creativity and identity from landscapes just as tangibly as they draw water or timber. SoNaRR (2020), highlighted this importance of the wildlife, landscapes and seascapes of Wales as a rich source of inspiration for many forms of artistic and cultural expression.

Places with strong spiritual or aesthetic significance e.g., mountain summits, ancient woodlands, sacred springs, dark-sky sites, all provide recognised settings for reflection, stress-reduction and grief-processing, complementing and supporting formal health services.

Changing ecosystems and biodiversity will have a substantial impact on Welsh culture (St. Leger, 2024). Welsh placenames, myths and festivals are often tied to particular habitats (e.g. Cader Idris, Coed Celyddon, Gŵyl y Fari Lwyd). Protecting those habitats therefore safeguards living cultural heritage and the vibrancy of the Welsh language. This is significant as we need to consider how placemaking, belonging and identity (Welsh names/farms/locations) may be impacted by different land use and development decisions, as well as effects of climate change and species loss.

Where the evidence is strongest

The evidence underlines the substantial and still widely accessible experiential value of Welsh landscapes and highlights the opportunity to enhance it further through green-infrastructure, dark-sky and soundscape-sensitive planning.

Presenting Aim 3's *"Spiritual, Artistic & Symbolic Services"* (Table 24) against this backdrop shows that safeguarding night-sky tranquillity, sacred groves or iconic views is not an optional extra: it is a public-health intervention, a cultural-heritage duty and a driver of green prosperity, all in one.

Table 24 Spiritual, Artistic & Symbolic Services (UK NEA Categories: Religious, spiritual, Cultural Heritage, Media & Inspirational) (from the SoNaRR 2025 ecosystem and resource assessments)

Ecosystem	Cultural Highlight
Coastal Margins	Coastal ecosystems provide a source of inspiration for expression and enable livelihoods.
Enclosed Farmland	The UK NEA (2011)(2011, p. 1032) highlighted public motivation to protect traditional family farm structures and traditional livestock husbandry in Wales (pp.1032). Agriculture, forestry and fishing has the highest share Welsh speakers across all sectors (43% of the total working population). Farmland is important for the wider historic environment with 13,894 earthwork sites and 5,264 buried archaeological sites recorded on agricultural land.
Freshwater	Traditional methods of fishing for inland fish species are recognised as having a heritage value (Russell *et al.*, 2011, p. 1020). In 2023, a total of 252 Salmon and 610 Sea trout were caught using these techniques (Environment Agency and NRW, 2024).
Marine	According to the Ocean Literacy in Wales report, the overriding emotional response to the marine environment is concern (48%) followed by wonder/awe (41%) (Atkinson *et al.*, 2022).

Ecosystem	Cultural Highlight
Semi Natural Grassland	Contributing to cultural and spiritual identity and acting as a source of inspiration for artistic expression. 57% of Wales by area is classified in the LANDMAP 'Grassland and Marsh' category (NRW, 2024). Tranquillity, wildness, naturalness and aesthetic appreciation are associated valued cultural services and benefits of this category. Semi-natural grassland is associated with a number of traditional management practices with high cultural and heritage value, such as hay making and grazing with rare livestock breeds. Wildflower-rich meadows have long been and remain an inspiration for artists.
Urban	Good quality urban greenspace can foster better levels of community cohesion, promote social inclusion and enhance social ties and a sense of community. The UK NEA highlights the role of churchyards and cemeteries in spiritual and religious service provision. The ONS Urban Natural Capital Accounts identify that there are 444ha of religious grounds and cemeteries within Wales' Urban Ecosystems.
Woodlands	Woodlands are often a major component of landscape character, scenic quality and sense of place. Wales has around 95,000 hectares of ancient woodland sites, of which 42,000 hectares are ancient semi-natural woodland (ASNW) They provide a source of inspiration for expression and cultural and spiritual identity including through art, folklore and language, historic features and practices.

Sir Partha Dasgupta's review of the economics of biodiversity argues that "our ability to understand and thus to manage nature ultimately rests on what we choose to teach and to learn." (Dasgupta, 2021). By classifying education, scientific enquiry and ecological knowledge as critical ecosystem-service flows, the review places schools, universities, citizen-science networks and outdoor-learning programmes on the same footing as woodlands that filter air or wetlands that store carbon.

For Aim 3 this matters in two ways:

- **Preventive health and equity**. Field-based science and nature-rich school grounds improve physical activity, concentration and pro-social behaviour, while citizen-science projects give people who may not feel welcome in traditional green spaces a purposeful reason to visit and return.
- **Resilience and green-economy skills**. Monitoring pollinators, flood-peaks or urban heat with low-cost sensors generates the data that planners need for Nature-based Solutions (NbS) and gives participants marketable STEM (science, technology, engineering, and maths) skills exactly the "investment in human capital" Dasgupta calls for.

Table 25 Education, Scientific and Research Services (UK NEA Categories: Education and Ecological Knowledge) (from the SoNaRR 2025 ecosystem and resource assessments)

Ecosystem	Cultural Highlight
Coastal Margins	Provide intellectual development, advancement of knowledge and understanding for people from interactions with coastal ecosystems. Several UK universities and schools use Welsh coastal habitats either in teaching and/or research. 64 peer reviewed papers were published between 2020 and 2024 in the UK for sand dunes and saltmarshes.
Enclosed Farmland	The UK NEA highlighted Enclosed Farmland in Wales offers educational opportunities through schemes such as the Schools Food and Farming Initiative (Russell *et al.*, 2011, p. 1025). (UK NEA, Chapter 20, pp.1025).
Freshwater	Traditional salmon coracle fishing (252 salmon landed in 2023) is formally recognised as living cultural heritage.
Marine	Universities in Wales deliver world-leading marine courses at undergraduate and postgraduate level, attracting students and research activity in Wales that has significant economic value. Rock-pool biodiversity enhances public interest and supports hands-on marine education.

Ecosystem	Cultural Highlight
Semi Natural Grassland	Many schools and other educational establishments make use of grassland sites for learning purposes; the amount of use often depends on proximity to an appropriate site. For example, Great Orme's Head receives around 200 school groups per year, excluding unofficial visits, many of which engage in environmental activities on the site.
Urban	Green flag schools and parks offer a proxy for this service but direct indicators for the scale of the use of this service are unavailable for urban ecosystems.
Woodlands	Woodlands are a place and subject of learning, intellectual development and advancement of knowledge. 31% of survey respondents joined woodland learning events in 2023 and participation is still rising. There are numerous forest research plots in Wales, however indicators for the scale of the use of this service are unavailable.

Dasgupta also warns us "*environmental problems are at root the consequence of citizens being distant from Nature*." Aim 3 therefore hinges not only on habitats and green infrastructure but on empowered citizens who understand, monitor and steward the places they live in.

When communities co-design pocket parks, count pollinators, test river water or map cooling shade, they convert ecological knowledge into everyday agency; they also generate the local data that planners need for Nature-based Solutions. Such participation closes the feedback loop between environment and well-being, strengthens social cohesion, and equips people with green-economy skills. Embedding citizen science, volunteer restoration and locally led decision-making across Aim 3 interventions turns passive beneficiaries into active custodians. If we are to transform the transport and built environment systems, as the UN calls for, such inclusion and participation will be essential.

The People & Nature Survey Wales (2021/22) (Owen, Rhydderch and Williams, 2025) reinforces these findings:

- **91%** of adults wanted to keep spending as much time outdoors as they did during the coronavirus COVID-19 pandemic.
- **49%** already spend more time outside than before 2020.

- **69%** say their local green space encourages physical activity and social contact.
- **59%** saying it was good to spend time with friends and family.
- **61%** say they feel part of nature (2021/22 data cited in PaNS Wales, 2025 Health and Well-being Brief).
- Volunteering is at the heart of Wales' identity. It is vital to the well-being of our communities**. 12%** of people say they volunteer their own time for an environmental cause. As noted from feedback to the Welsh Council for Voluntary Action, many report personal well-being benefits from volunteering.

NRW's LandMap (2024) classifies approximately 19% of Wales as having geological features of 'Outstanding' quality and 'exceptional scientific importance.' This rich geological heritage is reinforced by the broader network of Sites of Special Scientific Interest (SSSI), which cover 2,630 km² (roughly 10% of the country) and provide vital resources for education and research.

Cross-cutting challenges and opportunities:

- **Loss of practice**: urbanisation and changing livelihoods erode traditional skills such as hedge-laying, dry-stone walling and small-scale fishing. 29% of infrequent visitors feel nature "*isn't for people like me*" (2021/22 data cited in PaNS Wales, 2025).
- **Access barriers**: poor weather, lack of facilities, personal safety concerns and physical limitations keep some groups away; in 2021/22 40% of non-visitors cite facilities or safety, 20% cite poor health (PaNS Wales, 2025).
- **Equity gaps**: deprived or marginalised communities have fewer close-to-home spaces for celebration, learning and reflection.

Opportunities to strengthen cultural benefits

Table 26: Opportunities to Strengthen Cultural Benefits (From ecosystem and resource assessments)

Opportunity	Delivery route	Expected gain
Protect iconic scenic areas, dark skies and tranquil soundscapes.	National Park & AONB management plans; Dark-Skies Partnership.	Safeguards intrinsic inspiration and tourism revenue.
Celebrate nature-based heritage and festivals.	Local authority culture funds; Visit Wales marketing.	Deepens relational ties and visitor economy.
Expand outdoor learning and citizen science.	Curriculum for Wales; Local Nature Partnerships.	Builds ecological literacy and stewardship skills.

Opportunity	Delivery route	Expected gain
Promote nature-based arts and creative residencies.	Arts Council of Wales; Valleys Regional Park.	New cultural products, stronger sense of place.
Design inclusive green and blue spaces.	*Access for All* standards; Equality Impact Assessments.	Closes equity gap and supports the Well-being Goal “More Equal Wales”.

Why this matters for national well-being

Cultural ecosystem services directly contribute to:

- **Vibrant Culture & Thriving Welsh Language -** by sustaining festivals, arts and oral traditions.
- **Cohesive Communities -** by providing shared places for gathering and volunteering.
- **A Healthier Wales -** through mental restoration and active recreation.

They support many of the national wellbeing indicators, and protecting these services ensures that future generations inherit not only healthier ecosystems but also the living cultural fabric that makes Wales so special.

Equity lens

Public Health Wales says that the cost of health inequalities to acute NHS services in Wales is around £322 million per year. Health inequalities occur when people’s health outcomes are different due to factors e.g., where they live, income, or ethnic group. This results in people in the poorest areas of Wales living on average **17 less healthy years** of life compared to people in the wealthiest places (Public Health Wales, 2025). The data reveals other alarming statistics around persistent health inequalities:

- In 2022-2023, around **a quarter (24.8 per cent) of children aged 4-5 years in Wales were overweight or obese**. Children living in the most affluent areas in Wales are more likely to have a healthy weight.
- People living in the most deprived communities are nearly four times more likely to die from avoidable causes.
- People from **ethnic minorities are also disproportionately exposed to environmental hazards**, such as poor air quality and flood risk. They also report how they experience racism overtly when visiting or using green spaces (Welsh Government, 2024).The Welsh Index for Multiple Deprivation identifies there are **high pockets of environmental deprivation** (i.e., relatively higher exposure to poor air quality or flood risk and relatively lower accessibility to green space) around the large cities in South East Wales and, to a lesser extent, the South Wales Valleys (Welsh Government, 2019).

Structural inequalities mean environmental burdens still fall hardest on the least advantaged. Table 27 shows where those gaps are largest.

Table 27 Structural inequalities

Theme	Evidence of unequal distribution
Air-quality burden	Newport & Cardiff host >40% of the most deprived (environment) LSOAs; air-quality sub-domain drives index scores.
Flood risk	Deprived communities & ethnic-minority groups over-represented in high-flood-risk zones; lower capacity for insurance/adaptation.
Urban green cover	Only 37% of less-affluent wards have >15% tree cover vs 51% of affluent wards; Butetown/Riverside/Grangetown all <8%.
Woodland access	Mobility and car-ownership barriers; 21% cite mobility, 18% lack of car as reason not visiting woods.

Why integrate these trends?

Aligning natural resource management with demographic, housing and cultural change lets Wales design nature-based solutions (NbS) that:

- relieve pressure on the healthcare system.
- cut transport emissions.
- foster cultural exchange and volunteering, and
- narrow existing inequalities in access to clean air, flood protection and everyday nature.

Embedding future-trend thinking in Local Development Plans, Area Statements, Public Service Boards, Health-board Well-being Objectives and the forthcoming Natural Resources Policy refresh will ensure Aim 3 remains on track through the 2030s. A focus on cross sectoral policy to transform our energy, transport, construction and food systems will deliver most benefits according to UN scenarios (UN environment Programme, 2024).

Policy and legislative framework

Wales already has one of the strongest legal toolkits in Europe for linking environmental quality with public health and culture.

Table 28: Policy & Legislative Framework

Instrument	What it requires	Relevance to Aim 3
Well-being of Future Generations (Wales) Act 2015	Public bodies must pursue seven well-being goals and five ways of working.	Gives Aim 3 its long-term, preventative and equity mandate.
Environment (Wales) Act 2016	Introduces Sustainable Management of Natural Resources (SMNR) duty; biodiversity enhancement duty.	Powers Nature-based Solutions, Area Statements and ecosystem-services planning. Requires a cross sectoral, systems approach in the Natural Resources Policy (NRP).
Public Health (Wales) Act 2017	Makes health-impact assessment and clean-air zones possible; embeds “health in all policies”.	Aligns green/blue-space provision, air-quality action plans and flood-risk management with better health outcomes.
Planning (Wales) Act 2015 + TAN 16	Places sustainable development at the heart of spatial planning, and sets open-space and GI standards, considers information in SoNaRR and Area Statements to inform development.	Ensures every new neighbourhood includes accessible, multi-functional green and blue infrastructure.

Aim 3 & Cymru Can

The Office of the Future Generations Officer is focussing on five interconnected missions to deliver on the goals of the Well-being of Future Generations Act (Future Generations Commissioner for Wales, 2025). Aim 3 is particularly relevant to the **Health & Well-being and Culture & Welsh language missions.**

The Health and well-being mission recognises the need to prioritise long-term, prevention-based solutions to build a healthier population in Wales, targeting wider social and environmental factors of health (or wider determinants of health).

Aim 3 highlights important environmental risk factors that are determinants of health, including air, water and land pollution, flood risk, noise and heat. It also emphasises the role of regulating ecosystem services in Health Protection and mitigating the risks these factors place on people. Mainstreaming nature based solutions (NbS) and requiring appraisal alongside grey options in all capital programmes should become the normal in protecting people against these environmental risk factors. Especially given many of these risks will increase as a result of climate change.

While many funded schemes do consider multiple options including NbS, in practice it can be difficult for NbS to meet cost benefit thresholds under current appraisal rules, particularly where traditional approaches offer greater immediate reduction in risk. Alternative metrics (e.g., wellbeing, carbon, biodiversity) are underdeveloped and rarely integrated into formal appraisals. Recent UK government Green Book review shows this is now being acknowledged as a weakness in moving towards transformational change.

It is clear that many people are struggling with their physical and mental well-being, for instance evidenced by rising obesity rates, and mental health rates. Aim 3 reveals the role nature can play in providing opportunities for recreation that contribute to Health Improvement.

Equitable accessible natural greenspace standards (ANGST), describes a high quality green or blue space as being within 300m of every home. It also provides design guidance for age and disability friendly access, which are essential for boosting nature's contribution to better health outcomes for people in Wales.

The Culture and Welsh language mission highlights that Wales is the only country in the world that recognises cultural well-being as part of a statutory definition for sustainable development. Culture deeply shapes peoples identity and their sense of belonging in Wales. As with SoNaRR (2020), Aim 3 draws attention to the importance of the wildlife, landscapes and seascapes of Wales as a rich source of inspiration for many forms of artistic, cultural expression and cultural well-being.

The Future Generations Report 2025 calls attention to the limited action across public bodies to harness the role culture and arts can play in placemaking and the importance of protecting and developing cultural assets as key drivers of social cohesion, environmental resilience and economic regeneration. Expanding multi-sector, multi-land use approaches, such as Local Nature Partnerships (LNP) to every Public-Service Board (PSB) area and pooling health, climate and culture budgets around shared NbS projects is one way this can be improved.

It is important that decision-making around these projects and programmes recognises the relational and cultural values important to human well-being that are often low financial value e.g., togetherness, personal growth, health, and well-being, being in nature, contentment, and happiness (Pretty et al., 2025).

This can foster the appreciation that projects that generate less monetary benefit than they cost can still deliver good value for money from a well-being perspective (as recently recognised by the Green Book Review 2025: Findings and actions - GOV.UK).

Additional delivery levers include the NRW Greenspace Toolkit, Area Statements, Public-Service-Board Well-being plans and the national Clean Air Plan.

Opportunities for Action

Achieving Aim 3 requires addressing these pressures through targeted interventions that align with **protection, improvement**, and **cultural benefits**.

The following opportunities are all drawn from NRW Area Statements, and the 8 broad Ecosystem assessments, and 3 Natural Resources assessments.

** In future assessments we aspire to be able to better evidence and quantify the impact these actions may have.

Opportunities for Health Protection

Table 29: Opportunities for Health Protection

Opportunity class	Priority action **
Access to Nature	Target support to vulnerable residents (e.g. cooling hubs in green spaces, sensory spaces).
Community Engagement	Enable local community preparedness for floods and heatwaves.
Integrated Plans & Delivery	Tighten industrial and transport emission controls.
Integrated Plans & Delivery	Phase out domestic solid-fuel burning in urban smoke-control zones.
Nature-based Solutions	Invest in NbS to reduce flood risk and enhance resilience.
Nature-based Solutions	Expand urban greening (street trees, green roofs) to filter air pollutants.
Nature-based Solutions	Extend urban green infrastructure to lower heat-island temperatures.
Nature-based Solutions	Install sustainable drainage systems (SuDS) and other NbS to capture and filter highway drainage containing range of recalcitrant contaminants.

Opportunity class	Priority action **
Research & Technology	Strengthen monitoring and rapid response.

Opportunities for Health Improvement

Table 30: Opportunities for Health Improvement

Opportunity class	Priority action
Access to Nature	Improve access to and quality of green and blue spaces in deprived communities.
Access to Nature	Build walking and cycling networks linking homes, schools and workplaces.
Awareness-Raising	Work with the health sector to raise awareness of the physical and mental health benefits of visiting and prescribing nature.

Opportunities for Cultural Benefits

Table 31: Opportunities for Cultural Benefits

Opportunity class	Priority action
Awareness-Raising	Grow nature-based tourism to inspire connections with the natural world.
Community Engagement	Support place-based environmental projects and nature-linked festivals.
Integrated Plans & Delivery	Protect dark skies, tranquillity and natural soundscapes through planning controls and zones
Research & Technology	Expand citizen-science and outdoor-learning initiatives to build practical stewardship skills.

The People & Nature 2021/22 headline reports that **90%** of adults rate environmental protection as important and **85%** state that they would be willing to change their own behaviour (NRW and Natural England, 2024). Whilst the relationship between people's attitudes and actual behaviour is complex, the survey shows that there would be support for community-led nature based solutions (NbS) that unite sustainable natural resource management with public health & wellbeing gains.

Cross-cutting actions for all three tables

- Community engagement through Local Nature Partnerships, Area statements and Nature Service Wales.
- Dissemination of PaNS Wales, 2025 analysis to relevant stakeholders.
- Integrated spatial plans that combine LDPs, Area Statements and PSB well-being plans.
- Research & technology: real-time air-quality sensors and citizen-science data platforms

Conclusion

Wales has the **knowledge, the legal tools and a clear public mandate** to make Aim 3 "healthy places for people, protected from environmental risks" an everyday reality.

- Knowledge: We understand how ecosystems act as life-support systems providing vital goods and services e.g., woodlands help strip air pollutants, wetlands blunt flood peaks, and biodiverse landscapes nourish culture and health.
- Legal tools: Together the **Environment (Wales) Act 2016** hard-wires the sustainable management of natural resources (SMNR) into decision-making, supported by the Planning Act 2015. The **Well-being of Future Generations Act 2015** demands that environmental, cultural, social and economic goals are pursued together, and the **Public Health (Wales) Act 2017** makes protecting and improving population health a legal duty. Together they give Wales the powers to take an integrated approach to transforming our social and economic systems to deliver for people and the planet.
- Public mandate: Firstly, our Nature and Us (2022-23) consultation shows that citizens want a 2050 Wales where "society and nature thrive together", with greener transport, sustainable land use and easy access to nature. Secondly, The People & Nature Survey (2021/22) finds 85% of the population of Wales say nature makes them happy, 49% spent more time outdoors during the coronavirus COVID-19 pandemic, and 91% want to keep that habit - indicating that people are ready to act.

The risk of inaction is equally clear. Persistent exposure to polluted air, degraded water and heat stress will continue to drive chronic disease, widen health inequalities, impact the workforce, affect economic competitiveness and erode the cultural identity rooted in working landscapes and community traditions.

Table 32: What must happen next

Priority	Pay-off
Scale nature-based solutions (NbS) where risk and deprivation overlap	Cuts premature deaths, increases healthy lifespan (yrs), limits flood damage and delivers mental-health gains.
High quality and accessible green/blue space within 300m of every home	Narrows health and equity gaps; supports active travel.
Embed joint health–environment metrics in policy review cycles	Shows real-world benefits, guides adaptive management.
Support community-led NbS projects and citizen science	Builds stewardship, captures local knowledge and widens participation (ultimately delivers better designed NbS).
Accelerate carbon sequestration and climate resilience	Locks away carbon through peatland/woodland restoration while building natural flood management and heat mitigation.
Strengthen pollution reduction and waste management	Reduces environmental health burdens that undermine community well-being and ecosystem function.
Implement species recovery and habitat connectivity programmes	Restores nature, safeguards biodiversity and strengthens ecosystem resilience against climate shocks.
Protect and celebrate cultural landscapes	Preserves dark-sky benefits to biodiversity, human health and storytelling, working diverse landscapes, language and livelihoods as integral to environmental health.

By implementing these priorities within the statutory framework provided by the Environment (Wales) Act 2016, the Well-being of Future Generations (Wales) Act 2015, and the Public Health (Wales) Act 2017, Wales can deliver the future people have asked for: healthy, nature-rich places where communities and ecosystems thrive together.

Evidence Gaps and Measurement

Table 33: Evidence Gaps and Measurement Priorities for Aim 3 (2025-2030)

Area	Evidence Gaps	Measurement Priorities
Community Engagement	Citizen-science data under-used.	Formalise citizen-science schemes in monitoring programmes.
Integrated Metrics	Few indicators link ecosystem health with socio-economic outcomes.	Develop holistic indicators, and outcome tracking.
Multidisciplinary Research	Weak links between environment and public-health studies.	Fund joint research to map causal pathways. Synthesis of what actually works in practice.
Outcome Tracking	Limited data on quantifiable health gains from different NbS. Dose-response curves linking specific amounts of nature exposure to reductions in particular NCDs. Long-term tracking of how new green infrastructure in deprived wards shifts PaNS Wales, 2025 health metrics. Standardised methods for valuing mental-health savings in cost–benefit appraisals.	Use NRW Greenspace Toolkit, PaNS survey and health registers to track respiratory, mental-health and activity outcomes.
Policy Impact Assessment	Infrequent evaluation of policy effectiveness.	Schedule regular impact reviews with clear environment-health-resilience metrics.
Real-Time Data	Inconsistent live monitoring of air, water, INNS and floods.	Extend sensor networks and public dashboards.

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Aim 4 assessment: Contributing to a regenerative economy, achieving sustainable levels of production and consumption

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Executive summary

Our pathway of economic development has raised material standards of living in Wales and across the world. However, in the process of getting to where we are, we have degraded our natural resources to the point where the demands we make of nature far exceed its ability to meet them (Dasgupta, 2021). Some progress has been made on decarbonising the Welsh economy. Nonetheless, Wales continues to face significant challenges in achieving ***a Regenerative Economy, with Sustainable Levels of Production and Consumption.***

This 2025 assessment builds on SoNaRR 2020 and The Dasgupta (2021) Review on The Economics of Biodiversity, commissioned by HM Treasury. The assessment also aligns with the **mission-based priorities** set out in the ***Future Generations Report 2025***, with respect to achieving a well-being economy in Wales.

Vision: We describe success with respect to achieving Aim 4 as: Wales moving from an economy that degenerates its natural resources and ecosystems, through a sustainable, circular economy, which does no net harm and uses its fair share of natural resources, to a regenerative one which works with our natural systems to restore nature.

Key messages

The economy is still degrading natural resources in Wales:

- Pollution from rural areas (including agriculture and forestry), the waste water sector and urban and transport infrastructure are degrading Wales surface and groundwaters. Only 40% of these water bodies are of good status.
- Air pollution from energy, transport and industry has decreased but still impacts many people. Emissions of ammonia from the agriculture sector remain high at around 21 kilo tonnes in 2021. This is impacting habitats and people.

- Pollution of soils and waters from past and present industry and landfilling is a concern. This includes future impacts on water resources from persistent organic pollutants, micro-plastics and antibiotics used in different economic activities.
- The construction sector needs to increase its activity if housing targets in Wales are to be met. However, this needs to be in the right places, recognising these developments typically come at the expense of farmland, coastal margin ecosystems and urban green areas and may occur in areas of flood risk.
- We need to decouple our economic activity from these pressures for our long-term economic well-being. Chronic risks from changes to earth systems, biodiversity loss, natural resource shortages and pollution, and acute risks from extreme weather are among the greatest risks our economy faces.

We continue to use more than our fair share of resources.:

- If the world lived like Wales, humanity would need 2.08 Earths to sustain itself. This means Welsh consumption is creating significant unsustainable pressures on natural resources.
- The agricultural sector uses 90% of land in Wales. These productive ecosystems can also support a variety of species (e.g., farmland birds), safeguard and enhance natural resources (e.g., soil quality) and supply a range of regulating and cultural services (e.g., flood protection and recreation). However, we do not know how much of these are managed to maintain their regenerative capacity and supply these benefits beyond those linked to crop and biomass provisioning.
- At least 48% of all forests in Wales are managed to the UK Forestry Standard to maintain biodiversity and ecological functions, alongside social and economic functions (this is the known extent of woodland certified through the UK Woodland Assurance Standard (UKWAS)).
- We need to prevent more waste from being generated in the first place through better product design and increasing activities like repair and remanufacture.
- Wales' renewable energy sector is critical for achieving net zero. It is vital that development of this sector is planned to protect the resilience of our ecosystems and build community wealth.
- We need to work together to achieve Aim 4: Citizens need to be empowered to adopt more sustainable lifestyles. Many businesses also want to contribute; 5,000 have signed the Green Growth Pledge | Business Wales.

A regenerative economy goes hand-in-hand with a wellbeing economy

- Nature-based solutions (NbS) can contribute to economic productivity, deliver valuable societal outcomes, and restore nature. Due to the networked functionality of nature, nature-based solutions can deliver multiple value streams from a single investment in nature. Multiple values can be realised through buyers for high-integrity outcomes from a single NbS intervention (e.g. water quality, biodiversity and recreation-focussed buyers for outcomes from establishing riparian woodland), making co-funding or co-investment possible, which can deliver improved cost-benefit performance for the nature-based solution approach for all funding partners.

- Many jobs in the economy also depend on the sustainable management of natural resources. Employment data and sector analysis estimates that the agriculture, forestry & fishing sector, the water sector, nature based tourism, renewable energy, and the circular economy sector can support around 118,000 jobs, providing opportunities for fair work.
- Promoting social enterprises and building community wealth can realise the potential of Sustainable Management of Natural Resources (SMNR) to build community wealth.

The transition to a regenerative economy is essential if we are to live within the ecological boundaries that define the limits of the well-being economy. As highlighted by the Future Generations Commissioner, economic policies, incentives and investments all need to be explicitly designed to address the climate and nature emergency, alongside inequality and retaining wealth within communities. With the right investment and skills development, SMNR also provides opportunities to create decent jobs, build community wealth, as well as a focus for all parts of the economy to work together to build back up the stocks of nature in Wales for the benefit of current and future generations.

Introduction

Economic development has created huge benefits for society. We all now benefit from the assets we have built, things like our railways, reservoirs, roads, electricity grid and houses. We also consume a wide range of products and services that contribute to our well-being, from material goods such as food and computers to health and education services. At the same time, our economic activity have placed substantial demands on nature, driven by our need to use natural resources and ecosystem services and convert land for various economic uses (e.g., agriculture, housing, etc.). Our economic activities have also created substantial volumes of waste and pollution, which are returned to nature as an unintended consequence of our production and consumption. These include greenhouse gases and other emissions to air, emissions to freshwaters and contamination of our land and soils.

So, whilst our economic development pathway has raised material standards of living in Wales and across the world, the evidence is clear this has come at the expense of widespread loss and degradation of nature. This prompted the Treasury to commission the Dasgupta (2021) ‘Review of the Economics of Biodiversity’. Dasgupta. (2021) calls this growing imbalance of our demands on nature and its capacity to meet them the ‘impact inequality’ (left pane, Figure 1). These demands are the goods and services we take from nature, the land we use for economic activities and the flows of wastes and pollution back into nature. These demands are collectively referred to as the ‘Ecological Footprint’ (Ny / α) in Figure 1. Broadly, our global ecological footprint is a measure of the impact that each person has on the planet, as they use resources and create wastes (including greenhouse gases). It is determined by the number of people on the planet (N in Figure 1), the economic activity of each person (or for simplicity per person consumption) (y in Figure 1) and the efficiency with which we produce the things we want and use nature as a sink for waste (α in Figure 1).

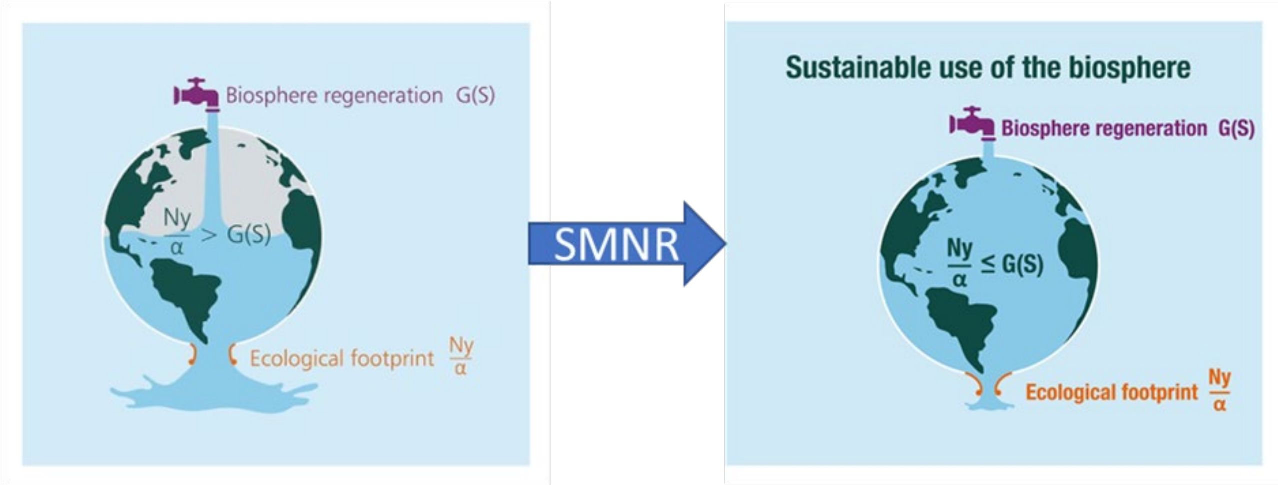

Figure 5: Addressing the 'Impact Inequality' and transitioning to a 'Regenerative Economy' based on the Sustainable Management of Natural Resources (SMNR) (adapted from Dasgupta et al., 2021)

Over much of human history, our demands on nature have been well within the regenerative capacity of the planet to meet them. This capacity is characterised as 'Biosphere regeneration' in Figure 1. It is the rate (G) at which the stocks of nature (S) replenish themselves over time (G(S) in Figure 1). However, substantial increases in populations and economic activity means our ecological footprint is unsustainable. We are now drawing down on nature's goods and services at a rate greater than nature can regenerate them. Each year this continues, we continue to reduce our stocks of nature (S in Figure 1). This is what characterises a degenerative economy.

Following Dasgupta (2021), a regenerative economy is one where the impact inequality is reversed. Where stocks of nature are restored and the biosphere regeneration exceeds our ecological footprint. Through Aim 4 of SMNR, Wales aims to move from the current, degenerating economy (left side of Figure 1), to a regenerative economy (right hand side of Figure 1). We describe success with respect to achieving Aim 4 as: ***Wales moving from an economy that degenerates its natural resources and ecosystems, through a sustainable, circular economy, which does no net harm and uses its fair share of natural resources, to a regenerative one which works with our natural systems to restore nature.***

The impact inequality in Wales

Consumption drives the Welsh economy, creating the demand for businesses in Wales, the wider UK and around the world to produce goods and services. Satisfying this demand creates a host of different employment opportunities. Box 1 provides an overview of the size, structure and workings of the Welsh Economy. The National Well-being Indicator 14 estimates the ecological footprint of the consumption of goods in Wales. The indicator is based on assessing the area of land needed globally to provide raw materials, energy and food and absorb the pollution and waste created from the consumption of goods and services in Wales. This area was estimated to be 12.3 million global hectares in 2018, a lower estimate than for 2004, although the methods and data are not directly comparable This means 2.08 earths would be needed if the whole of the world lived like the people of Wales in 2018. National well-being indicator 42 shows that the greenhouse gasses embedded in the goods and services households consume in Wales was 25 $MtCO_2e$ in 2020 (a lower estimate than the 40 $MtCO_2e$ in 2001,. The overall picture is Wales is using more than its fair share of resources (Welsh Government, 2025h).

The Welsh Government recently commissioned a report to assess how consumption of commodities in Wales drives pressures on the environment, both inside and outside of Wales (Lin, D. *et al.*, 2023). Using slightly different methods, it estimates the total Ecological Footprint of Wales for 2019 at 10.7 million global hectares. Economic activities linked to energy supply, transport and storage, agriculture, forestry and fisheries sectors have the biggest impact on our ecological footprint. Collectively, these sectors contribute to over 50% of the Welsh ecological footprint. An initial exploration of the global environment impacts of Wales consumption of agricultural crop commodities indicates this may be associated with a predicted loss of 1.2 to 1.6 species, around 669 to 884 ha of tropical or subtropical deforestation and associated emissions of 225 to 439 thousand tonnes of CO_2 in other parts of the world (Lin, D. *et al.*, 2023). On the positive side, evidence suggests that per person ecological footprints in Wales decreased between 2004 and 2018, driven by the reduction in greenhouse gas emissions from energy generation.

Box 1: Overview of the State and Trends of the Welsh Economy. The Welsh economy has grown slowly in the 21st Century, with Gross Domestic Product (GDP) rising from around £40 billion in 2000 to around £93 billion in 2023 (Office for National Statistics, 2025b). When the effects of inflation are considered, this is a growth of approximately 1.4% per year in real terms (based on chained volume measures, % growth / year). This is characterised by two shocks of negative growth associated with the financial crisis in 2008 / 2009 and covid n 2020 (Office for National Statistics, 2025b).

In 2023, the gross value added (GVA) of the economy in Wales was £81.5 billion (Welsh Government, 2025c). This is the value of all goods and services produced in a year (taxes minus subsidies make up the rest of GDP) (Office for National Statistics, 2018). This is dominated by the services sector, contributing around 73% of this figure. This sector includes health and social work, real estate, transport and storage, financial and public administration activities. The production sector contributes around 21% of GVA, dominated by manufacturing (15.6%). Other production sector activities linked to natural resources comprise energy supply (2.0% of GVA), water supply, sewage and waste management (1.9%); Agriculture forestry and fishing (1.2%) and mining and quarrying (0.2%). Finally, the construction sector (e.g., buildings and civil engineering) contributes the remaining 6.4% of GVA (Welsh Government, 2025c).. GVA for any individual production activity (e.g., agriculture) is different from total output (i.e., the price of all goods and services the activity produces). GVA is the difference between price of these total outputs (e.g., agriculture produce) and the costs of any inputs from other industries (e.g., machinery, fertilisers and veterinary bills) net of any taxes and subsidies (formally known as intermediate consumption) (Office for National Statistics, 2018)..

The economy of Wales also provides jobs for 1.41 million people (June to August 2024), down 60,400 (4.1%) from the same period a year earlier (Office for National Statistics, 2024a). Indicators for fair work reveals 64% of people on permanent contracts (or on temporary contracts, and not seeking permanent employment) earned at least the real living wage (Welsh Government, 2024c). However, there remains substantial inequality in economic well-being in Wales. Between the period 2020 to 2022, it is estimated that 21% of all people in Wales were living in relative income poverty. This has been a relatively stable trend in Wales for over 17 years (Welsh Government, 2024c). This is something the well-being economy mission of the Future Generations Officer aims to address.

More broadly, Dasgupta (2021) highlights that if the national development goal is to protect and promote well-being across the generations, we have to expand our measures of success. This means moving from concentrating on standard economic measures, like GDP and GVA, to a broader, more inclusive set of measures of wealth. Measures that recognise the value of nature, alongside broader measures of well-being like people's health, education, aptitude and skills. This should include the value of having an equitable society and the social and cultural importance of people's relationships with each other and nature, which may have low economic value and be hard to measure (Pretty *et al.*, 2025). Via the Well-being of Future Generations Act in Wales, we have a framework that sets out goals and indicators to provide these types of measures of success.

Why Aim 4 is important for well-being in Wales.

Why does Aim 4 matter? As SoNaRR (2020) observed, ***'Viewing society and the economy as if they are separate from the environment, has not worked'***. Dasgupta (2021) also observes: **"A healthy environment and a vibrant economy can go hand in hand, and indeed must do, otherwise we will have neither"**. As our societies and economies are wholly embedded in nature (Figure 2), transitioning to a regenerative economy that restores and reduces pressures on nature is essential to our long-term well-being and prosperity.

Figure 6: The Economy is Embedded in the Biosphere. Figure 17 Dasgupta, (2021))

The World Economic Forum (2024) Global Risk assessments highlighted this critical relationship between environmental and economic well-being, with its top 4 risks to the global economy over the next 10 years being: Extreme weather; Changes to earth systems; Biodiversity loss / ecosystem collapse; and natural resource shortages. Pollution came in at number 10 (World Economic Forum, 2024).

The need to transition to nature positive economies and societies is now a mainstream development concern ((Brotherton *et al.*, 2021; Dasgupta, 2021). The need for this systemic change was explicitly acknowledged by UN member states following the Stockholm+50 International Meeting, which recommended “Adopt system wide change in the way our current economic system works to contribute to a healthy planet” (UNEP, 2022). Given the current situation, the ambition here needs to be to move towards substantially nature positive economies and societies quickly if we are going to mitigate environmental risks we face. Table 1 summarises how a regenerative economy can enhance well-being in Wales.

Table 34: Why Aim 4 matters to well-being in Wales.

Contribution of SMNR	Linked National Wellbeing Indicator
Contributing to economic well-being Sustainably using natural resources to create prosperity and opportunities for fair work (Welsh Government, no date a). The contribution of natural resources to the economy are part of our demands on nature (or part of our Ecological footprint in Figure 1). For this use to be environmentally sustainable, natural resources can only be used at, or below, the rate at which they can replenish themselves (Biosphere regeneration in Figure 1). Reinvesting profits from this use in local communities also contributes to social and cultural sustainability.	**Indicator 18** (percentage of people in income poverty), **Indicator 21** (Percentage of people in employment) .
Managing the pressures on natural resources from the economy, safeguarding them and the benefits they provide for current and future generations. This implies, both changing our consumption patterns improving the efficiency with which we use natural resources as inputs and the environment as a waste sink (also part of our Ecological footprint in Figure 1).	Contributing to: **Indicator 4** (NO_2); **Indicator 43** (Area of healthy ecosystems in Wales); **Indicator 44** Status of Biological Diversity in Wales); **Indicator 45** (percentage of surface water bodies and groundwater bodies achieving good or high overall status)
Promoting sustainable production and consumption, by changing our consumption patterns to reduce our ecological footprint and our production activities to enhance our stocks of natural resources (S in Figure 1).	Contributing to: **Indicator 12** (Capacity of renewable energy installed), **Indicator 15** (Amount of waste not recycled), **Indicator 14** (Global footprint), **Indicator 33** (percentage dwellings with good energy performance); **Indicator 41** (GHG emissions); **Indicator 42** (GHG linked to consumption), **Indicator 43** (Area of healthy ecosystems in Wales); **Indicator 44** Status of Biological Diversity in Wales); **Indicator 45** (percentage of surface water bodies and groundwater bodies achieving good or high overall status)

The actions and well-being outcomes outlined in Table 1 overlap in various ways and represent perspectives of what it means to transition to a regenerative economy in Wales that uses its fair share of natural resources. This is the situation in Figure 1, where Dasgupta's (2021) impact inequality is addressed.

The contribution of natural resources to economic well-being

"Wales' natural resources and ecosystems underpin our well-being and quality of life. They fuel our industries, provide our food, clean air and water, and create jobs and wealth." (Welsh Government, 2018)

This statement draws attention to the relationship between safeguarding and enhancing stocks of natural resources (Aim 1 of the SMNR aims), maintaining ecosystem resilience (Aim 3 of SMNR) and the well-being of people in Wales (Aim 3 and 4 of SMNR). As Dasgupta (Dasgupta, 2021) observes, a key finding from both IPBES Global Assessment (2019) and Millenium Ecosystem Assessment (2005), our economic activities are associated with increasing use of provisioning ecosystem services. Both assessments also observe a corresponding decline in the supply of regulating and cultural ecosystem services, with implications for achieving Aim 3 of SMNR.

Accounting for all of nature's contributions can then help guide decision-making towards delivering better outcomes for both nature and people (Dasgupta, 2021) . To support this, Aim 3 provides a broad overview of the contribution of ecosystem services (the benefits we get from ecosystems) to social and cultural well-being. Table 35, Table 36 and Table 37 complement this by highlighting the use of nature (formally the contribution of ecosystem services) to economic production activities in Wales. These services will generally be highly relevant to the everyday, or foundational economy approach, which is gaining traction in redirecting spending in to Wales (Future Generations Commissioner for Wales, 2025). It is important that interventions associated with the supply of these, often provisioning services, recognise the trade-offs and synergies with wide contributions of regulating and cultural ecosystem services to people's well-being in Wales.

Table 35: Contribution of regulating ecosystem services to economic well-being in Wales

Regulating Ecosystem Service	Contributions to economic well-being
Water flow regulation and coastal protection services	The economic impacts of a flood can be substantial, including damage to vehicles, buildings, infrastructure and flood assets themselves (Welsh Government, 2020b). Modelled data from flood risk assessment for Wales indicates substantial lengths of rail and road infrastructure is at risk of flooding from rivers, surface waters and small watercourse and the sea. The amount of this transport infrastructure at risk will increase under predicted climate change (SoNaRR 2025: Water Assessment). The CCRA report (Netherwood, 2021, p. 109) estimate annual damages for non-residential properties in Wales at present is £51m. It also estimates that by the 2050s an additional 2,250 ha of the most versatile (BMV) agricultural land will be at significant risk of coastal flooding and an additional 24,100ha of BMV from fluvial (river) flooding (Netherwood, 2021, p. 31) . Woodland ecosystems can help to mitigate against some of these flood risks, reducing associated damage costs to businesses, agricultural land and infrastructure (DEFRA *et al.*, 2025). Green infrastructure in urban ecosystems such as urban parks, green spaces, green walls and urban trees has been shown to retain substantial volumes of surface and rainwater, helping to reduce flood risk to businesses (SoNaRR 2025: Urban Assessment). Coastal margins ecosystems play a significant role in nature-based flood management, it is estimated that around 2,000ha of agricultural land benefits from the protection provided by saltmarsh. (SoNaRR 2025 Coastal margins Assessment). The UK government have recognised that farmland should play a role in storing flood water in some places (House of Commons: Environment, Food and Rural Affairs Committee, 2016; DEFRA *et al.*, 2025).

Regulating Ecosystem Service	Contributions to economic well-being
Water purification services	Safeguarding and enhancing clean water resources will reduce chemical and energy costs associated with water treatment. Green (or nature based) solutions can contribute to these cost savings (Dŵr Cymru Welsh Water, 2023a). Peatlands alone supply over a quarter of the UK's drinking water supply according to the ONS experimental peatland accounts (SoNaRR 2025: Soils Assessment). Woodland ecosystems are also effective at mitigating diffuse pollution by trapping and retaining sediment in runoff, reducing water treatment and pollution management costs (SoNaRR 2025: Woodland Assessment). In urban ecosystems, water purification services supplied by green infrastructure can provide solutions for surface water management by filtering out pollutants. This would be more cost effective than installing new plant-based treatment approaches (SoNaRR 2025: Urban Assessment).
Local climate regulation services	Sunshine hours have increased by 6.1% since the 1970s and annual temperatures are expected to rise approximately 1.2°C by the 2050s from a 1981 to 2000 baseline (Netherwood, 2021). Local climate regulation from green and blue spaces benefits urban businesses by reducing heat stress and mitigating productivity losses in highly physical jobs. This also reduces air conditioning costs to businesses. Experimental data indicates the value of this was £1.3 million in avoided productivity losses in the Cardiff City Region, rising to £1.45 million when reduced air conditioning costs are included (SoNaRR 2025 Urban Assessment). Trees supply local climate regulatory services for livestock, providing shade for animals and reducing heat stress. This improves the health and productivity of the livestock (SoNaRR 2025: Woodland Assessment).
Air filtration services	The costs of air pollution not only include health costs but also reduced productivity costs from lost workdays. Collectively these are estimated at £1 billion per year in Wales (Grey *et al.*, 2018, p. 4). This highlights that maintaining healthy places for people is an economic concern for maintaining a healthy, productive workforce. Ecosystems can help mitigate these risks by adsorbing pollutants, including particulate matter. The ONS (2024b) estimate that 56 million kg of air pollutants were removed by Enclosed Farmland vegetation; 36 million kg by broadleaved and coniferous woodland; and 24 million kg by Semi Natural Grasslands in Wales in 2023

Table 36 Contribution of provisioning ecosystem services to economic well-being in Wales

Provisioning Ecosystem Services	Contributions to economic well-being
Crop & Biomass Provisioning Services	The Office for National Statistics (Office for National Statistics, 2024b) estimate 330,000 tonnes of agricultural primary biomass (Barley, Oats, Oilseed rape and Wheat) was produced in Wales in 2023, up from 275,000 tonnes in 2020. The value of these crops is not provided. Total value of agricultural biomass production estimated for 2020 was £450 million (2023 prices). Farmed ecosystems supply biomass for livestock as well. In 2024, the total number of sheep and lambs in Wales this service contributed to the production of was 8.75 million and the total number of cattle and calves in Wales was 1.09 million (Welsh Government, 2024b). In 2020, The number of sheep and lambs in Wales was 9.0 million and cattle and calves 1.1 million. Lamb grazed on saltmarshes is notable in that it can produce meat of a particularly high quality, commanding higher prices (SoNaRR 2025: Coastal Margins assessment). The supply of crop and biomass provisioning services underpins the agricultural sector and the jobs it supports. In 2023, the overall gross value added to the Welsh economy by Agriculture (and hunting) was estimated to be £923 million (Welsh Government, 2025c). Although, more recent estimates place the GVA of the agricultural sector at £648 million in 2024 (Welsh Government, 2025a, tbl. 1c) . Agricultural businesses also support other businesses via expenditure on inputs and services supplied by other sectors of the economy (called intermediate consumption, see Box 1). In 2024 this intermediate consumption was forecast at £1,567 million (Welsh Government, 2025a, tbl. 1b) (. It is estimated that 49,500 people were working on farms in 2024, of which 37,300 are farmers, business partners, directors and spouses. The remaining 12,200 are employees, comprised of full-time employees, managers and casual workers (Welsh Government, 2024b). Crop provisioning services are also supplied by urban allotments and gardens. The ONS (2024b) estimate that urban ecosystems supplied 4.1 million tonnes of food via ‘own production’ in 2020, based on estimated yields of 1.6kg / m^2 (SoNaRR 2025: Urban Assessment).

Provisioning Ecosystem Services	Contributions to economic well-being
Fish provisioning Services	The number of Welsh fishing vessels reduced from 263 in 2020 to 223 in 2023 with the number of people working in the fishing industry reducing from 129 FTEs to 109 FTEs in the same period (based on data from (Seafish, unpub.). Gross Value Added (GVA) and operating profits fell from £8.69m and £2.96m respectively in 2020 to £5.99m and £2.08 in 2023. In 2022 the combined GVA of fishing and aquaculture to the economy in Wales was £13 million (Welsh Government, 2025c) (SoNaRR 2025 Marine Assessment).
Timber provisioning Services	Softwood removals in Wales between 2014 and 2023 averaged 1,266,000 green tonnes per year, with the highest yield of 1,460,000 green tonnes recorded in 2014. Hardwood removals in Wales between 2014 to 2023 averaged 33,000 green tonnes per year, with the highest yield, of 39,000 green tonnes recorded in 2019 (SoNaRR 2025 Woodland Assessment). Wood provisioning services contributed £665 million Gross Value Added to the economy in 2017 (Welsh Government, 2019b) . This was made up of direct forestry and logging activities (circa. £50 million), which occurred in Wales. The remainder comprised manufacture of wood products (circa. £250 million) and manufacture of paper products (circa. £365 million). More recent estimates place the GVA of forestry and logging activities in Wales at 61 million in 2023, manufacture of wood products at £348 million and manufacture of paper products at £309 million (Welsh Government, 2025c). Whilst the manufacture of wood and paper products will have used wood logged outside of Wales, it highlights the potential to add value to natural resource inputs. Collectively, the sector employed over 10,000 people in 2017 (Welsh Government, 2019b) . (SoNaRR 2025: Woodland Assessment).
Water provisioning Services	Total water abstraction of nearly 12 million Megalitres (ML) was licensed in 2024. Out of this, 430,000 ML was actually abstracted for industry, 128,000 for amenity and 119,000 ML for agriculture. The greatest volume of abstraction is associated with the energy sector, comprising 9.7 million ML in 2024. This includes non-consumptive abstractions for hydropower generation. Dŵr Cymru's Activities in Wales is estimated to exceed £1billion per year and supports around 3,000 full time jobs (SoNaRR 2025: Water Assessment).

Provisioning Ecosystem Services	Contributions to economic well-being
Minerals and metals provisioning (Abiotic Flow)	The ONS (2024b) estimate that around 14.658 million tonnes of construction minerals were extracted from Welsh ecosystems in 2022. These were extracted from marine (estimated at 7.5 million tonnes) and Mountain Moorland and Heath (estimated at 7.1 million tonnes). The value of the minerals extracted mountains, moorland and heath was £60 million in 2022. Monetary values are not available for construction minerals extracted from marine ecosystems. These volumes of abstraction are similar to those estimated for 2019 in Wales (Office for National Statistics, 2024b). More broadly, the GVA of mining and quarrying to the Welsh economy was £202 million in 2023 (or 0.2% of Welsh GDP) (Welsh Government, 2025c).

Table 37 Contributions to of cultural ecosystem services to economic well-being in Wales

Cultural Ecosystem Services	Contributions to economic well-being
Recreation-related cultural ecosystem services	Around 250 million recreational visits were made by the people of Wales to green and natural space in 2021/22 to engage in various activities like walking, wildlife watching and boating (Owen, Rhydderch and Williams, 2025). Walking was the main activity undertaken by 60% of adults during their visits. Analysis of the Great Britain Visitor Survey indicates 20.8 million visited the outdoors in Wales in 2021 as tourists to participate in outdoor activities (Miller *et al.*, 2023, tbl. 9) . Activities undertaken most frequently were land-based, comprising walking, running, mountaineering, cycling and winter sports. In a UK survey in 2023 of 563 respondents, 87% of respondents had visited the outdoors for 3 hours or more to participate in an outdoor activity (Miller *et al.*, 2023)). Survey results show that overall, the average daily spend on the activity itself was £29.00 per person, with an associated wider spend of £31.62 (Miller *et al.*, 2023, tbl. 4). Average spends associated with overnight accommodation for non-day trippers was £39.51 per night (Miller *et al.*, 2023, para. 2.48) . Based on these figures, the contribution of outdoor activity tourism to the Welsh economy is estimated to be £1.6 billion per year, capable of supporting around 29,500 (FTE) jobs (Miller *et al.*, 2023, para. 2.68). Whilst all this spend cannot be directly attributes to the recreation-related service, it is the supply of this service that draws people to Wales in the first place. The Wales Coast Path alone has been estimated to provide an economic boost of 23.6 million (Welsh Government, 2015, p. 327). Dark skies and tranquil areas are also recognised as bringing benefits to an area including enhancing the environment, attracting visitors and can boost the local economy (DarkSky, 2024).
Visual and sensory amenity cultural services	Visual and sensory amenity services contribute to increased property prices and can improve the value of a development. Experimental data from the ONS suggests that in Wales this is in the order of 3% in Wales' urban areas. The Tree Cover in Wales' Towns and Cities study highlights evidence that customers are willing to pay more for goods and parking in landscaped shopping areas. For some products this can be up to 9-12%. (SoNaRR 2025 Urban Assessment).

Table 35, Table 36 and Table 37 provide an overview of the different discrete contributions of natural resources to economic well-being. These contributions can be direct (e.g., timber provisioning services as an economic input) or indirect (e.g., air filtration regulation services that help maintain a healthy and productive workforce). However, it is also important to draw attention to importance of ecosystem resilience (i.e., Aim 2 of SMNR) in maintaining these flows of benefits. This is because different environmental changes or shocks will affect different abiotic and biotic components of ecosystems in different ways. Resilient ecosystems will have a more diverse complement of these components, meaning they will be better able to tolerate these disturbances, whilst maintaining the same level of functioning and supplying the same level of services. This includes in the context of climate change adaptation (Pörtner *et al.*, 2023). Economists sometimes refer to this as an 'insurance value' (Baumgärtner, 2008).

We also do not how valuable all the diverse elements of nature will be in the future. A currently rare fish species may prove to be a valuable commercial fish species in the future as populations are impacted by climate change. This is the concept of "option value," the IPBES Global Assessment (2019) identify this maintenance of options as one of its 18 categories of Natures Contributions to People (NCP 18). As such, there is clear economic rationale for applying the precautionary principle to natural resource management in Wales.

Pressures on natural resources from the economy

Natural and human-induced 'Drivers' are the factors that cause ecosystem change (UKNEA, 2011). Following the UK NEA, drivers may be one of two types, indirect or direct. Indirect drivers are the factors across society and the economy that interact, often in quite complex ways, to influence the pressures on natural resources. The UK NEA (2011) identified the key indirect drivers of change to be: Demographic changes; Economic growth; Sociopolitical changes (especially policy); Cultural and behavioural changes; and Advances in science and technology. These factors rarely act in isolation and can influence the structure of the economy in many ways. For instance, demographic, political and technological trends (and associated behavioural changes) can heavily influence consumption patterns, leading to changes in the pressures on natural resources (IPBES, 2017).

Indirect drivers are also referred to as 'underlying causes', influencing not only each other but the direct drivers of pressures (IPBES, 2017). Following the UK NEA (2011), direct drivers are the ones that exert explicit pressures that affect ecosystem processes, usually causing a physical change that can be identified and monitored. Based on the UK NEA (2011), SoNaRR identifies the following as the most important direct drivers affecting natural resource in Wales: Pollution; Land and sea use change; Direct exploitation; Climate change; and Invasive Non-Native Species (INNS), pests and diseases (See SoNaRR 2025 glossary)

These collective set of pressures reflect our ecological footprint in Figure 1. As Dasgupta (2021) identifies, our measures of economic productivity should account for the environmental pressures they create, as well as the contribution (or use) of nature in production activities (Dasgupta, 2021, tbl. 2). Essentially, we need to decouple our economic activity from these pressures. This means overall economic development should be associated with reduced use and degradation of natural resources (as called for in the

(United Nations Environment Programme, 2024). To help inform this, Table 38, Table 39 and Table 40 provide an overview of the pressures on natural resources that arise from our economic production and consumption activities Wales.

Table 38: Pollution pressures on natural resources from the economy

Natural Resource	Pressures from the economy
Air	Emissions to air from power generation have fallen in Wales (SO_2 and NOx) due to the change from using coal to natural gas and renewable sources. Overall, emissions of NOx fell by 61% between 2005 and 2022, mainly due to changes in the transport sector, particularly in road transport. Emissions of particulate matter to air have fallen by 31% between 2005 and 2022, with trends since 2011 being influenced by all sectors. The increase in wood fuel use by the residential sector has caused this sector to increase emissions of particulate matter in recent years. (SoNaRR 2025 Air Assessment). In Wales, it is estimated that between **1,000 and 1,400 deaths** per year are attributable to air pollution (Welsh Government, 2025d).. Emissions of ammonia due to fertiliser and manure application on soils by the agriculture sector are increasing in recent years in some areas of Wales. In 2022, the agriculture sector emitted around 21 kilo tonnes of ammonia to air (See SoNaRR 2025 Ammonia case study). These emissions are affecting air quality, leading to particulate matter (PM 2.5) formation impacting human health and ammonia deposition affecting ecosystem resilience (SoNaRR 2025: Air Assessment). The effect of ammonia deposition on ancient woodland ecosystems is a particular concern, with around 66% of all ancient woodlands and 24% of Special Sites of Scientific Interest (SSSIs) exposed to ammonia concentrations above the critical levels for bryophyte- and lichen-rich woodlands in 2020-2022 (See SoNaRR 2025 Ammonia case) Metals emissions to air associated with industrial activities are reducing, including of nickel and lead. Emissions of lead fell by 0.7% between 2005 and 2022 due to reductions in industrial processes. This includes at Port Talbot, where industrial processes have also been a significant contributor to total emissions of Benzo(a)Pyrene (a carcinogen) in Wales (SoNaRR 2025 Air Assessment).
Water	In the 2024 interim classification for the Water Framework Directive (WFD), only 40% of water bodies in Wales achieved the target of good or high status and 60% failed. The main reasons waterbodies failed to achieve good status were pollution from poor management

Natural Resource	Pressures from the economy
	practices in rural areas (including agriculture and forestry) for 21% of these, pollution from waste water for 17% of these and pollution from urban and transport land uses for 10% of these (NRW, 2025). Source apportionment modelling identifies rural land use (7 out of 10 catchments) as the main source of phosphorus pollution in Special Areas of Conservation (SAC) river catchments, followed by wastewater treatment (3 out of 10) (data derived from Dŵr Cymru, 2023) (SoNaRR 2025: Water Assessment). The Nutrient Review (2023) highlights phosphate pressures to be more widespread than nitrate pressures, with no evidence to support any substantial reductions in these pressures should be expected by 2031 (NRW and ARUP, 2023). Poor water quality affects transitional waters and marine ecosystems, as freshwaters, surface waters and other discharges into estuaries and the sea. In the 2024 interim classification for the Water Framework Directive (WFD), only 21% of transitional and coastal waterbodies achieved good or high status. For the 20 habitat features across marine SACs that are found to be in unfavourable condition, 9 had a primary failure for water quality (Dissolved Inorganic Nitrogen, DIN). Some of these may also have failed for other water quality indicators such as contaminants, phytoplankton or nuisance algae (Hatton-Ellis, *et al.*, 2025). These failures due to DIN are believed to be driven by nutrient loading from the rural and urban land uses and water treatment activities identified above, which are affecting waterbodies generally in Wales. Bacteriological loading on waters appears stable (at least in net terms), based on the number of bathing waters receiving excellent classifications increasing from 65% in 2004 to 70% in 2025 (SoNaRR 2025: Water Assessment). The EA highlight the most important sources in England are agricultural diffuse pollution, sewage related pollution and urban diffuse pollution (including contamination from dogs and birds) (Environment Agency, 2021). This is likely to be the case for Wales too. Climate change may increase precipitation, possibly increasing levels of faecal indicator organisms in waters (Kovats and Brisley, 2021). Despite historic restrictions in the production and use of Polychlorinated Biphenyl’s (PCBs) and Polybrominated Diphenyl Ethers (PBDEs), concentration levels of these chemicals in water are static, highlighting the persistent nature of these pollutants (SoNaRR 2025 Water Assessment). Similarly, Polyfluoroalkyl substances (PFASs) that were used in manufacturing as surfactants and surface protectors are also persistent organic pollutants of concern, given

Natural Resource	Pressures from the economy
	that the predominant exposure pathway of PFASs into the environment is via water (O'Rourke *et al.*, 2024). Microplastics are widespread in the Welsh environment. Chemicals that may have an increasing impact on water include pyrene (a PAH), bisphenol A (a plasticiser) and insecticides commonly used in flea treatments. The long-term outlook for antimicrobial resistance is unclear as reductions in veterinary use of antibiotics may be offset by increased use for human health (SoNaRR 2025: Water Assessment). Historic metal mine discharges still affect 700km rivers in Wales, with 41 River Water bodies, 2 lakes and 5 transitional waters failing to meet Environmental Quality Standards for metals (notably zinc, cadmium and lead) (SoNaRR 2025 Water Assessment).
Soil	The most common soils contaminants are benzo(a)pyrene, lead, and arsenic (NRW, 2016), linked to historic industrial activities. Whilst the waste sector has substantially reduced material sent to landfill, there are around 1,500 historic landfills in Wales which may impact on local ecosystems (Annex 5: Aim 4 Waste evidence). 265 are at the coast and have the potential to release waste directly into the marine environment (SoNaRR 2025: Coastal margins Assessment) Elevated concentrations of microplastics in soils have also been identified where they have had fertilisers applied to them. Another source of plastic contamination of soils are agricultural films (Cusworth *et al.*, 2024) (SoNaRR 2025: Soils Assessment). Climate change may result in increased mobilisation of contaminants from soils potentially affecting aquatic as well as terrestrial ecosystems (SoNaRR 2025: Soils Assessment). This is a particular concern for persistent organic pollutants in contaminated soils, previously used in industry and manufacturing (e.g., PCBs and PFASs). PFAS has also been linked to diffuse land sources including sludge-amended agricultural soils (O'Rourke *et al.*, 2024).

Table 39 Land and Sea use and management change pressures on natural resources and ecosystems from the economy

Pressure category	Pressures from the economy
Agricultural intensification	The agricultural sector makes use of 90% of land area in Wales (although 9% of this is not used for agricultural production) (Welsh Government, 2024b). Permanent grassland is the main component of this, accounting for 62% of agricultural land and comprises of improved, semi-improved or unimproved (semi-natural) grassland for livestock (Welsh Government, 2023c). The remaining land comprises new grassland (9%), sole rights rough grazing (14%), arable crops (6%) and other land (9%) (Welsh Government, 2024b). Inorganic fertiliser application rates (kg/ha) in all farm types showed an overall decline in inorganic fertiliser (NPK) use between 2020-21 and 2022-23 (StatsWales, 2025). However, it is estimated that 10 million tonnes of organic manures are applied to the agricultural landbank in Wales each year (Rollett and Williams, 2022). Dairy farms generally have high application rates of nitrogen (132 Kg/Ha in 2022-23), followed by cereals and general cropping (70 Kg/Ha in 2022-23), mixed (59 Kg/Ha in 2022-23), lowland grazing (44 Kg/Ha in 2022-23) and less favourable area grazing (16 Kg/Ha in 2022-23) (Welsh Government, 2024a). (SoNaRR2025 Land Use and management change). Application of manure and other fertilisers to soils is leading to particulate matter (PM 2.5) formation affecting human health and ammonia deposition affecting ecosystem resilience (See ammonia CASE STUDY) (Air Assessment). The reasons for many waterbodies not achieving good status remain linked to rural land uses (including agriculture, as well as forestry). Pollution from agriculture and land management are amongst the top pressures on the environment and natural resources in (NRW, 2024d) (Water Assessment). Agricultural land use can also lead to habitat loss, fragmentation and declines in biodiversity. This is a particular concern in semi-natural grassland ecosystems (Emmett *et al.*, 2025) (Semi Natural Grassland Assessment). Within coastal margin ecosystems, overgrazing on saltmarshes is also affecting their state (Sherry and Douglas, In Preparation) (Coastal Margins Assessment).

Pressure category	Pressures from the economy
Afforestation	Forest Research estimate the extent of woodland in Wales was 313,000ha in 2025 (Forest Research, 2025a) . ERAMMP reported that woodland cover increased by 23,600 ha between 2010 and 2021 and represented 16.9% of Wales in 2021 (Emmett *et al.*, 2025). Forest Research report that the area of woodland increased by 7,000 ha between 2010 and 2021 and represented 15% of Wales in 2021 (Forest Research, 2025a)).(Woodlands Assessment). Despite the differences, which are due to different methodological approaches, tree planting / woodland creation activities have contributed to an increase in woodland cover in Wales since 2010 in the order of 600 to 2,100 ha / year. National ambitions to increase the extent of woodland cover will depend on ensuring that policy, strategy and funding mechanisms are aligned and that there is a positive shift in attitudes towards tree planting, particularly in relation to incorporating trees into agricultural businesses. Realising the potential of woodlands to deliver multiple benefits for well-being (timber, carbon sequestration, flood mitigation) and nature is predicated on having the right trees in the right places, to realise these benefits. Historically, woodland creation has created some pressure on other ecosystems but current regulations, the UK Forestry Standard, updated approval processes linked to grant funding, and improved guidance covering all tree planting including small scale planting that is privately funded and/or outside regulation thresholds, have significantly reduced these risks. For example, new woodland creation on deep peat or on dune habitats in coastal margin ecosystems is no longer permitted (Soils and Coastal Margins Assessments). Legacy issues associated with historical practices are also slowly being rectified through restoration programmes.

Pressure category	Pressures from the economy
Reduced land use / management intensity	In many places, maintaining agricultural and forestry activity is necessary to maintain the state of ecosystems and habitats (NRW, 2021). Reduced grazing (or abandonment) on cliff tops and sand dunes is shown to affect the diversity and condition of ecosystems (Coastal Margins Assessment). Undermanagement is also highlighted as the principal cause of poor condition of grassland SSSI features between 2004 and 2017 (affecting 80% of the features). Based on survey data from England, the main cause of this could be under grazing (Hewins *et al.*, 2005) (Semi natural Grassland Assessment). Reduced land management intensity can affect condition of woodlands and capacity to supply ecosystem services. However, since 2004 we see an improving trend in the amount of woodland managed to the UK Forestry Standard, increasing to at least 48% in 2024 (Woodland Assessment).

Built development and infrastructure	House building rates in Wales remained fairly static between 2014/15 and 2019/20 (at around 6000 to 7000 new dwellings per year) and have slowed thereafter (StatsWales data) (Semi Natural Assessment). The most recent data indicates only 5,161 new homes (including flats) were built in the 2023/24 financial year (Welsh Government, 2025e). Looking forward, the Welsh Government has prioritised increasing the stock of housing in Wales by 110,000 by 2040 (Welsh Government, no date b). The increase in the extent of urban ecosystems to accommodate housing and other development has largely been at the expense of enclosed farmland (Urban assessment). In some areas, the need to increase housing stock has led to development taking place within floodplains, raising concerns due to risk of flooding and pollution, loss of habitats and connectivity between rivers and flood plains, and between rivers and ponds/lakes (Freshwater Assessment). In coastal margin ecosystems, aerial imagery identifies substantial urban areas, caravans / holiday parks and maritime industries along Wales' coastline (Coastal Margins Assessment). Based on trends in English cities, it is likely urban densification has also reduced the extent of urban green space since 2001 (Dallimer *et al.*, 2011) (Urban assessment). There were approximately 35,100 km total road length in Wales, an increase of 0.3% on the previous financial year (2020-21) (Welsh Government, 2022) (Air Assessment). Between 2021 and 2024, 805m of watercourses were reported as having been modified as part of consented road schemes across Wales, including bank protection and culverts (NRW, 2024a). Overall, 14 % of waterbodies in Wales are not achieving good status under the Water Framework Directive Regulations 2017, due to the use of land for urban and transport purposes (Freshwater Assessment). The proliferation of infrastructure for renewable energy generation is also affecting ecosystems in Wales. Offshore Wind Farms can also change physical processes (e.g., currents), create collision hazards and other forms of disturbance in marine ecosystems (Marine Energy Wales, 2023) (Marine Assessment). This also has implications for coastal margin ecosystems, such as cabling where it makes land fall (Coastal Margins Assessment). In terms of onshore infrastructure, in July 2023, there were around 44 Operational Wind Farms and 123 Operational Solar Farms in Wales. There were also 62 Developments of National Significance (DNS), of which 26 were Wind Farms, covering over 20,000 hectares and 36 were Solar Farms, covering over 2,650 hectares. In addition, there were 64 Wind & Solar Farms in planning (non-DNS) of which 8 were Wind Farms and 56 were Solar Farms and 24 Other Proposed

Pressure category	Pressures from the economy
	Wind Farm Developments (Campaign for the Protection of Rural Wales, 2023) (Land Use and management change chapter). Welsh Government have pre-assessed large areas of Wales' land (Welsh Government and NRW, 2024) and sea (Welsh Government, 2019a). Annex 6: Aim 4 Energy evidence provides an overview of land and sea use and management changes associated with low carbon energy.
Physical modifications (freshwater and coastal)	Construction activities (e.g., coastal defence, railway infrastructure, port infrastructure) mean 29% of the Welsh coast (719km) has some form of linear or shore-parallel structure (Oaten, Finch and Frost, 2024). These activities result in coastal squeeze and loss of coastal margin habitats (Coastal Margins Assessment). The proliferation of infrastructure in rivers remains a concern, with the number of reported incidents involving river modifications increasing from approximately 100 per year between 2016 to 2020 to approximately 200 per year between 2021 and 2024 (NRW, 2024c)(Freshwater Assessment).
Access, sport and recreational activities	The tourism and leisure sector is a substantial pressure on coastal ecosystems due to trampling by foot, cycling, horse riding, access by vehicles and littering (Coastal Margins Assessment). Sea angling, boating (anchoring, mooring and launching), beach littering bait digging and collection of living resources are all affecting marine ecosystems (Marine Assessment).

Table 40 Direct exploitation pressures on natural resources and ecosystems from the economy

Pressure category	Pressures from the economy
Water abstraction and demand	Over the past 25 years Dŵr Cymru report a reduction in water supplied from around 1000 megalitres per day (Ml/d) to 850 Ml/d. This is due to a combination of reduced leakage, reduced demand from heavy industry and greater customer awareness of water conservation. Despite these reductions, by 2050 three of the 23 water resource zones in Wales are anticipated to have a shortfall for public water supplies unless water efficiency measures are implemented. These zones cover 70% of the Welsh population. People using private water supplies will become increasingly vulnerable due to prolonged dry periods associated with climate change (Water Assessment). The above is linked with the pressure of non-efficient use of water (Water Assessment). The People and Nature Survey for Wales identified in 2021/22 that 42% of people said their homes have a water meter and 39% water efficient appliances. The survey also identified 36% of people said that they had taken shorter showers in the previous month (although this could be motivated by saving money as well as reducing pressures on the environment) (NRW, 2024e).
Fisheries	Historical trends for the pressure of fisheries on marine ecosystems in Wales are not available. At a UK level, in 2020, 56% of quota fish stocks were fished within acceptable mortality ranges, increasing from 11% in 1990 (JNCC, 2024). Over the shorter term, 33 out of 43 stocks in 2022 in ICES Celtic Seas Ecoregion were fished at or below Maximum Sustainable Yield compared to 30 out of 45 in 2019 (ICES, 2022) (Marine Assessment). Legal exploitation of freshwater fisheries is now at a very low level for these species, and it is thought that illegal exploitation in rivers and estuaries is also at a very low level (Freshwater Assessment). However, the decline in species such as Atlantic salmon mean any level of exploitation can have substantial impacts on remaining populations.

Climate Change

Wales is committed to achieving net zero greenhouse gas emissions by 2050 via the Environment Act (2016) Wales. Greenhouse gas emissions have dropped from 56 $MtCO_2e$ / year in 1990 to around 34 $MtCO_2e$ / year in 2023 (National Indicator 41, (Welsh Government, 2025h)These substantial reductions were driven by a fall in greenhouse gas emissions for the industrial, waste and power generation sectors, with little progress made since 1990 on reducing emissions from transport, agriculture and land use. (Climate Change Committee, 2023).

Whilst Wales has made progress in reducing greenhouse gas emissions from the economy, the UN suggests the current global pathway is one that falls well short of the emission reductions needed to limit global warming to no more than 1.5 °C (United Nations, 2025b). As such, the global economy is anticipated to continue to drive global climate change and increase related pressures on natural resources in Wales. The effects of climate change on natural resources in Wales is assessed further in Aim 1.

INNS, Pests and Diseases

Domestic and international trade of goods is a key mechanism through which INNS, pests and diseases may enter Wales and place pressures on natural resources (e.g., via hull fouling and ballast water (DEFRA, Scottish Government and Welsh Government, 2023). In 2023, total 426 million tonnes of freight was transported in or out of the UK through shipping, down from around 500 million tonnes since 2010 (Department for Transport, 2024).

Imported commodities, particularly plants, plant products, animals and soils, may also bring pests and disease into Wales and threaten crops, trees, gardens and biodiversity (DEFRA, 2022). The value of imports of foods and live animals into the UK was around £37.5 billion from the EU plus £14.7 billion from outside the EU in 2022 (Office for National Statistics, 2024c) . It is unclear how much of this makes its way to, or through, Wales.

As part of a global economy, Wales remains at risk from new INNS, pests and diseases being imported into the country. Climate change and other factors will also encourage their spread in Wales. The effects of INNS, pests and diseases on natural resources in Wales is assessed further in Aim 1.

Achieving sustainable consumption and production

Achieving sustainable levels of production and consumption is the United Nations Sustainable Development Goal (SDG) 12 (United Nations, 2025a). This goal recognises the world is running out of resources and sustainable consumption and production patterns are essential for sustaining the livelihoods of current and future generations. In simple terms, the goal of SDG 12 is to address the underlying economic causes of Dasgupta’s (2021) impact inequality.

To achieve this, both SDG 12 and Dasgupta (2021) call for systemic change in our economic systems, characterised by improved resource efficiency, avoided waste, shifting energy supplies, considering the entire life cycle of economic activities, sustainable procurement and businesses reporting on their sustainability. SoNaRR 2020 focused on the food, energy and transport systems as critical entry points for transitioning to a regenerative economy (see: Natural Resources Wales / SoNaRR2020: Transforming Wales). These three systems remain unsustainable and hence priorities for achieving Aim 4 of SMNR in Wales. To complement this, this section provides a more cross-cutting assessment of systemic changes needed to achieve sustainable levels of production and consumption in Wales.

Sustainable consumption

As Dasgupta (2021) discusses, it is ultimately us as citizens who can bring about and shape the systemic changes we need to see. Citizens need to be empowered so they can adopt more sustainable lifestyles – this can involve consuming less, choosing products with lower environmental impacts, and reducing the carbon footprint of day-to-day activities (United Nations, 2025a). We can demand that firms disclose the environmental conditions along their supply chains. Product labelling can also help consumers make more sustainable consumption choices, potentially supporting price premiums for funding more sustainable production.

Over £10 billion is spent on public procurement in Wales each year, making this an important lever for achieving more sustainable consumption (Welsh Government, 2025f). The Social Partnership and Public Procurement (Wales) Act 2023 aims to ensure that public bodies spend this money in a way which focuses more on the well-being goals, supports the Welsh economy and helps protect the environment (Welsh Government, 2025g).

There are two accredited forest certification schemes operating in the UK: the Forest Stewardship Council® (FSC®) and the Programme for the Endorsement of Forest Certification (PEFC). Certification to one or both of these schemes assures the buyers and users of wood, and wood products, that they come from woodlands managed in accordance with the UK Forestry Standard (UKFS) (e.g., Natural Resources Wales / Our forest and woodland certification). It is essential that any product labelling follows this type of high-integrity approach and does not mislead the public (United Nations, no date).

In 2022, Nature and Us was set up to create a shared vision for the future of the natural environment in Wales for 2050 (The Nature and Us Vision for Wales 2050: Society and nature thriving together). As part of this national conversation, involving over 3,000 people, the following options were identified to empower citizens to make more sustainable consumption choices:

- Sharing knowledge to help people understand how nature impacts their lives, and the actions they can take to help protect and restore the natural environment.
- Greener transport and energy options enable more people to make environmentally friendly choices in their day-to-day lives.

- Sustainable land management to help communities buy local food and feel connected to the Welsh land.

At the individual level People and Nature Survey for Wales (PaNS Wales) also identifies that some people do have an appetite to make more sustainable consumption choices. For instance, 44% of people said they had bought local / seasonal produce and 26% bought products with environmental labels in the previous month (NRW, 2024e). It is highlighted that these are limited examples of sustainable consumption choices but should be nurtured and enabled where possible to scale uptake.

Circular economy

Our ecological footprint is not only made up of the material we take from nature, but also the wastes we return to nature (Dasgupta, 2021). Improving the efficiency of extraction from nature and production of less waste can help address the impact inequality and move to more sustainable consumption patterns. The need for government investment in waste management and renewable energy was called for in The Nature and Us Vision for Wales 2050: Society and nature thriving together conversation.

Transitioning to a circular economy is one of the key strategies to achieve sustainable consumption patterns and SDG 12 (United Nations, 2025a). A circular economy keeps resources and materials in use for as long as possible and avoids waste. Moving to a circular economy can significantly reduce our carbon emissions and our over-exploitation of natural resources, and help to reverse the decline in biodiversity (Welsh Government, 2021, p. 6). SoNaRR 2025 Annex to Aim provides a summary of progress with respect to more sustainable waste and energy production systems in Wales, key insights are summarised below.

Waste

An estimated 7.5 million tonnes of waste was generated in Wales in 2019 (excluding waste from mining and quarrying, agriculture, forestry and fishing). Almost half of this waste originated from the construction and demolition sector (46%). In comparison to 2012, there have been statistically significant reductions in waste from industry (2.00 million tonnes in 2012 to 1.44 in 2019); commercial (1.67 million tonnes in 2012 to 1.45 in 2019) and households (1.36 million tonnes in 2012 to 1.22 in 2019) in Wales (see Annex 5: Aim 4 Waste evidence).

Wales has made major improvements in managing waste over the last two decades by increasing the amount sent for recycling, and reducing the amount sent for disposal. These improvements have been so significant that Wales is now considered to be amongst the highest performing countries in the world for recycling municipal waste (Eunomia, 2024). This has contributed to a considerable decrease in the amount of waste generated, that is not recycled, per person from to 794 kg in 2012 to 523 kg in 2019 (National Well-Being Indicator 15 - (Welsh Government, 2025h).

The People and Nature Survey for Wales reports that the majority of people now regularly take actions to reuse, recycle or reduce wastes. In a recent survey (2021/22 data), 87% of people indicated they had recycled items and 83% used their own shopping bags. (NRW, 2024e). The findings also reported that 73% of people surveyed said they have composted or recycled food wastes within a month of being surveyed (NRW, 2024e).

Permitted Welsh landfills reported receiving around 1 million tonnes of waste in 2023, down from around 2 million in 2016 and the second lowest recorded this century (Annex 5: Aim 4 Waste evidence). As highlighted in Table 38, there are around 1,500 historic landfills identified in Wales which may impact on local ecosystems and may continue to have an impact for decades to come (NRW, 2024b). It is estimated 265 of these have the potential to release waste into the marine environment based on current flooding and coastal erosion (Robbins *et al.*, 2023). (Annex 5: Aim 4 Waste evidence)

The quantity of waste sent for incineration at permitted facilities in Wales has more than doubled from 0.5 million tonnes in 2015 to over a million in 2023, predominantly owing to more municipal energy recovery facilities becoming operational and diverting waste away from landfill. The quantity of waste incinerated at permitted facilities located in Wales has plateaued since 2020 (Annex 5: Aim 4 Waste evidence).

Focus to date has been aimed mainly at fast moving goods and household waste. However, recent Welsh legislation to mandate separate recycling collections from non-domestic properties and ban separately collected waste being sent for disposal is expected to further improve overall recycling rates in the next few years (CIWM, 2024).

There are examples of other positive steps being taken in recent years to prevent waste and develop re-use and repair infrastructure in Wales. For example, through zero waste shops, re-use hubs, resource libraries and repair cafes. 37% of people recently surveyed said they had bought second hand items within a month of being surveyed according to The People and Nature Survey for Wales (NRW, 2024e).

Whilst these positive changes are commendable, more needs to be done to accelerate the mainstream transition from our ingrained, unsustainable throw-away culture to one that is truly circular and sustainable. Improved policy drivers could further support these efforts to incentivise circular activities and put in place effective deterrents against over-consumption. Changes in product design would support this, such as through creating modular systems, having replaceable components, and making products that can be upgraded.

Consideration is also needed to the feasibility of diverting some waste flows elsewhere, especially for materials that cannot be easily managed higher up the waste hierarchy. For example, on new and emerging waste streams which may not have any economically or environmentally viable alternative other than disposal at present such as those that contain Persistent Organic Pollutants (POPs).

Diversion of waste by criminals away from legitimate routes compromises efforts towards creating a circular economy (Annex 5: Aim 4 Waste evidence) . This undermines progress in reducing our carbon emissions as well as an estimated 20,000 new jobs which a circular economy could create in Wales (based on downscaling 450,000 jobs that could be created in the UK, as estimated by Jobs for a green recovery (Green Alliance, 2021)) . Appropriate resources and tools must be in place to identify, stop and take enforcement against waste criminals.

Energy

Wales has substantial resources and potential for production of clean, renewable energy over the years to come. Generation of electricity from renewable sources, mainly wind and solar, has been steadily increasing over the past 15 years (Welsh Government, 2025b). The capacity of renewable energy was 3,663 MW in 2023, more than twice the installed capacity in 2012. The renewable heat capacity was 869 MW in 2023 (National Well-being Indicator 12 - (Welsh Government, 2025h).
The capacity of renewable energy projects in Wales (3663 MW in 2023) is similar to the capacity of fossil fuel projects (4,325 MW). However, actual electricity generation from renewable projects in Wales (7,798 GWh) was around a half of that generated from fossil fuel projects (15,413 GWh) in 2023. Electricity generation from fossil fuel projects is dominated by gas (14,487 GWh in 2023). No electricity is currently generated in Wales from coal or nuclear projects (Welsh Government, 2025b) It is also notable that Wales generates more electricity than it uses; its total electricity generation is actually 157% of its consumption (Welsh Government, 2025b)

The Microgeneration Certification Scheme (MCS) database shows significant growth in registrations of new domestic and small-scale solar and heat pump capacity during 2023 (The MCS Foundation, 2024). The total number of MCS registrations in Wales by 2024 was around 114,000 installations (15,000 air-source heat pumps, 92,000 solar PV installations, 3,000 solar thermal and 2000 biomass/micro-CHP) (Annex 6: Aim 4 Energy evidence). The People and Nature Survey for Wales identified 20% of people stated that their homes have some sort of renewable energy source (NRW, 2024e)..

Stopping electricity generation from coal and the increase in renewable energy generation has helped contribute reducing GHG emissions from Wales' energy sector. SoNaRR (2020) reported estimated reduction in Welsh GHG emissions of 37% between the 1990 baseline (17.8 Mt CO_2e) and 2018 (10.9 Mt CO_2e). Further gains have been achieved since then, with annual emissions estimated at 10.3 Mt CO_2e in 2022. This has contributed to the overall decline in emissions of greenhouse gasses in Wales from 56.2 Mt CO_2e in 1990 to 36.0 Mt CO_2e in 2022 (National well-being indicator 41 - (Welsh Government, 2025h).

Consistent with the UK trend, total energy consumption in Wales reduced by 22% between 2005 and 2021, with most sectors showing a reduction in use (Regen, 2024). Production of renewable heat was approximately 2.6 TWh in 2023 (Welsh Government, 2025b), which is equivalent to only about 11% of estimated Welsh domestic heat demand (Elias, Furet and Regan, 2025) and a reduction from 13% in 2019: (Welsh Government, 2020a). The bulk of heat demand in Wales is still met through fossil fuels, largely imported natural gas, and it seems that despite the uptick in domestic renewable heat installations, demand for heat is increasing more quickly than renewable heat capacity.
At the individual level, the People and Nature Survey for Wales identified 79% had made efforts to switch off lights and appliances . The survey also identified 46% of people say their homes have a smart meter device (NRW, 2024e). A large majority of people (80% or more) agreed that they try to reduce both their energy use and their water waste. These actions lower household costs, so reducing expenditure might be a strong motivation for the adoption of these actions, rather than concern for the environment.

Wales' low carbon and renewable energy sector (LCREE) is critical for achieving net zero and is estimated to have contributed £3.3 billion to GDP and supported 15,600 full time jobs in Wales in 2023 (Office for National Statistics, 2025a) (Annex 6: Aim 4 Energy evidence). In 2023 hydroelectric power generation was 332 GWh across 380 projects, including pumped storage facilities to store energy (Freshwater Assessment). Electricity generated from offshore renewables is playing an increasingly important role in this sub-sector of the economy. In 2023, there was £103.4m invested in marine renewable energy in Wales and the industry now sustains 440 FTE jobs (Marine Assessment). Project Demonstration Areas have recently been announced which could realise a further 4.5GW capacity in the Celtic Sea, with the first GW expected to create 3,000 FTE jobs and £682 million in supply chain opportunities in Wales and SW England (Marine Assessment).

Development of renewable energy resources, and the transmission or transportation of energy to markets throughout the UK and further afield, will require investment in infrastructure, with resulting impacts on land use and other natural resources. It is vital that future energy developments avoid the mistakes of past Welsh energy industries, by planning for and protecting the health of our ecosystems. These impacts vary. Offshore renewable energy generation creates multiple pressures on marine wildlife and ecosystem services (Marine Assessment). To support the environmentally sustainable development of offshore renewable energy, NRW has produced guidance on: Natural Resources Wales / Marine renewable energy developments; and, Natural Resources Wales / Offshore wind developments.

The Future generations Report 2025 also draws attention to the benefits of directly involving local communities in the development of renewable energy projects. Local natural resources can be of great value for community wealth building, where profits from renewables are reinvested into the local community. The development of the renewables sector can be an enabler for this type of community renewable projects, both in allocating resources for it and then in committing to buy back the energy.

Welsh electricity consumption is projected to nearly triple by 2050 as we transition away from fossil fuels (Welsh Government, 2025b) Whilst renewable energy is a key strategy for to achieving our net zero targets, it remains the case that the greenest energy will always be the energy we don't use. Welsh housing stock is relatively old, with approximately 33% of dwellings being pre-1930 in age, compared with an equivalent figure of 22% in England, for example (Office for National Statistics, 2023a). According to National Well-being Indicator 33, less than half (47%) of homes in Wales have adequate and cost-effective energy performance in 2017-18 (Welsh Government, 2025h). This is a concern for achieving energy efficiency objectives, as older properties are generally more difficult to insulate or modify to improve energy efficiency (Annex 6: Aim 4 Energy evidence).

Sustainable production

Sustainable production requires the sustainable management and efficient use of natural resources. Given we have drawn down on our stocks of nature so much, our production activities also need to contribute to enhancing natural resources and securing the multiple benefits they deliver.

Sustainable forest management is an example of working with productive ecosystems to deliver better outcomes for nature as part of our economic activity. It aims to use forests in a way that maintains their biodiversity, productivity, regeneration capacity and vitality, and their potential to fulfil relevant ecological, economic and social functions (Forestry Commission, 2023). The UK Forestry Standard (UKFS) provides a basis for achieving this alongside wider forestry objectives via sustainable forest management. At least 48% of all forests in Wales are managed to this standard and are certified through the UK Woodland Assurance Standard (UKWAS) in 2024. This means that out of the 313,000 ha of woodland in Wales, 149,000 ha are managed in accordance with the UKFS (Forest Research, 2025b).

Long-lived wood products from sustainably managed forestry ecosystems also have the potential to store and lock up carbon in the economy and reduce waste, compared to other short-lived products. Scaling up production of these types of products as substitutes for other materials or shorter-lived products will contribute to a more circular economy. The ONS (2023) estimate that harvested wood products in Wales captured 183,500 tCO2e in 2021 (Office for National Statistics, 2023b). A key potential area for increased use of long-lived wood products is the construction sector. Evidence suggests that substituting to home grown timber can help reduce construction times for housing (Welsh Government and Shirra, 2025), as well as reliance on other materials and imports with higher environmental footprints.

Agricultural production systems create pressures on ecosystems, principally through disturbance and pollution (see Table 3). The British Ecological Society recently completed a review on the evidence on agricultural production systems that are regenerative and deliver better outcomes for nature (British Ecological Society, 2025). Well managed and targeted livestock agriculture in coastal margin ecosystems is also shown to deliver benefits for biodiversity (Coastal Margins Assessment). Low intensity farming has been proposed as an option for farming (Norton *et al.*, 2022; Plantlife, 2023), enabling the production of food within a more environmentally and economically sustainable agricultural system. This in turn can deliver wider benefits, including increases in global climate regulation services via increased carbon storage and sequestration (Coastal Margins Assessment). However, we have no established measure system for knowing the extent of agricultural land that is managed in a way that safeguards and enhances biodiversity and natural ecological processes. The Sustainable Land Management framework established under the Agricultural (Wales) Act 2023 will develop indicators to address this.

The Nature and Us Vision for Wales 2050: Society and nature thriving together identified that people want to help communities buy local food and feel connected to the Welsh land. Enabling community growing and horticulture is one way the Wales Community Food Strategy is doing this (Food & Drink Wales, 2025). This can contribute to more sustainable food systems and better outcomes for nature. ‘Own production’ of fruit, vegetables and other crops in urban ecosystems (e.g., allotments) can reduce per capita environmental impact of cities and contribute to local food security (Edmondson *et al.*, 2020). It can also reduce reliance on imported fruit and vegetables, with relatively high carbon footprints. There are likely to be multiple co-benefits that can be realised from urban agriculture for wider ecosystem services and biodiversity (Urban Assessment). As well as increasing the resilience and reducing the carbon footprint of the food system in Wales, promoting local food production and small-scale horticulture can also support biodiversity by encouraging the cultivation of a variety of crops, enhance soil health and provide habitats for pollinators and other wildlife (Food & Drink Wales, 2025).. Analysis of the People and Nature Survey for Wales (data collection 2021/22), estimates around 5 million visits were made by people in Wales to allotments and community gardens (Owen, Rhydderch and Williams, 2025). Revealing an appetite to participate in 'Own Production.' At the same time, allotment sites have declined substantially from their maximum extent in the 20th Century (Urban Assessment).

The Welsh National Marine Plan identifies fisheries and aquaculture (e.g., Oysters, mussels, seaweed) as sectors to develop in Wales (Welsh Government, 2019a). However, it is important that associated pressures are well managed. To support this we have developed the Assessing Welsh Aquaculture Activities tool (Marine Assessment).

Analysis of the Great Britain Visitor Survey indicates 20.8 million visits to the outdoors in Wales in 2021 as tourists to participate in outdoor activities (Miller *et al.*, 2023, tbl. 9) The Welsh National Marine Plan highlights the role that the tourism and recreation sector can play in contributing to sustainable development by protecting and promoting access to the coast and improving the quality of the visitor experience (Welsh Government, 2019a). There is clearly a big potential for this sector to contribute to a regenerative economy and generate revenue to invest in nature restoration. In their report, the High-Level Panel for a sustainable ocean economy highlights the important role sustainable tourism can play in generating revenue to reinvest in and regenerate ecosystems, local markets and communities and build resilience to future threats and future shocks and crises (Northrop *et al.*, 2020). At the same time, it is important to recognise the pressures tourism and recreation can put on ecosystems and that these to be effectively managed.

With respect to addressing contaminated land in Wales, there remains a substantial number of high priority sites requiring detailed inspection and potential remediation. With the right support, it is estimated the construction sector can address 93% of contaminated sites in Wales (NRW, 2016) (Soils Assessment).

Scaling up Nature-based Solutions

One way to increase the stocks of nature is by diverting funding from grey infrastructure solutions to scale up investment in Nature-based solutions[3] that produce the services we need (e.g., flood defence). In this context, the World Economic Forum has called for a transition to nature positive cities by 2030, highlighting that investments in Green Infrastructure (or NbS) can be more cost-effective than "grey" alternatives, delivering more value and can create jobs (World Economic Forum, 2022) (Urban Assessment). Combing green and grey infrastructure solutions can also be effective. For instance, in sustainable drainage systems. As highlighted in Aim 3, urban Green Infrastructure can help mitigate flood and heat stress, adapting cities and towns to projected climate change effects.

[3] Defined by Resolution 5 of the UN Environment Assembly in 2022 as "Actions to protect, conserve, restore, sustainably use and manage ecosystems to deliver benefits that address social, economic and environmental challenges" (UN Environment Assembly 5 (UNEA 5.2) Resolutions | UNEP - UN Environment Programme)

Targeted tree planting can significantly increase the rates at which water permeates into ground and help reduce peak flood flows (Woodland Trust, 2012). In Wales, maps are available that identify potential areas for woodland planting that support water flow regulation: Natural Resources Wales / Maps for Natural Flood Management (Woodland Assessment). In coastal areas, physical modifications to establish flood defences are identified as a pressure on coastal margin ecosystems. At the same time, coastal margin ecosystems can supply important coastal protection services (e.g., sand dunes, shingle and saltmarsh) (Coastal Margins Assessment). The broad potential for 'working with natural processes' to deliver natural flood management is recognised in Wales (FRS21232 Main report provides an evidence directory for this). As part of an integrated landscape management approach, investing in improving grassland condition and extent can also be effective in improving water quality and mitigating flood risk with appropriate design (Semi Natural Grassland Assessment). The UK government has recognised the potential of farmland to play a role in storing flood water in some places (DEFRA *et al.*, 2025). Various features, such as ponds, leaky dams, swales, and buffer strips, are identified as potential ways to work with natural processes to reduce flooding in farmland landscapes .

Investing in nature can safeguard and enhance clean water resources, reducing costs associated with water treatment (Water Assessment). Water from functioning peatlands is naturally of high quality, increasing the value of the water for economic uses such as drinking or agricultural water supply (Office for National Statistics, 2019) (Soils Assessment). There is evidence that investment in river restoration and constructed wetlands in the right places can improve water quality (decreasing investments in treatment works) and mitigate flood risk (reducing the need for built infrastructure solutions) (Freshwater Assessment). Woodlands can also deliver effective solutions to tackling diffuse pollution (nitrogen, phosphorus and sediment) (Beauchamp *et al.*, 2020). Green (or nature based) solutions can deliver cost savings whilst also serving to build back the stocks of nature in catchments (Dŵr Cymru Welsh Water, 2023b) (Water Assessment). Saltmarsh areas can also deliver effective solutions to tackling nutrient pollution, faecal and heavy metal pollution (Hudson, Kenworthy and Best, 2021) (Coastal Margins Assessment).

It estimated the funding gap between current committed (or planned) level of investment in nature and what needs to be invested is £5 billion in Wales (covering the decade from 2022 to 2032) (Green Finance Institute, 2021). Given the multiple benefits NbS provide, there are opportunities to bring in funding from multiple public, private and civil society stakeholders with different objectives to address this gap.

Securing funding for scaling up NbS is highly dependent on them being high integrity and delivering against expected outcomes. Brotherton et al (2021) highlighted the potential of standards to encourage confidence in making these types of investment. As an example, in Wales the Peatland Sustainable Management Scheme Project (2017-2020) used the Peatland Carbon Code to validate the carbon benefit of five sites (Brotherton *et al.*, 2021). The Projects Map | IUCN UK Peatland Programme identifies 8 peatland projects in Wales currently implementing this code to secure finance for NbS.

Integrating nature into economic planning

As Dasgupta (2021) and the WEF (World Economic Forum, 2024) highlights, risks associated with the loss and degradation of nature have significant macroeconomic and financial implications. A recent report for the UK highlighted the substantial scales of nature-related financial risks the UK faces (Avery, 2024). These include chronic risks arising from the degradation of natural resources over many years. For instance, water shortages, pollution, soil health decline, and biodiversity loss. The report also draws attention to acute risks, such as acute climate or health shocks. These acute risks include anti-microbial resistance-driven pandemic linked to environmental pollution from antimicrobial medicines (Avery, 2024).

There is evidence that investors want to be able to consider these risks in their investment decisions. Businesses and financial institutions are being encouraged to report nature-related risks (dependencies and impacts), alongside other corporate information. The Task Force on Nature-related Financial Disclosures (TNFD) has been set up to report this. As of the end of May 2025, there were 72 organisations in the UK that have adopted the TNFD (Taskforce on Nature-related Financial Disclosures, 2025b) and 371 that have joined the TNFD forum (Taskforce on Nature-related Financial Disclosures, 2025b) (figures are not available at the Wales level). SoNaRR provides a framework to understand dependencies and impacts on nature that is broadly consistent with the TNFD reporting approach (Taskforce on Nature-related Financial Disclosures, 2025a). In Wales, Business Wales has supported 4,738 businesses to adopt or improve environmental sustainability strategies via signing up to the Green Growth Pledge | Business Wales (Tudor, 2025).

Aim 4 and the well-being economy

The Office of the Future Generations Officer is championing the well-being economy as one of five interconnected missions to deliver on the goals of the Well-being of Future Generations Act (Future Generations Commissioner for Wales, 2025). The idea of a well-being economy is it is structured so that it works within safe ecological boundaries, whilst also working to ensure everyone’s basic needs are met. The fundamental idea is that the economy becomes an engine to deliver environmental, social and cultural objectives.

We know that Wales is living beyond its means in terms of consuming its fair share of natural resources. Wales’ global footprint remains over twice the size of our estimated biocapacity (National Well-being Indicator 14). The transition to a regenerative economy that works within safe ecological boundaries, uses its fair share of resources and addresses the pressures in Table 38, Table 39 and Table 40 needs to occur fast enough to address the climate and nature crises, but also in a way that does not leave the public behind. At the same time as we are dealing with the nature and climate crisis, evidence indicates that inequalities have increased in many of the regions of the world (including western Europe) (Pretty *et al.*, 2025). In Wales, between the period 2020 to 2022, approximately 21% of all people in Wales were living in relative income poverty. This has remained a relatively stable trend in Wales since the start of the 21st Century (Welsh Government, 2023b).

Accounting for the above, the transition to a regenerative economy has to be just and fair. The Welsh Governments economic mission priorities for a prosperous, equal, and greener economy (Welsh Government, 2023a). highlight the opportunities of the everyday (or foundational) and low carbon, circular economy support business growth and towards a just transition. As shown in Table 3, there are around 49,500 people with agriculture livelihoods in 2024, the water sector supports 3,000 jobs and nature based tourism has been estimated to support 29,500 Wales' low carbon and renewable energy sector has been estimated to have supported 15,600 full time jobs in Wales in 2023. The broader transition to a circular economy in Wales could create an estimated 20,000 new jobs in activities such as increased repairing, remanufacturing, rental and leasing. Collectively, these jobs provide opportunities for fair work, which can address some of the inequalities in Wales. They also represent around 10% of the 1.4 million employment opportunities supported by the Welsh economy (see Box 1).

However, the ambition of a well-being economy is to go beyond standard measures of economic prosperity, job creation and the foundational economy approach. It requires a fundamental restructuring of the way economic activities are planned, so financial flows are directed to nature restoration and profits from economic activities are retained within communities. There are multiple ways Sustainable Management of Natural Resources (SMNR) can be an engine for achieving this ambition, delivering better outcomes for nature whilst building community wealth. Encouraging social enterprises and cooperatives can promote a more sustainable food system that connects people to land in Wales. Nature-based tourism, Nature-based Solutions and local renewable energy projects also offer opportunities to grow social enterprise and the cooperative economy locally, as called for by the Future Generations Commissioner . These types of social businesses will better retain wealth and are more likely to involve local people in decision-making, operate in Welsh and prioritise social and environmental outcomes over profit (Future Generations Commissioner for Wales, 2025).

Wales is investing in the people who will deliver and steward these places. Y Gwasanaeth Natur / The Nature Service , a new national initiative, will knit together nature-based learning, volunteering, training and employment so that more citizens gain the skills and eco-literacy needed for a nature-positive economy . s. It represents an emerging example of this approach in action. It is developing national enabling infrastructure to improve visibility, access, and coordination across the growing network of organisations delivering nature-based learning, volunteering, training, and employment. By raising awareness, connecting people with local opportunities, and commissioning research to identify and address structural barriers. The service is actively working to strengthen the social foundations required for ecosystem resilience and nature recovery.

As highlighted by the Future Generations Commissioner, economic policies, incentives and investments all need to be explicitly designed to address the climate and nature emergency, alongside inequality and retaining wealth within communities. Therefore, the economic mission for Wales all four regional economic strategies of Corporate Joint Committees should fully embed achieving SMNR and the Well-being of Future Generations Act as the framework for designing economic development strategies and in implementing and measuring progress (Future Generations Commissioner for Wales, 2025, p. 98) .

Opportunities for Action

Achieving Aim 4 and sustainable consumption and production requires addressing both the direct and indirect drivers of pressures on natural resources that are associated with the way our economic systems work. It also requires scaling up economic investment in nature restoration and conservation to secure and boost nature's contributions to people and the economy in Wales. Table 41 identifies opportunities for action to achieve a Regenerative Economy in Wales based on the assessment presented here in. These should be viewed as contributions to a set of opportunities for action that can inform future discussions on the best way forward in Wales. They are not set out in any order of prioritisation.

Table 41: Actions for achieving Aim 4 of SMNR and opportunities to deliver them

Opportunity Category	Action
Integrated plans, strategy and delivery	• The Future Generations Report (2025) calls for the economic mission for Wales and all four regional economic strategies of Corporate Joint Committees to fully embed achieving Well-being of Future Generations Act as the framework for designing economic development strategies and in implementing and measuring progress. Achieving SMNR should be included as essential to this. • Social enterprises need to be supported to realise business opportunities linked to SMNR to deliver better outcomes for nature locally and build community wealth. • A resource mobilisation strategy needs to be built for transitioning to a regenerative economy. This should identify the best way to bridge the financing gap for nature via a combination of structural changes to the economy, scaling private finance and deployment of public funding for environmental management (Gonon, Svartzman and Althouse, 2024, fig. 5)
Sustainable manufacturing	• Implementing circular principles in product design stages and extended producer responsibility models • Remove persistent organic compounds from manufacturing processes to protect the environment (soils and waters) and human health and enable more recovery of waste.

Opportunity Category	Action
Sustainable transport	• Greener transport options enable more people to make environmentally friendly choices in their day-to-day lives • Address the impact of road infrastructure on freshwater ecosystems
Pollution Management	• Address historic contamination from industry and waste sectors (including persistent organic pollutants and legacy landfills) by targeted remediation and via the planning system and construction sector • Investment in adequate monitoring to monitor waste flows and handling. Investment in regulators to identify, stop and take enforcement against waste criminals. • Reduce nutrient emissions to air and water associated with agricultural sector and manure and fertiliser applications. • Reduce nutrient emissions to water associated with wastewaters
Renewable energy / Sustainable construction	• Greener energy options enable more people to make environmentally friendly choices in their day-to-day lives • Support community owned renewable energy projects • Plan for and protecting the health of our ecosystems when scaling up renewable energy infrastructure to secure job opportunities in an environmentally sustainable sector.

Opportunity Category	Action
Nature-based Solutions / Sustainable construction	• Encourage the construction sector more to use a better mix of built infrastructure and high-integrity Nature-based Solutions for climate change adaption. This could focus on increasing the supply of water flow regulation, coastal protection services and local climate regulation ecosystem services. This will also mitigate pressures from engineered coastal defences on coastal margin ecosystems. • Encourage a transition within the water sector towards financing a better mix of built infrastructure and high-integrity Nature-based Solutions for water supply and water purification at landscapes scale and via green infrastructure in urban areas. • Support community projects and social enterprises to develop Nature-based solutions • Design, deployment and financing of NbS. For instance, in collaboration with the Development Bank for Wales

Opportunity Category	Action
Nature Finance	• Increase consumer awareness of variance in environmental footprint of different products. In so doing, promoting sustainable consumer choices, driving environmental investment in supply chains. • Work with key consumer supply chain operators in Wales to continue to enhance and promote environmental transparency and standards – building on Brand Wales. • Stimulate the development and use of high-integrity nature markets in Wales, using both voluntary and compliance (legislative) drivers. Such markets should adhere to the WG Sustainable Investment Principles, BSI Nature Standards etc. • Work to align public sector investment in nature and climate with private sector and philanthropic investment, recognising unique characteristics of each and maximising opportunities for blending / leverage / investment readiness. The Sustainable Farming Scheme provides a considerable opportunity here. • Ensure that opportunities for Payment for Ecosystems (PES) are identified and aggregated in Wales, if necessary, through public sector mechanisms. Organising these opportunities into a pipeline of larger investable opportunities will enable larger investments from institutional investors and minimise transaction costs. • Work to develop stacking approaches that enable the cross-silo cost-benefit credentials of multi-outcome environmental interventions to recognise & stimulate greater investment in nature-based solutions. • Develop a regenerative tourism sector that secures local jobs and generates revenue to reinvest in local ecosystems, local markets and communities. Support community projects and social enterprises to develop opportunities to deliver this.

Opportunity Category	Action
Sustainable Agriculture, forestry and fisheries	• Transition to agricultural production systems that are regenerative and support nature, maintain the right grazing intensities and support local jobs over the long-term. • Scale up that area of forestry operations that are managed in accordance with the UK Forestry Standard. • Add as much value as possible locally to timber products to create value, local jobs and lock up carbon in the economy. • Scale up sustainable aquaculture production and value chains to create local jobs • Support community-led initiatives and 'Own production' of fruit, vegetables and other crops to make a more sustainable and resilient food system in Wales and help people buy local food and feel connected to the Welsh land
Increase resource use efficiency	• Improve uptake of water meters in homes and encourage shorter showers. • Improve energy efficiency, especially in housing stocks • Investment in technology and high quality recycling
Waste prevention (reduce & re-use)	• Design products for longevity and repair. Grow re-use, repair and rental models. Encourage more people to buy second hand items. • Create the right conditions for helping Welsh citizens only buy what they need and fully utilise what they have bought

Opportunity Category	Action
Awareness raising	• Continue to support businesses to be more sustainable (e.g., via the Green Growth Pledge | Business Wales). • Support and encourage businesses to report on their nature related risks, dependencies and impacts via mechanisms such as the TNFD . • Raise awareness of how people can prevent waste and recycle • Empower people to make more sustainable consumption decisions and take actions to help protect and restore the natural environment • Support businesses to adopt or improve environmental sustainability strategies and business models

Evidence Needs

Table 42 identifies key evidence needs for informing the transition to a Regenerative Economy in Wales. These have been identified on the basis of carrying out the assessment presented here in. They are intended as a starting point for discussions on where to best direct our SMNR research efforts in Wales. Wales. They are not set out in prioritised order.

Table 42: Evidence needs for Aim 4

Area	Evidence needs
Assessing transformational change	To realise Aim 4 of SMNR better approaches are needed to help reveal the broad range of benefits, and costs, associated with transformative change. This will allow the full range of benefits realised from achieving the well-being and regenerative economy Wales can be properly considered in economic planning. This was recently recognised in the Green Book Review 2025: Findings and actions - GOV.UK better approaches are needed to support the assessment of the benefits and investment cases surrounding transformation change.
Measures of natural resources contributions to well-being	Businesses need better evidence on the nature impacts and dependencies and how these can be integrated into business models.

Area	Evidence needs
Measures of natural resources contributions to well-being	Better information on the value of nature and its contribution to well-being is needed to guide better decision-making for people and nature. Generally planning of natural resources has concentrated on maximising flows of provisioning services at the expense of regulating and cultural ecosystem services (IPBES, 2019). This information needs to include better knowledge on the relational and cultural values important to human well-being that have low financial value (e.g., togetherness, personal growth, health, and well-being, being in nature, contentment, and happiness) so they can be better considered in economic planning (e.g. as Petty et al.(2025)propose with respect to the concept of "Regenerative Good Growth" .
Sustainable agricultural production systems	Area of agricultural land that is managed in a way that is regenerative (e.g., in a way that safeguards and enhances biodiversity and natural ecological processes, alongside social and economic functions). The Sustainable Land Management framework established under the Agricultural (Wales) Act 2023 will develop indicators to address this.
Increasing confidence in NbS for flood risk management	Further research is needed to quantify the flood risk impacts of multiple on-farm features and other NbS at catchment / landscape scales (DEFRA *et al.*, 2025).
Increasing confidence in NbS for addressing water quality issues in catchment	Risk-based frameworks to support the experimentation and deployment of NbS. For instance, in the context of achieving catchment nutrient neutrality targets with confidence.
Understanding the size of the NbS market to invest in high integrity NbS in Wales	Wales' approach to funding nature recovery is based on creating high quality and integrity opportunities for investment. This means Wales can potentially offer a different type of product to consumers / investors. However, this may come with an additional cost the market would not support. Further research is needed to understand this.

Area	Evidence needs
Land Use Planning	Land use planning in Wales would benefit from an integrated map of different land use activities and environmental data. This would help planners understand which land is most appropriate for which purposes, avoid building on best food growing land or land at risk to flooding, where food growing initiatives could be best placed and where nature-based solutions could be scaled up. Online digital twin software architecture could help here.
Land Use Planning	Understanding where the economic sectors in Wales have key dependencies on resilient ecosystems can help identify where to prioritise action to enhance resilience in the context of climate change and other pressures.

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Include Deep dive – Waste and Energy as annex

Opportunities for action – delivering for Wales

Lead Author: Michael Gerardo

From degradation to regeneration

Wales stands at a critical moment as our economy continues to degrade the natural resources that underpin our health, security, and prosperity. Climate change is already impacting on all ecosystems within Wales, reducing ecosystem resilience and intensifying risks from other pressures. Pollution from wastewater, towns and cities, transport, agriculture and abandoned mines is compromising all water resources. These pressures cascade from rivers, lakes and groundwaters into estuarine and marine environments, threatening biodiversity and coastal resilience.

Air pollution has improved, yet nitrogen emissions, such as ammonia, from agriculture remain high, impacting sensitive habitats and public health. Legacy contamination from industry and landfilling adds further complexity, with emerging pollutants such as microplastics and persistent chemicals posing long-term risks to soil and water security.

Land use decisions are intensifying these pressures. The construction sector must expand to meet the needs of our growing population; however, development often displaces farmland, coastal margins, and urban green spaces, frequently in areas vulnerable to flooding.

Meanwhile, Wales' consumption levels far exceed sustainable limits. If replicated globally, our resource use would require more than two Earths, demonstrating the amount of natural resources we import, all accompanied by impacts on other countries, hampering the national Globally responsible Wales Wellbeing Goal.

Agricultural land dominates the landscape, yet the extent to which it is managed to sustain nature to deliver a consistent flow of ecosystem benefits remains low despite its provision of critical food supply. Given that the agricultural sector makes use of over 90% of Wales' land area, some of our greatest opportunities to improve the sustainable management of natural resources lies in the ecosystems and activities across Welsh farms.

These challenges are not isolated, they are systemic. Chronic risks from biodiversity loss, pollution, unsustainable management and inequitable distribution of resources, alongside acute risks from extreme weather, represent some of the greatest threats to Wales' natural resources, our wellbeing and economic prosperity. Decoupling the dependency of economic activity from environmental degradation is essential. A regenerative economy, one that protects and restores ecosystems, retains wealth within communities, and supports fair work is not just desirable, but necessary.

Based on our evidence from the ecosystems, natural resources and all Wales aims assessments, the opportunities for action are clear and must be pursued at every scale:

- Local scale: empowering people and communities to adopt sustainable and healthy lifestyles, enhance green infrastructure, and participate in ecosystem restoration.
- Regional scale: place-based approaches such as catchment solutions including natural flood management, riparian buffers, and woodland expansion to address interconnected environmental risks.
- National scale: aligning political and policy frameworks with the climate and nature emergency, investing in skills, infrastructure, and innovation to support a regenerative economy.

This chapter sets the foundation for the actions that must follow and must be bold, integrated, and inclusive if Wales is to thrive within the limits of its natural systems and secure a prosperous future for generations to come.

Opportunities across scales

Local scale: people and communities

Communities shape landscapes, influence behaviours such as consumption patterns and generate the social capital needed for systemic transformation. Therefore, empowering people and communities is essential to achieving the sustainable management of natural resources.

Wales needs to strengthen participation and stewardship. Dasgupta's warning that environmental problems stem from citizens being "distant from Nature" highlights the need for participatory approaches including development of practical stewardship skills. When communities are enabled to co-design pocket parks, map cooling shade, test river water, create and restore local habitats and even prepare for floods and heatwaves, they convert ecological knowledge into everyday agency. These actions strengthen social cohesion, enhance opportunities for health improvement and equip people with green economy skills. Community engagement can be enabled by creating volunteer networks, linking volunteers to schools, businesses, farmers and public services. Creating and sustaining engaged farming communities is critical to enable knowledge exchange, education and training at a community level. These local farming communities can be supported by policies and schemes such as Ffermio Bro and the Sustainable Farming Scheme (SFS).

Opportunities for action include providing funding that empower locally led nature-based solutions, enabling community groups and area-based partnerships, such as Local Nature Partnerships, to design and implement projects ranging from neighbourhood-scale initiatives like pollinator corridors, rain gardens, and urban tree planting, to larger landscape-scale interventions that strengthen ecosystem resilience and deliver transformative change for nature and the environment. To inform, monitor, and prioritise these actions, local plans (such as wellbeing plans, local nature recovery plans, Place plans) should embed community-generated data on biodiversity and climate risks, ensuring that decision-making is grounded in robust, locally relevant evidence.

We need to empower citizens to adopt sustainable lifestyles that drive sustainable consumption and a circular economy. Wales People and Nature Survey (PaNs) data shows promising trends with 44% of people buying local or seasonal produce, and 26% choosing products with environmental labels, however these behaviours need scaling up. Wales also benefits from a high number of visits to Welsh landscapes, from different types of spatially disparate communities (walkers, bikers, surfers and family holiday makers) which provides further opportunities to influence people's behaviours also at a local scale. The public sector can influence consumption through infrastructure, incentives, and information. These can include active travel infrastructure, community energy generation and enabling local food strategies and partnerships by expanding allotments, creating community gardens, promoting urban horticulture, and using public sector procurement to purchase local and healthier food. Furthermore, local circular economy hubs such as reuse centres, repair and zero waste shops can provide communities with opportunities of employment and cheaper goods.

Changing community behaviours requires environments that make sustainable choices easy and attractive, supported by economic signals that reinforce those choices. Local authorities have a critical role in shaping these conditions through planning, education, fiscal measures, land management, procurement rules and collaborative partnerships. One approach is to create incentives that reward circular practices which not only encourage positive behaviour but also signal that resource efficiency is valued at the community level. At the same time, deterrents for over-consumption are essential to counteract the ingrained *throw-away* culture. Differential pricing for waste disposal and restrictions on single-use products in public venues can help curb unnecessary consumption and reduce environmental impacts.

Regional scale: area statement to deliver place-based approaches

Area Statements are central to implementing the Sustainable Management of Natural Resources (SMNR) in Wales. Grounded in the Welsh Government's Natural Resources Policy (NRP) and informed by SoNaRR, these place-based strategies translate national priorities into relevant actions at multiple-scales. At a regional scale, Area Statements enable the identification of local environmental challenges and opportunities, promote cross-sector collaboration and stakeholder co-production, and support strategic and resilient interventions. Especially Nature-based Solutions (NbS) that deliver multiple benefits including biodiversity, climate resilience, community wellbeing, and economic sustainability. They provide a nuanced understanding of regional ecosystems, pressures, and opportunities, helping to restore habitats, enhance ecological connectivity, and build resilient ecological networks.

Resilient Ecological Networks (RENs) form the backbone of nature recovery and climate resilience by connecting protected sites and biodiversity-rich areas across Wales. They can be planned and implemented at multiple scales to enable species movement and ecosystem function, which are critical in the face of environmental change – planning and conservation efforts also need to consider climate adaptation. Strengthening the management of protected areas and Other Effective Area-Based Conservation Measures (OECMs) will be essential to secure ecological integrity and deliver wider wellbeing benefits. Many protected sites are small, fragmented, and isolated, with boundaries that make them vulnerable to external pressures and less resilient to ecological change. Opportunities to review and strengthen protected sites to create RENs include expanding existing sites and bringing forward new ones to improve connectivity and ecological resilience, incorporating features that support climate mitigation such as carbon-rich habitats, and embedding effective site management and monitoring to ensure long-term ecological health. Embedding RENs into regional spatial planning would ensure that major programmes such as woodland creation, peatland restoration, and flood risk management actively contribute to network connectivity. This integration would align nature recovery with climate resilience and wellbeing objectives, making RENs the foundation of regional planning and systemic transformation.

A shared priority across area statements is reversing biodiversity decline and strengthening protected areas to ensure long-term social and economic benefits. Key environmental risks such as poor air quality, flood vulnerability, water pollution, contaminated land, and urban heat and noise require coordinated action tailored to local contexts. In our evidence, there is limited demonstration of the effective use of Area Statements to address environmental, social, cultural and economic challenges. This is likely due to lack of systematic implementation approaches and no accepted methodology for evaluating place-based activities. This area of future opportunity may also include addressing the limitation and challenge of cost-benefit ratios which typically drive local decision making.

Corporate Joint Committees (CJCs), through Strategic Development Plans, will set the overall spatial strategy for their region, including energy, housing and transport systems. CJCs will be crucial in leveraging systems transformation at the regional level. CJCs could translate the Natural Resources Policy into action via the city and regional growth deals and through working with Public Service Board (PSB) partners like NHS Trusts. Leverage points include shortening food supply chains, increasing procurement of local food, zoning sites for renewable energy and planning grid connections, setting net zero investment priorities, and developing multi modal transport.

National scale: political and policy action

National-scale action and the cross departmental Natural Resources Policy is essential for delivering SMNR in Wales. Recent legislation and policy commitments provide a solid foundation for addressing the climate and nature emergencies, but progress depends on coordinated implementation. The challenge now is to align regulation, incentives, and investment to deliver measurable outcomes for biodiversity, climate resilience, and wellbeing.

This section sets out the key opportunities that policy makers could take to drive systemic change and ensure that Wales meets its environmental ambitions. Based on the evidence collected from the national aims assessments, the opportunities for action at national scale are summarised below.

Sustainable Land-Use Change

A coherent Land Use Decision Framework is needed to deliver multifunctional landscapes that meet the declared climate and nature emergency, and community goals. Such a framework must unite environment targets, farming practices, housing needs, transport solutions, and business activities, while involving communities and fostering co-operative approaches among landowners and managers. Clear multi-scale direction on priorities could strengthen delivery through Area Statements, RENs, and other place-based mechanisms. Nonetheless, current evidence shows gaps in spatially integrated data, valuation methods, and definitions of land categories, alongside inefficiencies from ownership information.

Operationalising Sustainable Land Use (SLU) offers a practical way forward by recognising synergies and managing trade-offs: for example, balancing housing and infrastructure needs with space for food production, renewable energy, recreation, and nature recovery. Improving soil health and adopting better practices across ecosystems can deliver multiple benefits, including enhanced water quality, biodiversity, and climate resilience. Success depends on co-ordinated and collaborative landscape-scale partnerships that integrate land use with habitat restoration, and water management, particularly in Less Favoured Areas, which hold ecological and cultural value. Supporting stewardship in these areas can secure carbon storage, nature recovery, and community benefits while supporting rural economy.

Pollution Reduction

Pollution remains a major pressure across air, water, and soil, undermining the quality of our natural resources, ecosystem resilience and public health. A coordinated approach should combine incentives and regulation to reduce agricultural emissions of ammonia and nutrient runoff, implement statutory air quality targets, and address urban and legacy pollution. Measures such as Sustainable Drainage Systems (SuDS), improved wastewater management, and contaminated land remediation are vital to protect water quality and reduce flood risk. Tackling pollution at source and through integrated catchment management will deliver benefits across multiple ecosystems.

Nature Targets and Integration

The statutory biodiversity targets aligned with the Global Biodiversity Framework must be embedded across sectors such as agriculture, planning, energy, and infrastructure to ensure coherent and consistent delivery. The Natural Resources Policy could be a vehicle for doing this. The Sustainable Land Management (SLM) framework and the Sustainable Farming Scheme will play a central role in achieving these goals by incentivising actions that enhance habitat connectivity and ecosystem resilience. Robust monitoring and reporting systems will be essential to track progress and inform adaptive management.

Effective Management of Ecosystems

Delivering ecosystem resilience requires an integrated approach that safeguards all habitats while pursuing opportunities for large-scale restoration. Wales has significant potential to expand woodland networks and restore degraded peatlands – actions that provide major climate and nature benefits through carbon storage, water regulation, and biodiversity enhancement. Updated forestry standards and planning controls will help ensure these interventions protect soils and habitats, while integrated approaches can link woodland creation with flood risk management and ecological network enhancement. However, these opportunities must not compromise other irreplaceable habitats such as the Section 7 priority habitats. Some habitats, such as some semi-natural grasslands, are among the most fragmented, smallest, and least protected ecosystems in Wales, yet they deliver critical services including pollinator support, soil carbon storage, and cultural value. Making use of RENs within spatial planning must, therefore, guide large-scale interventions which reflect the local and regional ecosystems for which investment will return value for money to strengthen habitat connectivity whilst minimising long-term maintenance costs.

The Urban Environment

Communities and people in urban areas face combined pressures from air pollution, noise, heat and flooding, requiring integrated solutions. Implementing the Clean Air Plan for Wales and the Noise and Soundscape Plan for Wales that combine air quality improvements and noise management, alongside cooling hubs and green-blue infrastructure will enhance health and wellbeing. Drainage and Wastewater Management Plans must deliver outcomes across the established urban landscape and not only target new urban development. Sustainable Drainage Systems deliver multiple benefits across the urban landscape whilst minimising flood risk, protecting water quality, enhancing biodiversity and creating amenity spaces.

Marine Resilience

Marine ecosystems need more collaborative and strategic planning. Developing a spatial approach through the Wales National Marine Plan, for example exploring resource areas for sectors such as aggregates, ports and shipping, renewables, and aquaculture, offers the opportunity to guide sustainable economic growth, with appropriate development that ensures the maintenance and enhancement of marine ecosystems. Climate-induced changes to species distributions and habitat extents are already being observed within the marine environment. Going forwards, sustainable management of marine natural resources needs to be climate-smart, taking account of predicted changes and adapting approaches to meet the implications of a changing climate. In terms of the management of fisheries, we need to take advantage of the delivery of Fisheries Management Plans which are key tools for delivering sustainable stocks, a healthy marine environment, and a vibrant and profitable fishing sector.

Nature-positive tourism and marine renewable energy development should be guided by evidence-based spatial planning to balance economic opportunities with environmental protection.

Role of regulation

Regulation sets clear, enforceable standards that safeguard natural resources and ensure compliance where voluntary measures alone are not sufficient. Key regulatory instruments such as the Control of Agricultural Pollution Regulations, Environmental Impact Assessment requirements, and planning guidance help prevent harmful practices and protect sensitive habitats. The Environment (Air Quality and Soundscapes) (Wales) Act 2024 introduces statutory targets for air quality and a Noise and Soundscape Plan for Wales, while Drainage and Wastewater Management Plans now have a legal basis to address urban water quality and flood risk. Regulation also tackles legacy issues, including contaminated land and hazardous waste, through planning and remediation obligations. By embedding SMNR principles into permitting and compliance frameworks, regulation ensures consistency across sectors and underpins national commitments such as biodiversity targets and the *30 by 30* goal. Working alongside incentives, innovation, enabling others and advice and guidance, regulation forms part of an integrated approach, rewarding action while maintaining a minimum standard critical for achieving integrated outcomes for air, water, soil, and ecosystems.

Cross-cutting dimensions

Social and Cultural

Nature is not only vital for health and climate; it is deeply woven into our cultural identity and sense of place. There is strong public support for environmental protection, with 90% of adults valuing it and 85% willing to change their behaviour. This presents a powerful foundation for community-led nature-based solutions that deliver cultural, health, and sustainability gains. We can build on this momentum by supporting place-based environmental projects and nature-linked festivals, which celebrate local heritage and foster community pride. Expanding citizen science and outdoor learning helps people develop practical stewardship skills and deepen their connection to the natural world. Growing nature-based tourism offers another opportunity to inspire meaningful engagement with landscapes, if managed sensitively to the impacts that visitors can have.

Protecting dark skies, tranquillity, and natural soundscapes through planning controls ensures these cultural assets are preserved for future generations.

In Wales, farming has deep roots in our language, landscape and identity. These communities own and manage large parts of our landscape. There is a deep connection to nature through many generations of farmers who provide vital social value to Welsh communities. Local sustainable food supply provides further opportunities to connect people with natural resources. There are opportunities for raising awareness about local food production through local partnerships for food supply to schools and public sector bodies, but also in the private sector such as care-homes, local retail and hospitality.

Cross-cutting actions such as community engagement through Local Nature Partnerships, awareness campaigns informed by PaNS Wales, integrated spatial planning, and real-time data platforms will help embed these cultural benefits into broader environmental and public health strategies.

Health and Wellbeing

We must seize every opportunity to protect and improve public health through smarter, greener, and more inclusive approaches. Expanding access to nature through Nature-based solutions is a powerful tool. By investing in flood-resilient landscapes, expanding urban greening, and installing sustainable drainage systems, we can reduce exposure to air pollution, lower urban temperatures, and trap harmful particulates from road runoff. Such approaches can also promote physical activity, reduce stress, and foster social connection. Improving the quality and access to green and blue spaces in deprived communities also supports vulnerable individuals (e.g. sensory spaces). Building walking and cycling networks that link homes, schools, and workplaces makes active travel safer and more appealing, embedding movement into daily life. But equal access alone is not enough. We must also raise awareness of the health benefits of nature by working with the health sector. Promoting the physical and mental wellbeing gained from time spent outdoors can help shift behaviours and attitudes, encouraging more people to engage with natural spaces. These interventions not only protect and improve health but also enhance the quality of life and climate resilience of our cities. Integrated planning and delivery must go further in tightening industrial and transport emissions, as well as domestic solid fuel burning in urban zones, to significantly reduce respiratory risks and improve air quality for all.

Community engagement is also essential. Empowering local preparedness for floods and heatwaves, and providing targeted support, such as cooling hubs in green space, ensures that vulnerable residents are protected and included in resilience efforts. To support this, research and technology must underpin our response. Strengthening environmental monitoring and rapid-response systems will allow us to act swiftly and effectively when new threats emerge – one that prioritizes prevention, equity, and long-term resilience.

Together, these actions form a powerful, coordinated response to environmental health risks to deliver healthier and more connected communities where nature is not a luxury, but a foundation for wellbeing.

A sustainable and regenerative economy

To transition to a regenerative economy, we need to identify the best way to bridge the financing gap for nature via a combination of structural changes to the economy, scaling private finance and deployment of public funding for environmental management.

Due to the networked functionality of nature, Nature-based Solutions can deliver multiple value streams from a single investment in nature. If multiple values can be realised through buyers for high-integrity outcomes from a single NbS intervention (e.g. water quality, biodiversity and recreation-focussed buyers for outcomes from establishing riparian woodland), then co-funding / co-investment becomes possible, delivering improved cost-benefit performance for the nature-based solution approach for all funding partners. In this manner, nature-based solutions can contribute to economic productivity, deliver valuable societal outcomes and restore nature.

Developing high-integrity nature markets, guided by principles such as the Welsh Government's Sustainable Investment Principles and BSI Nature Standards, can attract both voluntary and compliance-driven investment into nature restoration and Nature-based solutions. Aligning public sector funding with private and philanthropic capital will be essential to scale impact, with the Sustainable Farming Scheme offering a major opportunity to lead this transition.

To unlock broader investment, opportunities for Payment for Ecosystem (PES) need to be identified and aggregated, potentially through public sector mechanisms, to make them viable for large-scale investors. Innovative stacking approaches that demonstrate the cross-sector benefits of nature-based solutions can further stimulate investment. Ensuring community-led projects and social enterprises can access PES funding will help deliver nature restoration benefits locally and equitably.

Beyond these nature-based solution opportunities, wider and deeper benefits can be fostered by combining natural, built and civic capital approaches for whole system regeneration. Such systemic finance and investment opportunities will require new governance structures to facilitate innovation and methodologies for the allocation of finance to deliver positive returns for nature, communities and employment opportunities. Public sector money can then be actively deployed to build a better system from the ground up by actively creating structures for improved place-based value circulation and retention. Sustainable agriculture, forestry, and fisheries must transition to regenerative systems that support biodiversity, local jobs, and food resilience. Scaling sustainable aquaculture and adding value to timber locally will lock carbon and create economic opportunity.

In the manufacturing sector, adopting circular design and extended producer responsibility can reduce waste and pollution. Removing harmful compounds from manufacturing processes protects ecosystems and human health and potentially enables more recovery of waste. Greener transport and construction options must be scaled, with community-owned renewable energy and nature-based infrastructure playing a key role in managing pollution, climate adaptation, and job creation.

Improving resource efficiency through better energy use, water conservation, and waste prevention will help citizens live more sustainably. By raising awareness across businesses and communities, we can empower people to make informed choices driving the shift toward a nature-positive, resilient economy. Together, these actions lay the foundation for a regenerative economy; one that restores ecosystems, builds community wealth, and secures a healthier future for Wales.

Research and Technology

Research and technology must be harnessed to support sustainable management across all scales, from households to national infrastructure.

At the household level, further development and uptake of water-saving technologies, including digital water meters, are needed to reduce consumption and improve efficiency. Energy efficiency measures, such as improved thermal insulation, smart energy systems, and renewable generation and storage can reduce heat loss and reliance on fossil fuels, contributing to climate mitigation and energy security.

At the national level, investment in advanced recycling technologies is critical to improving the quality and circularity of material flows. High-quality recycling infrastructure will reduce waste, conserve resources, and support a regenerative economy. In transport and infrastructure, novel technologies must be embedded to reduce environmental impacts, including noise pollution. Public bodies should be supported to implement the recommendations of the Noise and Soundscape Plan for Wales 2023-28, ensuring soundscapes are considered in planning and development. Research is also needed to deepen our understanding of air pollution and its effects on terrestrial and freshwater ecosystems. This includes targeted studies within sensitive habitats such as the Mountain, Moorland and Heath ecosystem, focusing on soil structure, fertility, nutrient cycles, and historical changes.

Technology can also strengthen environmental monitoring and rapid response capabilities. For example, digital tools and sensors can be used to detect and control invasive non-native species (INNS) and monitor outbreaks of diseases such as Avian Influenza. Furthermore, real-time data platforms and citizen science initiatives can strengthen enforcement activities, expand public engagement, build stewardship skills, and enhance the evidence base for decision-making. Rapid advance and implementation in surveillance technologies must also consider unintentional impacts on people, specifically related to privacy and use of territories and species for subsistence.

Across all domains, research and technology must be leveraged to build resilience, improve environmental outcomes, and empower communities. By investing in innovation and knowledge, Wales can lead the way in regenerative, evidence-based management of its natural resources.

Conclusion

Wales already benefits from strong legal and regulatory foundations for enabling people and nature to thrive together. To accelerate implementation, we must adopt adaptive management through monitoring, evaluating, and iterating based on the best available evidence. Across all scales and ecosystems, there is significant uncertainty about what actions will work best; however, time is short: urgency, agility, and innovation are essential. Decision-making should go beyond cost-benefit ratios to reflect the full value of nature and its many benefits. Strengthening Area Statements and applying the SMNR framework will be critical to guide choices and maximise impact.

The main pressures driving degradation of ecosystems and compromising their resilience, usually combined, are being driven by climate change, pollution, and land and sea use. The pressures threaten biodiversity, water quality in both marine and freshwater environments, and the urban environment. Urban areas, though only covering 6% of the land, exert disproportionate demand on ecosystems and experience the most severe climate impacts. Careful planning and impact assessment are essential to ensure interventions deliver multiple benefits for people and nature without creating new pressures elsewhere. Changing habits and reconnecting people with nature requires better information, equal access to high-quality green and blue spaces, community engagement, and an economy focused on repair, reuse, and responsible consumption.

The greatest opportunities for action at scale, which have potential to generate most impact across multiple ecosystems and natural resources, reside in agriculture and land management. These must adapt to deliver goods and services alongside wider benefits for ecosystems and health, while supporting thriving businesses. Incentives, community support, and economic opportunities linked to environmental stewardship will foster a culture of positivity and social cohesion.

New mechanisms to provide payment for provision of public goods can be a catalyst for transforming agriculture and land management into systems that deliver food, ecosystem health, and economic resilience. By embedding sustainability into supply chains, aligning public and private investment, and supporting community-led initiatives, these mechanisms can make environmental stewardship a driver of thriving businesses. High-integrity nature-based solutions, nature markets and innovative approaches such as stacking benefits will scale impact, while regenerative tourism and community-driven projects can help ensure that prosperity and restoration go hand in hand.

Climate adaptation will require better planning of our infrastructure, as well as our conservation actions. Developing our understanding of ecosystem resilience using indicators embedded within the RENs and SLM frameworks will be fundamental to nature recovery and climate adaptation. Effective implementation to enhance ecosystem resilience will connect fragmented habitats and enabling species movement as environmental conditions shift. Changing climate patterns are likely to bring new species and alter ecosystems, requiring flexible planning and use of best available information to ensure RENs stay current and facilitate action. Expanding, managing, and safeguarding habitats through RENs, while embedding them into spatial planning, ensures that major programmes such as woodland creation, peatland restoration, infrastructure planning and house building, and flood risk management actively strengthen connectivity and resilience.

We must seek synergies between actions to address the climate and nature crises wherever possible, but with finite land and resources, trade-offs and difficult choices are unavoidable. Expanding low-carbon transport, housing and energy infrastructure will put more pressure on the environment, adding to those already coming from our current food, energy and transport systems. Urban expansion illustrates this conflict as it frequently results in the loss of the best and most versatile agricultural land, thus reducing local food production capacity. Nonetheless, there are opportunities for win-wins. For example, restoring nature in Less Favoured Areas, where sustainable land management can deliver carbon storage, biodiversity recovery, and cultural benefits while supporting rural livelihoods. A systems approach to designing new energy, transport, and construction will better enable us to maximise such synergies with food production.

Policymakers must avoid short-term fixes and evade paralysis in the face of complexity. The challenge is not whether to act, but how to act boldly and collaboratively. Integrated strategies, grounded in robust evidence and co-designed with communities, are essential to navigate competing interests and deliver long-term gains for climate, nature, and society. Wales has the chance to lead by example turning ambition into action and ensuring that every decision counts toward a sustainable future.

The forward-looking chapter, *Bridges to the Future – a Briefing for Policy and Place Makers'* distils these clear messages for Wales: choices made today by government, business, and communities can raise living standards, strengthen resilience, and restore nature by redesigning the systems that meet our everyday needs.

Annex 1: Climate change evidence

Lead Author: Lucia Watts

External reviewers: Kim Dowsett and Ruth Gregg (Climate change commission)

Current situation, past trends and future outlook for pressures related to climate change

The evidence below sets out

- The past trends and future outlook for pressures related to Climate Change in relation to the broad ecosystems (coastal margins, enclosed farmland, freshwater, marine, mountain, moorland and heath, semi-natural grassland, urban, woodlands) and natural resources (air, soil, water). See method: **Defining the long and short term**

- Any new evidence, strategies, policies and interventions since 2020 that are likely to impact future trends.

It is intended as an update to the relevant trends set out in the 2020 Climate change chapter (NRW, 2021a).

Pressure: Changes in intensity and frequency of weather events

Climate change is projected to increase the frequency and intensity of rainfall, droughts, inland and coastal floods, and heatwaves, which are predicted to further reduce ecosystem resilience, and have a direct impact the ecosystems themselves. Other climate-related weather events could include wildfires, winter and summer storms and high wind events. All these weather events are likely to have negative impacts to both natural ecosystems and human society. This can include loss of habitats, damage to infrastructure and increasing risks to life.

Table 43 Evidence of trends for changes in intensity and frequency of weather events

Timescale of change	Assessment and description of change in intensity and frequency of weather events
Long term 1960-2022	**Deteriorating** Confidence High The average annual rainfall across Wales has not changed markedly. However, there is some evidence of seasonal changes and more heavy rainfall events. For the UK as a whole, the most recent decade between 2013 and 2022 has been on average as wet as the 1991-2020 decade and 8% wetter than 1961-1990 (Kendon et al., 2023). This is a slight change from the previous assessment, but without major differences. The number of named storms occurring in the UK has increased over the past decade, but with most storms occurring in January and February. Extremes in high and low rainfall and temperature have become more common with a greater number of winter storms occurring in recent years and longer, more prolonged summer droughts, as seen in the summer of 2022 (Barker et al., 2024). In Wales we experienced notable droughts in 2025, 2022, 2005-6, 1995-6, 1989-90, 1984, 1975-76. Frosts and snowy periods have also been decreasing, with the most recent decade between 2013 and 2022 had 4 to 7% fewer days of air and ground frost than the 1991-2020 average, and 15 to 23% fewer than 1961-1990 (Kendon et al., 2023). Widespread periods of snow have occurred in the UK, and Wales, in 2021, 2018, 2013, 2010 and 2009, but these fewer in number and less severe than those pre-1960s (Kendon et al., 2023). Updated figures from the 2025 State of the UK Climate report (Kendon et al., 2025), exploring the climate to 2024, report similar trends to previous publications. Within the 2015-2024 decade, the UK has recorded its all-time highest maximum temperature at any station in five months of the year; January 2024, February 2019, July 2022, November 2015 and December 2019 (Kendon et al., 2025).

Timescale of change	Assessment and description of change in intensity and frequency of weather events
Short term trend 2020- 2025	Confidence Medium Increased intensity and frequency of extreme weather events observed Since SoNaRR2020 (NRW, 2021a), Wales has experienced a number of significant storm events, with 33 named storms occurring between 2020 and January 2025. For example, Storm Eunice in February 2022 was the most severe storm to affect Wales since February 2014 (Kendon et al., 2023). Summer 2022 saw record-breaking temperatures across Wales, with a new maximum temperature record of 37.1°C set at Hawarden Airport, Flintshire. Wales was in 'prolonged dry weather' drought status for both summer 2022 and part of summer 2023 (Natural Resources Wales / Dry weather updates), with low flows, low rainfall and high temperatures impacting both ecosystems and communities. An attribution study to assess whether specific events were likely to have occurred due to climate change, found that the heatwaves of 2019 in Europe were 10 times more likely because of climate change, with temperatures 1.5 to 3°C hotter than they would have been without anthropogenic influence (Vautard et al., 2020). Looking at very short term trends, that although cannot be strongly correlated with climate change, we can use these as potential indicators of change. From September 2023 to March 2024, 194 flood warnings and 3 severe flood warnings were issued by NRW. There were 2619 wildfires attended to in 2022 to 2023, an increase of 7% from 2021 to 2022, with 65% of these fires occurring in April, July and August, correlating with low rainfall levels (Welsh Government, 2023b). Summer 2025 has been reported as the hottest on record, with the unprecedented average temperature of 16.1°C made 70 times more likely by anthropogenic climate change (Met Office, 2025).

Timescale of change	Assessment and description of change in intensity and frequency of weather events
Future outlook of pressure To 2030 To 2050 To 2100	**Deteriorating** Confidence Medium Over the coming decades, it is predicted that Wales will experience warmer, wetter winters and hotter, drier summers, with a greater frequency of extreme events including heavy rainfall events and more intense droughts (Lowe et al., 2019). Mean winter precipitation in Wales is likely to increase by 9% by the 2050s compared to a 1981-2000 baseline based on a high emissions scenario (RCP8.5) (Lowe et al., 2019). By the 2070s, rainfall in Wales under a high emission scenario is projected to become up to 29% wetter in winter, and 56% drier to 2% wetter in summer (Met Office, 2018b). These changes are likely to lead to a greater incidence of extreme weather events including a higher number of intense storms and longer term droughts in Wales. This could lead to greater pressures on water availability during times of drought, impacting communities and ecosystems.

Pressure: Changes in air temperature

Changes in air temperature threaten ecosystem resilience and ecosystem services through shifting species ranges, localised extinctions, change to life-cycle events, impacts to habitats and other impacts on ecosystem function. Changing air temperature also interacts and exacerbates other environmental stressors, such as the increase in invasive species and disease vectors.

Changes in air temperature are also the main driver of changes in longer-term rainfall trends, therefore, any impacts to ecosystems from changes in rainfall trends such as seasonal shifts are also relevant.

Changes in water temperature are likely to impact species distributions as different areas change in suitability for the resident species. Changes may include northward movement of species distributions or the arrival of species not commonly found in those areas.

Table 44 Evidence of trends for changes in air temperature

Timescale of change	Assessment and description of changes in air temperature (includes rainfall trends)
Long term trend of pressure 1961-2022	**Deteriorating** Confidence High In Wales, the 2008-2017 decade was 0.8oC warmer than the average temperatures between 1961-1990. All of the top 10 warmest years for the UK since records began in 1884 have occurred in the 21st century (Kendon et al., 2023). The most recent decade of 2015 to 2024 has been on average 0.41oC warmer than the 1991-2020 average, and 1.24oC warmer than the 1961-1990 average in the UK (Kendon et al., 2025). Average temperature in Wales is increasing every year, with these trends likely to continue. UK winters (2013-2022 decade) have been 10% wetter than the 1991-2020 average with smaller changes for other seasons (Kendon et al., 2023). Overall, the most recent decade between 2013-2022 has been as wet as the 1991-2020 average (Kendon et al., 2023), with little changes seen in annual rainfall amounts.

Timescale of change	Assessment and description of changes in air temperature (includes rainfall trends)
Short term trend 2020-2025	Confidence High Weather trends can't be categorised as the time period is too short Average temperatures in Wales have increased between 2020 and 2025 with UK average temperature in 2023 exceeding 1.4^{o}C (Met Office, 2023) 2024 is likely to be the first year in which global average temperature exceeds 1.5^{o}C increase since pre-industrial (Met Office, 2023) which is also likely to see an increase in average temperature in Wales, although potentially under this average. 2022 was the hottest year on record in the UK since 1884, 0.9^{o}C above the 1991-2020 average (Kendon *et al.*, 2023). Wales had two consecutive warmest years on record in 2022 and 2023, which is considered to be a 1-in-3 year event in the current climate (Ciavarella and McCarthy, 2024). Short term rainfall trends with data between 2020 and 2022 report annual rainfall approximately 95% of the previous decade (Kendon *et al.*, 2022, 2023), but with some of the wettest months on record. For example, 2021 rainfall was 95% of the 1990-2020 average, but with the wettest February, April, June, November and December on record (Kendon *et al.*, 2022) suggesting that seasonal patterns are changing more than overall rainfall amounts. Wales experienced 153% of the long term average rainfall in 2024, with the wettest 9 months on record in 189 years (Brown, Unpublished). Long term trends are beginning to show an increase in wetter long-term winter rainfall trends.

Timescale of change	Assessment and description of changes in air temperature (includes rainfall trends)
Future outlook of pressure To 2030 To 2050 To 2100	**Deteriorating** Confidence High When compared to the 1980-2010 baseline, temperatures in Wales are predicted to increase between 2025 and 2100. Between 2020 and 2030 a projected 1°C increase, 1.4°C increase between 2030 and 2050, increasing to 2.8°C between 2050 and 2080 and up to approximately 4°C of warming by 2100. These predictions are based on a worst-case-scenario warming trend if current global emissions continue on an increasing upward trend (Met Office, 2018b). As air temperatures increase, warmer air is able to hold more moisture, leading to heavier, and more intense rainfall and increasing the risks from floods. A central UK estimate suggests that a high intensity rainfall event occurring typically once every 2 years will increase by 29% due to warming air temperatures (Met Office, 2022). However, it should be noted that while these intense events are predicted to become more frequent, summers are predicted to be overall hotter and drier than currently observed (Met Office, 2022). Changes in air temperature are also likely to impact changes in the timing of ocean stratification, with projections to 2100 suggesting that thermal stratification of the UK shelf seas will extend in duration by about 2 weeks (Sharples et al., 2022).

Pressure: Changes in water temperature

Increases in water temperature has a negative impact on both freshwater and marine ecosystems, ocean water circulation and water quality, affecting both the natural environment and human society. For example, warmer river, lake and ocean water has a lower dissolved oxygen concentration, which has a detrimental impact on habitats and species. Increased temperatures can kill freshwater organisms and plants directly, or indirectly due to reductions in dissolved oxygen (Crozier and Hutchings, 2014), leading to changes in population dynamics. Additionally, warmer conditions combine with other pressures such as nutrient pollution to exacerbate impacts such as earlier, longer or more acute algal blooms, deoxygenation of deeper lakes, and increased toxicity of other pollutants (Crozier and Hutchings, 2014).

In marine environments, the amount of sinking cold water is decreasing in warming ocean waters, which could slow down or, in some places stop, ocean currents. This could have enormous impacts on both marine and terrestrial life, as well as impacting other important global systems. Sea water absorbs double the heat of that of air e.g., 1.5°C warming of air translates to 3°C warmer water temperatures.

In freshwater environments, increased water temperatures can increase the susceptibility to the ecosystem, and increased likelihood of establishment, of INNS (NRW, 2020).

Changes in water temperature are likely to impact species distributions as different areas change in suitability for the resident species. Changes may include northward movement of species distributions, or the arrival of species not commonly found in those areas.

Table 45 Evidence of trends for changes in water temperature

Timescale of change	Assessment and description of changes in water temperature
Long term trend of pressure 1990-2022	**Deteriorating** Confidence High River water temperatures increased over the last half of the 20th century broadly in line with air temperature (Watts and Anderson, 2016). Between 1990 to 2006, river waters in England and Wales have warmed by about 0.3°C per decade (Orr et al., 2015). Average near-coastal sea surface temperature for the UK in last decade (2013-2022) was 0.8°C warmer than the 1961-1990 average, and 0.2oC warmer than 1991-2020 average (Kendon et al., 2023). Sea surface temperatures have warmed by approximately 0.3°C per decade over the last 40 years (Cornes et al., 2023). However, trends noted less observed warming to the west of the UK, which could include the Welsh coast with values of 0.1-0.2°C increase per decade recorded (Cornes et al., 2023).

Timescale of change	Assessment and description of changes in water temperature
Short term trend 2020-2025	**Deteriorating** Confidence Medium Steady increases in freshwater temperatures are likely to have occurred in the short term, with on average 0.15°C warming in the five years between 2020 and 2025 if warming trends (Orr *et al.*, 2015) have remained consistent. If decadal observations of water temperatures (Cornes *et al.*, 2023) are consistent, sea surface temperature is likely to have increased by 0.05-0.15°C over the five years between 2020 and 2025. In addition to this, 2022 was the warmest year for UK near-coastal sea surface temperature since 1870 (Kendon *et al.*, 2023).

Timescale of change	Assessment and description of changes in water temperature
Future outlook of pressure To 2100	**Deteriorating** Confidence High Freshwater water temperatures are expected to increase across the UK through the 21st Century, but the rate and pattern of change are not clear (Watts and Anderson, 2016). This may be due to the larger number of variables involved as inputs to freshwater such as land use and pollution. These higher temperatures combined with decreased summer flows, which are likely to increase with climate change, are expected to increase the levels of phosphorous within freshwater in the UK and therefore, the risk of eutrophication is predicted to also rise (Charlton *et al.*, 2018). Sea water temperatures are projected to increase by 3°C by 2100 in the Irish and Celtic seas, which is likely to lead to a decrease in dissolved oxygen content. This is also likely to increase ocean stratification due to sea warming and impact changes to ocean circulation (Robinson, Maltby and Buckley, 2020). Climate models indicate a continued warming trend with average annual mean sea surface temperature increases of 3.11°C predicted for the end of the century (Cornes *et al.*, 2023). As the west coast of the UK has seen observed temperature increases less than the average, we can assume that this may occur for predictions of sea surface temperature. Therefore, the Welsh coast may experience slightly less warming than the predicted 3.11°C average annual increase. In the longer term, the Atlantic Meridional Overturning Current (AMOC) is predicted to slow significantly by 2100, with models suggesting a complete shut off becoming more likely. This was found to occur in all high warming scenarios tested, but also more likely in the tested medium and low warming scenarios (Drijfhout *et al.*, 2025).

Pressure: Ocean acidification

Increasing anthropogenic CO_2 emissions are leading to acidification of marine waters, with projections suggesting that deeper continental shelf waters will become corrosive to some forms of calcareous invertebrates (Findlay et al., 2025)

Impacts of ocean acidification on shellfish fisheries may be more pronounced in Wales than other regions of the UK due to their relative importance to the industry (NRW, 2021b). Maximum direct economic losses to the shellfish industry in the UK have been estimated at nearly 30% by 2100 (Mangi et al., 2018), with potential indirect impacts to the food webs at the population-level (Heath et al., 2012).

Additionally, there is potential for the altering of ecosystems through changing trophic interactions, herbivorous behaviours and predator-prey interactions which will have impacts on the wider habitat.

Exposure to the interaction of ocean acidification and warming together are likely to have significant impacts to marine life (Greatorex and Knights, 2023)

Table 46 Evidence of trends for ocean acidification

Timescale of change	Assessment and description of ocean acidification
Long term trend of pressure [2000-2022	**Deteriorating** Confidence High Ocean acidification is happening faster in the UK than the wider North Atlantic (Greenhill, Kenter and Dannevig, 2020), with the North Atlantic surface waters experiencing an ongoing decline in pH leading to increased acidity as the North Atlantic Ocean contains more anthropogenic CO_2 than any other ocean basin (Findlay *et al.*, 2025). In 2020, surface ocean water in the North Atlantic was 40% more acidic than pre-industrial times (Findlay *et al.*, 2025)
Short term trend 2020-2025	**Deteriorating** Confidence High Ongoing ocean acidification is occurring, with a global average pH decline of about 0.0016 /year. However, some observations of acidification in the North Atlantic suggest decreases in pH faster 0.002 /yr.(Findlay *et al.*, 2025), indicating a greater degree of acidification.

Timescale of change	Assessment and description of ocean acidification
Future outlook of pressure To 2050	**Deteriorating** Confidence High Ocean waters around the UK are also likely to become more acidic and contain less dissolved oxygen with climate change (MCCIP, 2020). This could have a particularly significant impact on shellfish fisheries in Wales (MCCIP, 2020). The rate of pH will continue to decline to 2050 at similar rates to today (Findlay *et al.*, 2025) e.g. a decrease of 0.002 /yr. under a moderate warming scenario (RCP4.5) and a decrease of 0.003 /yr under a worst-case scenario of climate warming (RCP8.5). There is significant spatial variability in projections of ocean acidification with changes as fast as an increase in acidification of 0.005 /yr in the Bristol Channel, which could also impact South Wales.

Pressure: Sea level rise

Increased risk to people, properties, infrastructure and agricultural land, terrestrial and freshwater habitats. As half of sea level rise is thermal expansion, we can expect that increases in water temperature will have an impact on sea levels alongside melting ice

Table 47 Evidence of trends for Sea level rise

Timescale of change	Assessment and description of sea level rise
Long term trend of pressure 1900-2022	**Deteriorating** Confidence High Mean sea-level rise around the UK (driven principally by thermal expansion of the oceans but also a range of other factors) has risen by around 16cm since the start of the 20th Century (Met Office, 2018). Over the past 30 years between 1993 and 2022, sea levels around the UK have risen by 11.4cm (Kendon et al., 2023). In recent years, there has been an acceleration of sea level rise up to 4mm per year (IPCC, 2014), with 3.7mm per year observed between 2006 to 2018 (Met Office, 2018a). The contribution of sea level rise from ice sheets has increased by almost four times from the 1990s to 2010s, a large increase in the loss of ice sheets and addition of water to oceans (Met Office, 2018a).
Short term trend 2020-2025	**Deteriorating** Confidence High Sea level has continued to rise slowly since SoNaRR2020, with on average, a 4mm per year increase. Between 2020 and 2025, sea levels in North Wales (Llandudno tidal gauge) rose on average a projected 1.05 cm, with increases projected of 1.30 cm in South Wales (Newport tidal gauge). Predictions are from the Met Office UKCP18 climate change projections of sea level rise at the 70th percentile confidence interval, considered to be a likely prediction.

Timescale of change	Assessment and description of sea level rise
Future outlook of pressure To 2030 To 2050 To 2010	**Deteriorating** Confidence High Sea level will continue to rise over the next century even if global warming is restricted to below 2ºC. It is difficult to derive a good estimate of historical sea-level rise for Wales alone due to data limitations. Predictions from the Met Office UKCP18 climate projections estimate that sea level rise in North (Llandudno tidal gauge) and South Wales (Newport tidal gauge) will rise by 0.12m and 0.24m respectively between 2030 and 2050 compared to the 1981-2000 average. Longer term predictions estimate sea level rise of 0.40m and 0.47m for North and South Wales respectively between 2050 and 2080 again compared to the 1981-2000 average. When incorporating potential ice sheet and glacier melting into sea level rise, if high-melt years continue, then the Greenland ice sheet could add approximately 0.78m of sea level rise throughout the 21st century (Box *et al.*, 2022).

Pollution in relation to Climate change

The release of Greenhouse Gas (GHG) emissions from the burning of fossil fuels increases the amount of CO2 in the atmosphere which directly increases global surface temperatures which has led to climate change. This climate change puts both the natural environment and human society at risk as global cycles, events and weather patterns change over time. There is likelihood that this change may become irreversible and that the planet could shift into an alternate climate state, of which we do not know the consequences. Even without this alternate state shift, emissions on the current increasing trajectory will make parts of Earth unliveable for all life and make others increasingly inhospitable.

Table 48 Evidence of trends of Greenhouse Gas Emissions

Timescale of change	Assessment and description of greenhouse gas emissions
Long term trend of pressure 1990-2021	**Improving** Confidence High Total territorial greenhouse gas emissions in Wales have fallen by 35% between 1990 and 2021 (Welsh Government, 2023a). Between 2001 and 2020, embedded emissions in imported goods and services were the largest source of consumption emissions in Wales. However, these have decreased by 24% in the 20 year period (Welsh Government, 2023c). Wales met its First Carbon Budget (2016-2020) on the road to Net Zero with a 28% reduction in greenhouse gas emissions compared to 1990 levels (Climate Change Committee, 2023b), a greater reduction than the required reduction of 23%. Although emissions in Wales are falling, global greenhouse gas emissions are on the rise with these increases in atmospheric CO_2 having a negative impact on the climate, nature and humans. It is likely that anthropogenic emissions of greenhouse gasses have already contributed to a global warming of between 1°C and 2°C (IPCC, 2023). Global net anthropogenic greenhouse gas emissions are estimated to be 12% higher than 2010 and 54% higher than 1990 in 2019, with the rate of growth between 2010-2019 of 1.9% /yr. lower than between 2000-2009 of 2.1% /yr. (IPCC, 2023).

Timescale of change	Assessment and description of greenhouse gas emissions
Short term trend 2020-2025	**Stable** Confidence High Yearly greenhouse emissions totals are more changeable than the overall trend, and it should be recognised that the longer trend (here the reduction in emissions from 1990) is a more important and clear result than a year-by-year number. Between 2020 and 2021, greenhouse gas emissions rose slightly by 7% (Garland *et al.*, 2023), with the greatest increases within the transport sector (+10.9%). Overall, in 2021, industry and business contributed 39% to the total emissions of Wales, electricity and heat production 17%, transport and agriculture 16% each, residential buildings 10% and public sector buildings 1%. Land use, land use change and forestry contributed to -2% emissions, a sink of carbon (Garland *et al.*, 2023). When comparing to changes between 2020 and 2023, emissions have remained stable, with a 0.4% increase in Welsh emissions (Bennett *et al.*, 2025). For each sector between 2020 and 2023, there were decreases and increases in emissions. Agriculture (-1.78%), waste (-13.68%) and buildings (-19.5%) all saw decreases in emissions. However, domestic transport (+10.43%), electricity supply (+1.37%), fuel supply (+5.56%), industry (+5.59%), and international aviation and shipping (+21.89%) saw increases (Bennett *et al.*, 2025). The sink of land use, land use change and forestry increased by 18.20% indicating a greater amount of carbon sequestered in Welsh land use (Bennett *et al.*, 2025). Some of these increases may be due to the lower recorded emissions in 2020 due to the Covid19 pandemic and therefore may not reflect a longer term trend. Between 2022 and 2023, overall Welsh emissions decreased by 6% (Bennett *et al.*, 2025). Emissions from power stations reduced by 29%, with 2% and 6% decrease in domestic transport and residential buildings respectively (Bennett *et al.*, 2025). There is some progress in policy to reducing GHG emissions in Wales. For example, all major road projects were cancelled in 2023, and there has been a focus on job development for the Net Zero transition (Climate Change Committee, 2023b).

Timescale of change	Assessment and description of greenhouse gas emissions
Future outlook of pressure To 2030 To 2050 To 2100	[] **Mixed picture** Confidence High Wales is currently into the Second Carbon Budget (2020-2025) period, with a requirement of 37% reduction of emissions compared to 1990 levels (Climate Change Committee, 2023b). The emissions reduction plans from Welsh Government aim to exceed this target with a reduction of 44%. The only potential increases are likely to be within the agriculture sector, which would result in an average reduction in this sector of 9% compared to 1990 levels (Climate Change Committee, 2023b). The Third Carbon Budget period is between 2026 and 2030 aim to reduce emissions by 39% compared to 2019 levels (Climate Change Committee, 2023b). For both current and future Carbon Budgets, change is required in every sector in Wales. This is to meet overall targets to make Wales net zero by 2050. Many Local Authorities, businesses and organisations have pledged to cut emissions and/or become Net Zero in the future. For example, NRW has pledged to support the ambition for a carbon neutral Welsh public sector by 2030 (Welsh Government, 2022a). Welsh Government have also pledged to become net zero as an organisation by 2030, which requires a 90% reduction in emissions compared to 2019-2020 baseline (Welsh Government, 2022b). However, initial modelling suggests achievement of a 55-75% reduction in emissions, with a 15-35% shortfall (Welsh Government, 2022b). These findings suggest that although organisations in Wales, including NRW and Welsh Government, have ambitious targets to reduce emissions, more work is required to meet these targets in the near future. The CCC progress report (Climate Change Committee, 2023b) does flag that Welsh Government is not currently using its full policy powers in terms of emissions reductions. At a global level, greenhouse gas emissions will continue to rise up to 2040 in the majority of scenarios (IPCC, 2023), which will have an impact on Welsh ecosystems and the human population. Post 2040, the rate of greenhouse gas emissions at a global level is dependent on global and country-specific policies.

Effects of climate change on Wales’ ecosystems

An update to the key effects on ecosystems identified in SoNaRR2020 for climate change pressures Key changes and new evidence since 2020 that are likely to impact every ecosystem – **coastal margins, enclosed farmland, freshwater, mountains moorlands and heath, semi-natural grasslands, urban, and woodlands:**

- Updated climate risk in 3rd UK Climate Change Risk Assessment (Climate Change Committee, 2021), with a summary for Wales (Netherwood, 2021)
- Internal climate change adaptation (James *et al.*, 2023) and mitigation (Net Zero Plan in draft, to be published in September 2024) plans outline actions to be embedded into everyday work by NRW staff to ensure our work is resilient to change and reducing our impact on the planet.
- The second Welsh National Adaptation Plan, the Climate Adaptation Strategy for Wales (Welsh Government, 2024) was published in Autumn 2024. This provides an update on the Climate Conscious Wales report (Welsh Government, 2019) and sets out adaptation actions Welsh Government are committing to delivering over 15 cross-sectoral adaptation plans. These include specific actions for nature, agriculture, forestry and woodland, fisheries and aquaculture, communities, and the historic environment amongst others. Natural Resources Wales are included in the plan as a strategic body, with some actions including NRW as a key stakeholder in delivery of those adaptations.

In tables below, if final column is empty, there have been no key changes or new evidence to that effect since 2020, but the effect of that pressure to that ecosystem is still present.

Table 49 Effects of changes in intensity and frequency of weather events on individual ecosystems

Ecosystems affected	Effect on ecosystem	Confidence Assessment	Key changes or new evidence since 2020
Coastal margins	Predicted to lead to the loss in extent of ecosystems from coastal squeeze, increased flooding, erosion and storm damage.	High	None
Coastal margins	Increased risk to people, properties and infrastructure from storm events.	High	(Welsh Government, 2020)

Ecosystems affected	Effect on ecosystem	Confidence Assessment	Key changes or new evidence since 2020
Coastal margins	Increased risk to agricultural land, terrestrial and freshwater habitats.	High	None
Coastal margins	Likely to lead to changes to species composition and habitat distribution due to damage from severe weather events.	Medium	Papers including (Burden *et al.*, 2020; Burton *et al.*, 2023)
Coastal margins	Impacts to ecosystems (including dune systems), terrestrial, marine and freshwater habitats from drought events	Low	Not much evidence at UK or Wales scale, but likely to have an increasing impact in future. Some information in (Burden *et al.*, 2020).
Enclosed farmland	Increased risk of extreme weather events that include flooding, damaging crops, endangering livestock and impacting farmland quality	High	(Wheeler and Lobley, 2021) – recognition that the impacts to farming are generally from extreme events/weather (Farmlytics, 2024)
Enclosed farmland	More frequent prolonged period of dry weather could lead to increased pressure on water resources, soils and the natural environment. Some areas will see an increase in productivity and others a decrease.	High	(Wheeler and Lobley, 2021)

Ecosystems affected	Effect on ecosystem	Confidence Assessment	Key changes or new evidence since 2020
Freshwater	Inadequate flows/water levels to maintain water quality, aquatic biodiversity and river health.	High	(Lane and Kay, 2021) (Dallison *et al.*, 2022) – more water quality focussed but these will still impact freshwater ecosystems
Freshwater	High flow events lead to scouring of habitats, potential wash-out of species and a reduction in water quality due to increased sediment load.	Medium	None
Mountains, moorlands and heaths	Loss of carbon and habitat deterioration from drained/ drought soils, more surface run-off and erosion. Knock-on impacts on water quality from increased run-off.	Medium	Hot, dry summers increasing management recovery times (England focused with fire/cutting management – maybe not as applicable to Wales) (Lees *et al.*, 2021) Scotland focussed (Baggaley *et al.*, 2021)
Mountains, moorlands and heaths	Increased risk of flooding impacting downstream areas habitats and waterlogging upland areas.	Low	This could have a positive impact on ecosystems and could decrease downstream flooding
Mountains, moorlands and heaths.	Increased risk of wildfires.	Medium	Wildfires, when ignited, are likely to be more intense in the future, with chance of a longer fire risk season (Watts, 2023).

Ecosystems affected	Effect on ecosystem	Confidence Assessment	Key changes or new evidence since 2020
Semi-natural grasslands	Causing the altering of the hydrology of some wet grassland systems and die back caused by extreme drying and/or extreme flooding.	Medium	None
Urban	Leading to people being put at high risk from the impacts of severe weather events such as flooding, damage to buildings, power outages and heatwaves.	High	(Huang *et al.*, 2024) – the amount of daytime hours without heat stress are likely to dramatically reduce, and peak heat stress is likely to increase.
Woodlands	Changes in the range, distribution, composition, condition and even survival of native woodland types.	Medium	UK wide predictions of future impacts to forests (Yu *et al.*, 2021)
Woodlands	Impacts on woodland flora and fauna from extreme events such as wildfire, flooding, storms and drought.	Medium	Forest Research – Ovendon et al., 2022 (need access)
Woodlands	Changes in carbon sequestration rates due to loss and changes in health of trees from the impacts of extreme events.	Medium	None
Woodlands	Changes in land availability and suitability.	Medium	None

Ecosystems affected	Effect on ecosystem	Confidence Assessment	Key changes or new evidence since 2020
Marine	Impacts on habitats and species in the shallow subtidal / intertidal and due to changes in wave exposure at the coast, and increased precipitation / riverine discharges	Medium	Increases in storms and waves have occurred but observed trends cannot be directly attributed to climate change because of the high variability and limited understanding of mechanisms (Bricheno *et al.*, 2025, 2025) Assessment of potential impact of climate change pressures on Annex I marine habitats (Oaten *et al.*, 2021).
Marine	Impacts to the marine and coastal environment from increased storminess and turbulence	Medium (current impacts) Low (future impacts)	(Bricheno *et al.*, 2025)

Table 50 Effects of changes in air temperature on individual ecosystems

Ecosystem	Effect on ecosystem	Confidence Assessment	Key changes or new evidence since 2020
Coastal margins	Slow changes to species composition and habitat destruction	Low	Changes likely to be less impactful than for other pressures – less evidence in the literature
Enclosed farmland	More frequent prolonged periods of warmer weather leading to increased pressure on water resources, soils, and the natural environment	Medium	(Arnell and Freeman, 2021)

Ecosystem	Effect on ecosystem	Confidence Assessment	Key changes or new evidence since 2020
Enclosed farmland	Area for best more versatile land predicted to substantially decrease from 2050 under high emissions scenarios	Low	None
Mountains, moorlands and heaths	Loss of carbon and habitat from drained and/or drought soils exacerbated by higher average temperatures	Medium	Potentially more impacts from management than climate change, but both will have an impact e.g. (Gregg *et al.*, 2021) although England example
Mountains, moorlands and heaths	Higher natural treeline and northern drift of species leading to the reduction of montane habitat climate envelope which is likely to cause the loss of plan and bird species including loss of C-sequestration potential from peat forming species	Medium	Not much observed impacts but likely to be a greater issue in the future
Semi-natural grasslands	Causing the altering of the hydrology of some wet grassland systems and die back caused by extreme drying from warmer average temperatures	Medium	Potential impacts of temperatures changing in soils and to the water in the soils which could lead to less water in warmer air temperature conditions.
Urban	Leading to people being put at higher risk of the impacts of long-term warmer temperatures	High	(Huang *et al.*, 2024)

Ecosystem	Effect on ecosystem	Confidence Assessment	Key changes or new evidence since 2020
Urban	Urban heat island effects affecting green space and urban trees	High	(Huang *et al.*, 2024) Some positive impacts to cites through 'greening' (Knight *et al.*, 2021)
Woodlands	Increased risk from pests and diseases including higher likelihood of establishment of INNS	Medium	(Beauchamp *et al.*, 2020)
Woodlands	Changes in tree species suitability based on tree growth and woodland productivity	High	None
Woodlands	Changes in the range, distribution, composition, condition and even survival of native woodland types	Medium	None
Woodlands	Impacts on woodland flora and fauna such as changes in seasonality including budding dates	Medium	Pollen season trends changing - (Adams-Groom *et al.*, 2022) Impacts to woodland birds (southern and eastern UK and species interaction focused) (Pearce-Higgins and Morris, 2022)
Woodlands	Changes in carbon sequestration rates	Medium	None

Ecosystem	Effect on ecosystem	Confidence Assessment	Key changes or new evidence since 2020
Woodlands	Changes in land availability and suitability	Medium	None
Marine	Changes in the length of thermal stratification in UK shelf seas	Low	(Sharples *et al.*, 2022)
Marine	Changes in species distributions impacting life histories, species behaviour, food webs and migration patterns.	Medium	(Burton *et al.*, 2023; Martin, Banga and Taylor, 2023) Intertidal habitats in south Wales may be particularly vulnerable to increases in air temperature over the next century (Oaten *et al.*, 2021).

Table 51 Effects of changes in water temperature on individual ecosystems

Ecosystem	Effect on ecosystem	Confidence Assessment	Key changes or new evidence since 2020
Woodlands	Increased risk from pests and diseases from potentially greater chance of survival in warmer waters in or near woodlands	Low	None
Freshwater	Interference with life cycles and changing population dynamics as a	High	None

Ecosystem	Effect on ecosystem	Confidence Assessment	Key changes or new evidence since 2020
	result of increased water temperature that could include direct mortality of aquatic organisms and indirect impacts to		
Freshwater	Increased susceptibility to INNS and increased likelihood of establishment of INNS due to temperature increases.	High	None
Marine	Increased susceptibility to INNS and increased likelihood of establishment of INNS due to temperature increases.	Medium (high confidence of the presence/impact of INNS but low confidence as to how this will manifest.	(McKnight *et al.*, 2021; UK Climate Risk, 2021)
Marine	Reduced dissolved oxygen concentrations impacting ocean circulation and water movements, increasing	High (low for stratification)	(Oaten *et al.*, 2021) (Mahaffey *et al.*, 2020) (Sharples *et al.*, 2022)

Ecosystem	Effect on ecosystem	Confidence Assessment	Key changes or new evidence since 2020
	water stratification.		
Marine	Impacting on food webs, with effects seen in seabed-dwelling species, as well as plankton, fish, birds and mammals.	High	Temperature changes are affecting fish growth and age at maturation in UK waters (Fox *et al.*, 2023).
Marine	Reduced dissolved oxygen: Impacting on food webs, with effects seen in seabed-dwelling species, as well as plankton, fish, birds and mammals.	Low	Short term measurements (2014-2015) for the Celtic Sea indicated oxygen deficiency in late summer, which can have negative effects on marine ecosystems, although the lack of historic data means it is not possible to verify whether this is a recent development or a regularly occurring phenomenon (Mahaffey *et al.*, 2020)
Marine	Changes in species distributions impacting life histories, species behaviour, food webs and migration patterns due to losses in	Medium (likely that these changes will occur but hard to predict where)	(MCCIP, 2020; Martin, Banga and Taylor, 2023) (Moore and Smale, 2020) – infauna experiencing greatest impacts of distribution changes due to air temperature changes

Ecosystem	Effect on ecosystem	Confidence Assessment	Key changes or new evidence since 2020
	breeding ground, warmer conditions in northerly areas and greater extremes of temperature		

Table 52 Effects of ocean acidification on individual ecosystems

Ecosystem	Effect on ecosystem	Confidence Assessment	Key changes or new evidence since 2020
Marine	Impacting on food webs, with effects seen in seabed-dwelling species, as well as plankton, fish, birds and mammals.	Medium	(Greatorex and Knights, 2023; Findlay *et al.*, 2025)
Coastal margins	Changes to water quality and/or salinity in coastal waters	Low	(Mahaffey *et al.*, 2020)
Coastal margins	Changes to species and ecosystem composition	High	None

Table 53 Effects of sea level rise on individual ecosystems

Ecosystem	Effect on ecosystem	Confidence Assessment	Key changes or new evidence since 2020
Coastal margins	Predicted to lead to the loss in extent of ecosystems from coastal squeeze, increased flooding, erosion and storm damage.	High	(Masselink *et al.*, 2020; Burton *et al.*, 2023)

Ecosystem	Effect on ecosystem	Confidence Assessment	Key changes or new evidence since 2020
Coastal margins	Changes to ecosystem composition and habitat destruction	High	(Masselink *et al.*, 2020)
Enclosed farmland/semi-natural grassland	Increased risk to agricultural land, terrestrial and freshwater habitats	Medium	(Keay, 2020; Netherwood, 2021)
Urban	Leading to people in coastal urban areas being put at high risk from gradual coastal erosion, flooding and loss of land	High	(Buser, 2020) (Young and Essex, 2020)
Urban	Increasing risk of the loss and damage to infrastructure and transport networks	High	(Beaven *et al.*, 2020) (Haigh *et al.*, 2022)
Marine	Intertidal features of marine SACs and all saltmarsh communities will be highly vulnerable to sea level rise	Medium	(Oaten *et al.*, 2021)

Responses and Opportunities for action

Responses to SoNaRR2020 Opportunities

In SoNaRR 2020 we identified both mitigation and adaptation opportunities for action. Table 54 and Table 55 give examples of actions that have taken place in Wales, UK, or further afield.(NRW, 2021a, sect. 6)

Table 54 Update to mitigation opportunities identified in SoNaRR2020

Mitigation Opportunity from SoNaRR2020	Response
Nature recovery and habitat restoration will be crucial to climate change mitigation by both reducing emissions and increasing carbon sequestration from ecosystems.	There are multiple projects working towards and delivering nature recovery and restoration that contributes to a reduction in GHG emissions and increasing carbon sequestration. These include the Nature Recovery Programme, National Peatland Action Programme and Natur am Byth supported by the 30 by 30 and Biodiversity Deep Dive initiatives. In 2022, Welsh Government led the Biodiversity Deep Dive, to develop a series of actions to protect and manage 30% of Wales' land, freshwater and sea for nature by 2030. This comprises of eight objectives with associated actions of climate relevance including; Ensuring that designation of a new National Park in northeast Wales provides climate change mitigation opportunities as a key delivery priority (Biodiversity deep dive: recommendations [HTML] | GOV.WALES). NPAP restored approximately 2280 ha peatland in Wales between 2020 and 2023, increasing the carbon storage potential of these habitats and reducing emissions from degraded peat.
Restoring peatlands and other soils is also key to maintaining carbon storage and reducing GHG emissions. Avoiding damage and erosion is important for retaining existing carbon stores and vegetation.	NPAP is a 5-year programme begun in 2020 funded by WG and led by NRW. >1650ha restored in first two years, exceeding targets. Further 630 ha in 22/23. Programme likely to be extended to 2031. The restoration targets will significantly ramp up and reach 1800 hectares of peatland restoration action per year by 2031, i.e. a tripling of ha restoration targets by 2031.

Mitigation Opportunity from SoNaRR2020	Response
Sustainable agriculture can maintain soil carbon stores, help regulate water quality and contribute to other ecosystem functions, e.g. reducing fertilizer and ploughing, better hedgerow management, woodland creation	NRW is working with Welsh Government on development of the Sustainable Farming Scheme, including to achieve the climate mitigation outcomes. NRW has a role to play in both advising WG on the Sustainable Farming Scheme (SFS) proposals and in providing data, advice and officers to assist in delivery of the SFS proposals relating to freshwater ecosystems. For example, we have advocated for more prominent inclusion of incentives to improve water quality, quantity, efficiency of use and riparian zone management under the Universal Action layer of the Scheme. We have also inputted to the SFS continuing professional development (CPD) e-modules. These modules are designed as an introduction to SFS themes for farmers. Relevant to this CCC recommendation, we have contributed to modules on farm nutrient, waste and emissions management. The SFS provides an opportunity for farmers to implement sustainable farming methods that have positive impacts now and into the future.
Enhancing blue carbon through protecting and restoring marine and coastal ecosystems as another contributor to meeting mitigation goals	Seagrass restoration is occurring at a small scale in Wales. One project in Pembrokeshire (Unsworth, Furness and Rees, 2022) has succeeded in replanting seagrass with 2 hectares of grasses restored. While currently at a fairly low density, these seagrass beds will sequester carbon which should increase as the beds establish. The Blue Carbon Forum (Blue Carbon Forum Cymru – epwales.org.uk) has just had it's inaugural meeting in September 2024 with an aim to share information and knowledge, and to increase the expertise and experience around blue carbon in Wales.

Table 55 Update to adaptation opportunities identified in SoNaRR2020

Adaptation Opportunity from SoNaRR2020	Response
Restoring damaged ecosystems, such as woodlands, peatlands, rivers and wetlands will contribute to adaptation and increase resilience of the natural environment	The idea of Resilient Ecological Networks (RENs) is to improve functional connectivity between protected sites to improve their resilience and adaptability to climate change. RENs are being developed in Wales and NRW is working to help embed them within local planning. NRW was involved in WG's Biodiversity Deep Dive (2022) which gave eight recommendations to deliver 30x30, including actions to review the contribution of existing protected sites to 30x30, and to develop a Nature Networks Map. The first stage of the map was completed in 2023, indicating how different habitats are functionally connected across Wales. A version of these maps known as PENs (Priority Ecological Networks) indicate functional connectivity between and around protected sites. These maps (available on Datamap Wales) can be used to inform the location of actions such as habitat creation and restoration to improve functional connectivity and hence resilience to climate change.
Further adaptation measures will also be needed to protect biodiversity in a changing climate	Internally, NRW are implementing adaptation actions through the first Climate Change Adaptation Plan (James *et al.*, 2023), with some actions tailored to our work protecting biodiversity. Wales-wide, Welsh Government are imminently publishing the second Welsh National Adaptation Plan (NAP) in Autumn/Winter 2024 (to be updated when published). This new report will build from the 2019 national adaptation plan Prosperity for All: A Climate Conscious Wales (Welsh Government, 2019), and respond to recommendations from the Climate Change Committee (Climate Change Committee, 2023a).

Adaptation Opportunity from SoNaRR2020	**Response**
Increasing evidence is available of the effectiveness of adaptation measures e.g. improved water quality also lowering water temperatures, reducing habitat fragmentation to increase species resilience	For example: river restoration projects have found that reforesting riparian zones can lower water temperatures in shaded areas (Bowler *et al.*, 2012)Increases in water quality have been successfully modelled (Hutchins *et al.*, 2024), with observed impacts not yet reported widely. However, an adaptation progress report from the CCC (Climate Change Committee, 2023a) analysing the uptake of the first Welsh NAP (Welsh Government, 2019) stated that while some positive examples of adaptation in Wales exist, the is insufficient progress in delivery and implementation, and a lack of monitoring, with significant data gaps. Suggesting that this opportunity is not fully met from SoNaRR2020 and should be taken forward into SoNaRR2025. Reports such as the Keeping Rivers Cool manual (Lenane, 2016) developed by the Environment Agency, with some NRW involvement provide ways to reduce the risks of climate change to rivers in multiple different ways.
Urban and rural green infrastructure can deliver adaptation benefits alongside other ecosystem services	Recent publication detailing the future impacts of heatwaves to Welsh cities (Huang *et al.*, 2024) highlights the need for urban green infrastructure to reduce damaging impacts to people.
Sustainable drainage systems (SuDS), which manage water flow to reduce flooding, can be an important climate change adaptation measure	Uptake of SuDS remains limited but is becoming more encouraged in new construction (Gimenez-Maranges, Breuste and Hof, 2020).
A range of measures must be put in place to reduce the risk of river and flash floods, with a recognition that a more holistic approach is needed, including natural flood risk management methods	The 2023-2027 Flood Risk Management Plan developed by NRW includes consideration of implementing natural flood risk management methods through nature-based solutions to reduce the risk of flooding in Wales (NRW, 2023).

Adaptation Opportunity from SoNaRR2020	Response
Similar adaptation strategies can be put in place along the coast with potential for collaboration. Working with natural processes enhances strategies.	The Coastal Adaptation Programme (CAP) is a range of projects led by NRW to review options for managing coastal flood risk in areas most at risk from sea level rise, which is exacerbated by climate change. An example of one ongoing project at Laugharne Lower Marsh, where approx. 58 ha of freehold land has been acquired by NRW to create wetland and saltmarsh habitat through managed realignment contiguous with the current Special Area of Conservation (SAC). This proactively seeks to address the challenge of managing an area within an SSSI at risk of sea level rise and also progresses the implementation of the second Shoreline Management Plan epoch.
Drought plans of both NRW and water companies in Wales provide a flexible framework for identifying and managing drought events.	Ongoing work with the Drought Review internally in NRW aims for a more proactive identification and response to droughts. Welsh Water has published both a Drought Plan (Dŵr Cymru Welsh Water, 2021) and Adaptation Report (Dŵr Cymru Welsh Water, 2023) since 2020 to outline the risks from droughts and set out actions to adapt to a higher likelihood of hot, dry conditions.

For many of the existing adaptation opportunities, the first NRW Climate Change Adaptation Plan (James *et al.*, 2023) provides priority actions for each Business Group, Sub-Group and Directorate. Many of these priority actions cover the above opportunities, with the aim to embed adaptation to climate change into everyday work at NRW. These will be monitored and evaluated through a light-touch process that will follow the Corporate Plan monitoring framework, when available.

Externally, Welsh Government published the second National Adaptation Plan as the Climate Adaptation Strategy for Wales (Welsh Government, 2024) in October 2024. The Strategy sets out adaptation actions over the next 5 years that Welsh Government, and delivery partners, are committed to delivering to adapt and respond to the changing climate.

Opportunities for SoNaRR2025

Opportunities from SoNaRR2020 remain relevant to SoNaRR2025. These are outlined below for both mitigation and adaptation. Often these opportunities are aligned with both mitigation and adaptation, and wider natural resource management opportunities, so are often linked.

Integrating adaptation and mitigation into other natural resource management, for example, flood risk management and designated site management, has the ability to increase the resilience of communities to multiple threats, while reducing the impacts of climate change.

Adaptation and mitigation are both crucial in reducing the impacts of climate change, and the rate of greenhouse gas emissions. Both hold the potential for significant opportunities to enhance ecosystems and natural resources in Wales.

Mitigation

Nature recovery and habitat restoration is crucial to climate change mitigation through reducing emissions and increasing carbon sequestration from ecosystems. Opportunities for action include updated nature recovery and carbon mitigation targets committed to by Welsh Government, such as increasing the number of hectares of peatland to be restored.

The launch of the Sustainable Farming Scheme is an opportunity to help maintain soil carbon stores, regulate water quality and contribute to other ecosystem functions, with the correct support.

Mitigating against climate change through enhancing blue carbon through protecting and restoring marine and coastal ecosystems.

Urban and rural green infrastructure has the opportunity to reduce carbon emissions through tree planting and the development of diverse green space.

Adaptation

Restoring damaged ecosystems and increasing the diversity of these ecosystems increases their resilience to climate change and provides an opportunity for adaptation.

There is increasing evidence of the effectiveness of adaptation measures, although there are further opportunities to increase the amount of adaptation implemented on the ground.

Urban and rural green infrastructure provide multiple benefits and opportunities for adaptation to climate change, including the implementation of SuDS projects.

Working with natural processes at the coast enhances adaptation strategies, with opportunities for collaboration and multiple benefits for communities and coastal stakeholders.

Plans in place for significant events like drought, flooding and wildfire provide flexible, proactive frameworks for identifying and managing events likely to be exacerbated by climate change.

Synergies and Trade-offs

Each Ecosystem and Theme chapter in SoNaRR2020 includes a section on Synergies and Trade-off. These are summarised below

- CCRA3 – UK climate change risk assessment with associated Wales summary highlights risks to Wales from climate change in terms of everything from nature to infrastructure and international aspects.
- Climate change will restrict certain species' habitat niches e.g. 'pushing' species to higher elevations which may mean other species/habitats lose out from others moving into their suitable spaces
- Multiple benefits are likely from both adaptation and mitigation strategies in multiple ways
    - One intervention can meet both mitigation and adaptation e.g. habitat restoration increases the ability of an ecosystem to sequester carbon and increases the resilience of that ecosystem to change such as through natural flood management
    - Collaboration between teams internally within NRW and with partners may lead to better partnerships and the dissemination of knowledge and sharing of practices
    - Mitigation strategies may reduce the need for or scale of an adaptation strategy and vice versa which could reduce costs in all areas (financial, people, resource)
- Responding to climate change in a proactive and integrated way will reduce the trade offs, although these are likely to remain
- Trade-offs between land use and availability are likely to occur. This could arise, for example, through increasing land into natural flood risk management for adaptation (e.g. flood plain creation, re-meandering of a river, tree planting upstream of flood-prone area) which then may remove land from another land use such as farming, recreation, forestry, grassland etc. Care must be taken to understand the impacts of all interventions, including no active intervention, and decisions made on a variety of viewpoints including the future resilience of the system.

Evidence needs

Research is often at large spatial scales and may not explore the finer scale that might be required for making Wales-based decisions. The evidence needs at this finer scale are discussed within each of the SoNaRR 2025 assessments – ecosystem, natural resource, biodiversity and National Aims.

Evidence needs from SoNaRR2020 are still relevant

Climate Change Driver of Change References

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Annex 2: INNS evidence

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Why do INNS matter

INNS are one of the five direct drivers of biodiversity loss worldwide (Secretariat of the Convention on Biological Diversity, 2020; IPBES, 2023). They can affect ecosystem resilience in many ways including through competition, predation, environmental impact, spreading diseases, genetic impacts/hybridization and by altering the structure of ecosystems (Manchester and Bullock, 2000; Roy *et al.*, 2017; IPBES, 2023).

INNS can impact on well-being by affecting recreational activities, exacerbating flooding and affecting overall human health (Pejchar and Mooney, 2009; Ebi, Frumkin and Hess, 2017; Jones and McDermott, 2018; Kumar Rai and Singh, 2020).

INNS also have impacts on the prosperity of Wales; they primarily affect agricultural, forestry, and horticultural activities, and can also impact aquaculture, transport, utilities, and construction (Booy *et al.*, 2017; Eschen *et al.*, 2023).

The economic valuation of the cost of INNS to Wales carried out in 2010 (£125 million a year (Williams *et al.* 2010)) was updated in 2023 and is now estimated to be at least £343 million a year (£147 million excluding the cost of fungi)(Eschen *et al.*, 2023).

INNS affect all the ecosystems identified in SoNaRR 2020 (Natural Resources Wales 2020) in Wales, therefore tackling INNS will be key to maintaining and enhancing the resilience of ecosystems and the benefits they provide for current and future generations and thereby support the delivery of the sustainable management of natural resources. Improving ecosystem resilience by tackling INNS will also help to mitigate the impact of climate change.

A key reason for addressing INNS when trying to achieve SMNR is that there are clearly defined ways in which national, regional and local management can be implemented to minimize their risk, unlike other pressures such as climate change, where mitigation needs to be enacted globally to be effective.

Targeted management can have significant impacts on the potential impacts of INNS (e.g. New Zealand where strong INNS prevention and control limits the damage this pressure presents (Hulme 2020).

Current situation, past trends and future outlook for pressures from INNS

Table 1 describes:

- The past trends and future outlook for pressures related to INNS in relation to the broad ecosystems (coastal margins, enclosed farmland, freshwater, marine, mountain, moorland and heath, semi-natural grassland, urban, woodlands) and natural resources (air, soil, water). See method: **Defining the long and short term**

- Any new evidence, strategies, policies and interventions since 2020 that are likely to impact future trends.

It is intended as an update to the relevant trends set out in the 2020 INNS chapter (NRW, 2021).

The evidence to describe the specific effects and pressures on Wales' ecosystems from pests and diseases is provided through the relevant ecosystems, particularly coastal margins, enclosed farmlands, marine, urban and woodlands. You can find the evidence within the SMNR assessments and the SoNaRR 2025 evidence portal.

Long term trend of INNS as a pressure in relation to broad ecosystems and natural resources

Timescale: **1500/1800-2023**

Overall assessment: **Deteriorating**

Confidence of assessment: **High**

Historically over 2,000 plants and animals have been introduced to Britain from all over the world by people. Most are harmless but a small proportion (10-15%) become invasive (NNSIP, 2020; GBNNSS, 2023). This situation is reflected globally with 13.5% of reported and 14.2% of established non-native species being identified as becoming invasive (IPBES, 2023).

A 'pathway' is the route by which an INNS can be introduced or spread. An in-depth analysis of pathways of introduction to GB was undertaken in 2019 (Booy, 2019; GBNNSS, 2019b) which identified pathways of introduction for the most damaging INNS. The top five priority pathways identified were:

1. hull fouling
2. horticulture escapes
3. contaminants of ornamental plants
4. ballast water
5. stowaways on fishing equipment.

Historically most established non-native species in GB have been introduced for ornamental purposes (e.g. garden planting and introduction of exotic animals). There is an increasing number of non-native species for which the pathway of arrival is unknown (see figure 1, NNSIP, 2020).

In terrestrial ecosystems in Britain the majority of the established non-native species arrived through ornamental introductions (NNSIP, 2020).

The dominant pathways for non-native species in the freshwater ecosystem is both ornamental and aquaculture (NNSIP, 2020).

In Wales the marine pathways of most concern are commercial shipping, recreational boating, shellfish gathering/production sites and offshore activities (Tidbury *et al.*, 2014; Dewey, N., Pack, K., Williamson, D, Walsh, A., 2021). Figure 1

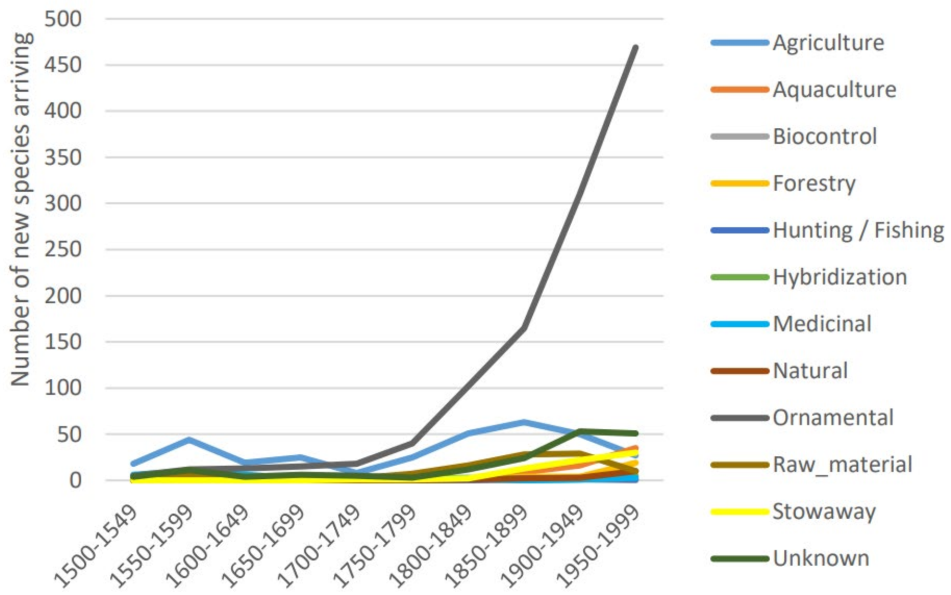

Figure 7 Number of established non-native species arriving in GB through different pathways against the date of first arrival (NNSIP, 2020).

Globally the number of established INNS have risen at continuously increasing rates for several centuries recently reaching the highest total number of established alien species and highest annual rate of new records (IPBES, 2023). This is mirrored by the situation in Britain with similar trends in introduction (Keller, Zu Ermgassen and Aldridge, 2009; Roy *et al.*, 2014; NNSIP, 2020; Kinlock *et al.*, 2022). Between 1950 and 2020 non-native species established on average at a rate of 10.7 annually, compared with a rate of 0.9 species annually between 1600-1799 (NNSIP, 2020). The number of established non-native species identified as having a negative ecological or human impact has been increasing with 2 new species per year causing an impact in GB since 2000 (IPBES, 2023).

Globally the annual rate of the first records of non-native species has increased during the last 200 years, with 37% of all first records reported most recently (1970–2014) (Seebens *et al.*, 2017). This is attributed to the spread of European settlers to new areas of the globe in the nineteenth century and to the acceleration in trade in the twentieth century. Research (Seebens *et al.*, 2017) shows the increase in numbers of alien species globally for all taxa does not show any sign of saturation with most taxa showing increases in the rate of first records over time.

Globally the highest numbers of established alien species records have been reported for vascular plants, insects, fish, fungi, and molluscs (IPBES, 2023). For invertebrates, algae, and microorganisms, numbers and rates showed a marked increase particularly after 1950, this is likely to be due to increasing trade (IPBES, 2023). Globally mammals represent the only taxonomic group where the rate of new annual records has consistently declined since 1950 (however non-native mammal species are still arriving), this is likely to be caused by stricter regulations (IPBES, 2023).

In Britain the highest number of established alien species have been plants, followed by insects, non-insect invertebrates, vertebrates, algae and then lower plants (Roy *et al.*, 2014).

A key finding of the recently published Plant Atlas (Stroh *et al.*, 2023) is that there are now more introduced plant species growing in the wild in Great Britain (GB) than natives (plant species recorded 3,445, 1,692 were native to GB and 1,753 were non-natives). Many of these newly arrived taxa are of interest and have been identified as needing their invasive potential to GB assessed (Dehnen-Schmutz and Conroy, 2018; Jones *et al.*, 2024).

Indirect drivers (social, cultural, economic, governance, technological) and other direct drivers which interact with INNS.

The introduction of non-native species is driven by human activities Figure 2 shows that invasion trends and trends in human socio-economic activities are often closely corelated (Levine and D'Antonio, 2003; Meyerson and Mooney, 2007; Pysek *et al.*, 2010) (e.g. global trade, shipping, human population size and migration, land use for urban and agricultural purposes and tourism (Roy et al., 2023)).

Before 1800, the introduction of non-native species worldwide was largely driven by European colonialism, while recently introductions for ornamental purposes or those associated with international transport have become more significant (Hulme, 2009; IPBES, 2023).

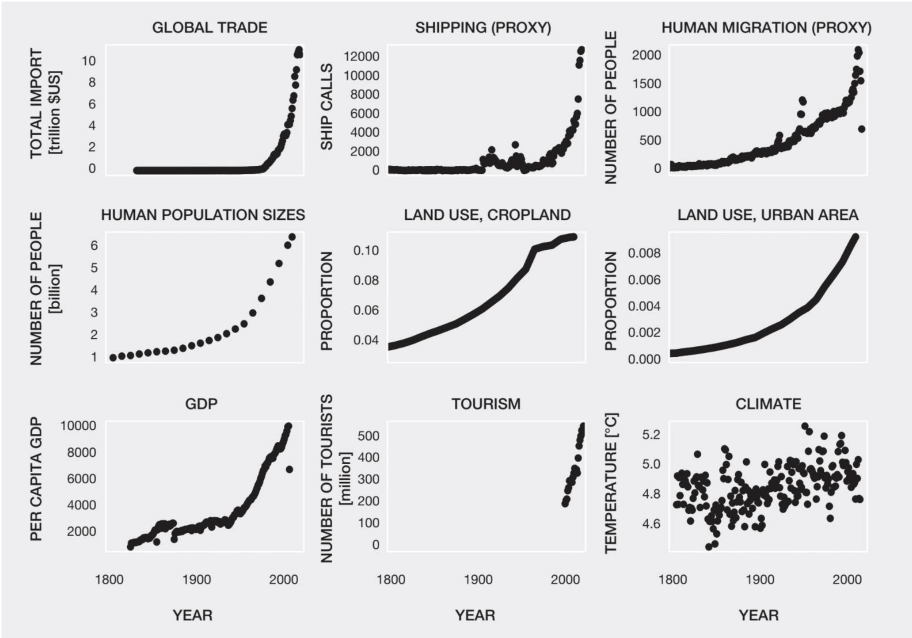

Figure 8 Trends in drivers of change in nature and correlates of biological invasions averaged globally (IPBES, 2023).

Different drivers may affect invasion dynamics and become important during different stages of the invasion process. For example, the increased movement of people and goods (Westphal *et al.*, 2008; Hulme, 2009; Convention on Biological Diversity, 2014; GBNNSS, 2019b) are major drivers promoting the intentional or unintentional introduction of non-native species, while climate change and habitat degradation can have a more significant impact on the establishment of non-native species (Firn *et al.*, 2015; Seebens *et al.*, 2015). Climate change could provide conditions that would enable some new non-native species to be introduced and establish (Walther *et al.*, 2009) or enable non-native species that are present in Wales to become invasive (Poland *et al.*, 2021). Also climate change may lead to a greater demand for plants which can tolerate the new climate conditions which may lead to the introduction of new INNS (Bradley *et al.*, 2012). Conversely climate change may inhibit the establishment, spread, invasive tendencies and/or range of some INNS (Bellard *et al.*, 2013; Sorte *et al.*, 2013; Bezeng *et al.*, 2017; Merow *et al.*, 2017).

Recent assessments required for Descriptor 2 of the MSFD showed a static rate of new introductions in the marine environment from 2009 – 2014 (OSPAR Commission, 2017) and reducing range of established marine INNS from 2003 – 2020 (Cefas, in prep) which goes against the general overall trend for the introduction of INNS.

However a recent re-survey of non-native species in marinas in Wales in 2023 shows that there has been an increase in marine INNS at Welsh sites, in particular in north Wales, compared to 8-10 years ago (Wood et al., in prep). This suggests on a micro-scale at least, that Wales, especially north Wales, could be ‘catching up’ with the number of INNS present in other areas of the UK.

Short term trend of INNS as a pressure in relation to broad ecosystems and natural resources

Timescale: **2020-2025**

Overall assessment: **Mixed Picture**

Confidence of assessment: **High**

Short term trends in the rate of the establishment and spread of INNS and trends in the pathways of arrival have continued to remain the same as the historic trends. With approximately 10-15 non-native species establishing in GB annually and approximately 2 of those likely to be reported as being invasive (NNSIP, 2020).

Globally the overarching drivers affecting the introduction and spread of INNS are likely to continue to increase (e.g. climate change and the movement of goods and people) (IPBES, 2023).

Often there is a lag in terms of the establishment of new non-native species which can make it difficult to detect short term trends and the effectiveness of interventions in the short term (GBNNSS, 2019b). The GB pathways analysis predicts that the pathways of introduction are likely to remain the same in the short term (GBNNSS, 2019b).

Figure 3 shows that the number of INNS of priority to Wales present in the UK and in Wales has increased between 2020 and 2024.

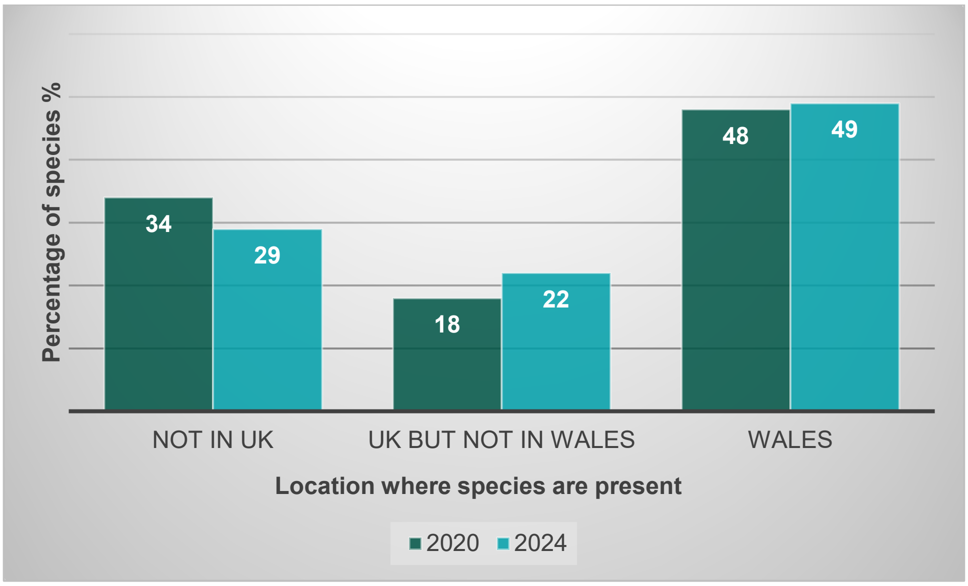

Figure 9 the change between 2020 and 2024 in the percentage of INNS of priority to Wales present in three locations (not in the UK, in the UK but not in Wales, in Wales).

There have been some range expansions of notable marine INNS species in Wales since 2020, for example *Crepidula fornicata* has arrived in the Menai Strait and *Didemnum vexillum* in Milford Haven.

At a GB level action is being taken to address unmanaged pathways of introduction and to take action to address newly arrived species and to prevent priority species from establishing (GBNNSS, 2023). This has been achieved by implementing legislation and through commitment to the renewed GB INNS Strategy 2023-2030, including the creation of a Non-Native Species Inspectorate for GB (GBNNSS, 2023).

The focus of INNS policy and legislation in GB is on prevention (GBNNSS, 2023; IPBES, 2023).

The main interventions that have occurred since 2020 include the embedding and implementation of the Invasive Alien Species (Enforcement and Permitting) Order 2019 which enabled the retained EU Invasive Alien Species Regulations (EU 1143/2014) (IAS Reg) to be enforced and regulated. The main focus of this legislation is to prevent the introduction of listed species of special concern into the environment by restricting activities associated with them. The use of Wales INNS contingency plans drafted to support the action of government and agencies in tackling incursions of prevention priority species (including species of special concern listed under the IAS Reg) has been demonstrated to be effective in preventing the establishment of newly arrived listed species (i.e. Raccoon dog (*Nyctereutes procyonoides*)).

A pilot GB non-native species inspectorate (NNSI) has been established that covers Wales and they have begun to gather information and inspect sectors that pose a risk of introductions of INNS and as part of this raise awareness and provide advice about bringing activities under regulation. The role and powers of the NNSI are likely to extend in future as they become fully operational.

Another key intervention since 2020 has been the continued drafting and implementation of GB pathway action plans that target the priority pathways identified in the GB pathway analysis undertaken in 2019.

In the marine environment, a number of INNS and biosecurity projects which have the potential to reduce rates of introduction and spread are or have been implemented in Wales since 2020.

Some of these interventions have had an immediate impact on INNS, for example the implementation of contingency plans, while others are likely to take longer to affect the rate of establishment and spread. It is challenging to determine the impact of these interventions as short term trends are difficult to identify given establishment of INNS is around 2 species per year and there is often a time lag before they establish. It is anticipated that the rate of establishment and spread of INNS will continue in the short-term with the effect of interventions not being known for some time.

Future outlook of INNS as a pressure in relation to broad ecosystems and natural resources

Timescale: To 2030 and To 2075

Overall assessment: **Deteriorating**

Confidence of assessment: **Medium**

Models and scenarios that predict biological invasion dynamics are scarce and underdeveloped, hindering a robust assessment of future dynamics (IPBES, 2023). There is a need to build on and apply recent research that models and predicts pathways and biological invasion dynamics (GBNNSS, 2019b; Essl *et al.*, 2020; Roura-Pascual *et al.*, 2021).

The key global drivers affecting the introduction and spread of INNS have been the increased movement of people and goods (Levine and D'Antonio, 2003; Meyerson and Mooney, 2007; Westphal *et al.*, 2008; Hulme, 2009; Convention on Biological Diversity, 2014; GBNNSS, 2019b), unmanaged pathways of introduction and climate change (Firn *et al.*, 2015; Seebens *et al.*, 2015).Changes in the climate may lead to changes in the establishment and spread of INNS and INNS can make ecosystems less resilient to the effects of climate change (IPBES, 2024).

The historic global trends of INNS are predicted to continue to accelerate for many taxonomic groups (Seebens, Bacherj, *et al.*, 2021). The number of established non- native species is expected to rise further with a predicted 64% increase in species establishing in European countries by 2050 (Seebens, Bacher, *et al.*, 2021). This prediction is based on a business as usual scenario and given the projected acceleration of the majority of direct and indirect drivers of change in the spread of INNS, it is likely that the numbers of established non-native species will be higher than those predicted (IPBES, 2023).

Globally the rate of increased establishment of non-native species is expected to accelerate for most species, for example rates are predicted to rise further for invertebrates, such as insects and molluscs and this is likely to be a consequence of anticipated increasing trade and transport (IPBES, 2023). While the rate of the establishment of mammals is expected to slow down (but still be increasing), this is likely to be due to legal restrictions and efforts to prevent their introduction and spread (Seebens, Blackburn, *et al.*, 2021).

Globally the abundance of INNS is also expected to increase as already introduced species begin to spread further (IPBES, 2023).

The Celtic Sea (including Welsh and Irish waters) has approximately 2-3 new introductions of non-native species every year (European Environment Agency, 2021). Historic marine pathways in Wales are unlikely to change substantially in the medium/long term (20-50 years (e.g. commercial shipping and recreational boating) possibly with the exception of offshore activities and new shellfish gathering/production sites (Dewey et al., 2021). The interest in Wales of cultivating non-native seaweeds is increasing and could be a new pathway in future (Dewey *et al.*, 2021).

It is anticipated that the full implementation of the Ballast Water Management (BWM) Convention' in Wales will reduce the risk of INNS spreading through this pathway in future. The 'Marine Invasive Non-Natives Species (INNS) Biosecurity Planning Across the Marine Protected Area (MPA) Network Project' may reduce the rate of the establishment and spread of marine INNS in Wales.

Effects of Invasive Non Native Species

An update to the **key effects** on ecosystems identified in SoNaRR2020 for INNS

Evidence describing effects on ecosystem services and the benefits provided or lost

Table 56 Effects on Ecosystems and Ecosystem Services – Coastal Margins

Effects on coastal margins ecosystem, ecosystem service and benefits	Key changes or new evidence since 2020
INNS have the potential to alter the structure of the coastal margin ecosystem by outcompeting or predating on native species, thereby affecting their abundance and diversity and can act as a stabiliser on dune systems. Confidence: High	There has been no significant new evidence since 2020, however below is a review which provides links to sources of evidence which support the changes to the current statement. Examples of species that outcompete native species on dunes systems which were targeted by the Sands of LIFE project in Wales (2018-2024) include: *Rosa rugosa*, Sea buckthorn (Hippophae rhamnoides), *Cotoneaster Spp.*, Montbretia (Crocosmia pottsii x aurea = C. x crocosmiiflora), Rhododendron (*Rhododendron ponticum*), Himalayan balsam (Impatiens glandulifera), New Zealand flax (*Phormium tenax*) and Laurel (*Prunus laurocerasus*). The Article 17 (JNCC, 2019a) habitat report identifies in detail which non-native species affect the condition of the different protected habitats in this ecosystem in Wales. For example, Himalayan balsam (*Impatiens glandulifera*), Montbretia (*Crocosmia pottsii x aurea = C. x crocosmiiflora*) and *Rhododendron ponticum* were reported as affecting 'vegetated sea cliffs of the Atlantic and Baltic coasts' habitat (e.g. within Clogwyni Pen Llyn SAC). Examples of non-native species that have been found to stabilise dune habitats in Wales include Sea buckthorn (*Hippophae rhamnoides*) and *Cotoneaster Spp*. Sea buckthorn (*Hippophae rhamnoides*) is reported as being a significant issue on sand dune systems in south Wales (e.g. affecting 'Humid dune slacks' and 'Dunes with *Salix repens* ssp. Argentea (*Salicion arenariae*)').

Effects on coastal margins ecosystem, ecosystem service and benefits	Key changes or new evidence since 2020
	The Article 17 report also highlighted that Australian tubeworm (*Ficopomatus enigmaticus)* and *Agarophyton vermiculophyllu*m (previous synonym *Gracilaria vermiculophylla*) are a potential risk to coastal lagoon habitat. Risk assessments produced by the GB Non-Native Species Secretariat and other government bodies and data sheets produced by CABI provide a useful overview of the likely impacts of INNS on coastal margins and these have been referenced below where they support the statement above. Non-native species which may predate or outcompete native species found in coastal margins include the Wall Lizard (*Podarcis muralis*) (GBNNSS, 2015c) which affect Sand lizards and native invertebrates. The Killer shrimp (*Dikerogammarus villosus*) (GBNNSS, 2010b) can cause localised extinctions of invertebrates and American mink (*Neovison vison*) (Palazón and Roy, 2014) can affect ground nesting birds (Craik, 1997). Sea buckthorn (*Hippophae rhamnoides*) (National Biodiversity Data Centre, 2014) can fix nitrogen in the soil and affect nutrient levels (Mason, A., 1985), and Killer shrimp (*Dikerogammarus villosus*) can displace native species which can affect nutrient dynamics. A heat map that shows the distribution of INNS that have the potential to impact coastal margin ecosystems is available on the Wales Environmental Portal (Natural Resources Wales, 2024).

Table 57 Effects on Ecosystems and Ecosystem Services – Freshwater

Effects on freshwater ecosystem, ecosystem service and benefits	Key changes or new evidence since 2020
INNS introduce pests and diseases and outcompete or predate native species affecting their abundance and diversity in freshwater ecosystems. Confidence: High	There has been no significant new evidence since 2020 however below is a review which provides links to sources of evidence which supports the changes to the current statement. The INNS targeted by the Four Rivers for LIFE project in Wales (2022-2027) include: Himalayan balsam, (*Impatiens glandulifera*), Skunk Cabbage (*Lysichiton americanus*), Japanese knotweed (Fallopia japonica) and Giant hogweed (*Heracleum mantegazzianum*). They have been selected due to the impact that they are currently having on four riverine SACs in Wales. As well as the Article 17 reporting risk assessments produced by the GB Non-Native Species Secretariat or the EU provide a useful overview of the likely impacts of INNS on freshwater habitats in GB/EU and these have been referenced below where they support the statement above. The 2019 Article 17 species (JNCC, 2019b) condition assessment report for White clawed crayfish highlighted that Signal crayfish (*Pacifastacus leniusculus*) are a major pressure for this species as they aggressively outcompete White clawed crayfish and carry crayfish plague which is lethal to White clawed crayfish (Bubb, 2004; GBNNSS, 2011g). While the assessment for Atlantic salmon highlights the impact that Signal crayfish (*Pacifastacus leniusculus*) can have on recruitment in head waters (Peay et al., 2009; Findlay, Riley and Lucas, 2015). The Atlantic salmon assessment also highlights that species such as Pink Salmon (*Oncorhynchus gorbuscha*) pose a potential risk of introducing novel pests and diseases to wild salmon stocks and that Topmouth gudgeon (*Pseudorasbora parva*), could be a threat to Salmon as it is a known vector for the parasite *Sphaerothecum destruens* (GBNNSS, 2011h; Spikmans et al., 2020) but the Article 17 report also acknowledges that the current populations of Topmouth gudgeon (Pseudorasbora parva) in Wales have not affected salmon. The Article 17 (JNCC, 2019a) habitat report identifies in detail which non-native species affect the different protected freshwater habitats in Wales for example *Elodea spp*. and *Crassula helmsii* (GBNNSS, 2011b, 2017a, 2017b), are highlighted as a significant threat to ‘oligotrophic to mesotrophic standing waters with vegetation of the *Littorelletea uniflorae* and/or of the Isoëto-Nanojuncetea’. While for ‘Hard oligo-mesotrophic waters with benthic vegetation of Chara spp’ *Elodea canadensis* and *Lagarosiphon major* (GBNNSS, 2011f, 2017a) are identified as affecting it by

Effects on freshwater ecosystem, ecosystem service and benefits	Key changes or new evidence since 2020
	outcompeting other vegetation and concern is also raised about killer shrimp (*Dikerogammarus villosus*) being a potential risk to this habitat (GBNNSS, 2010b). Elodea Sp. and killer shrimp are also highlighted in the Article 17 report as an important pressure for 'Natural eutrophic lakes'. While riparian non-native vegetation (e.g. Himalayan balsam (*Impatiens glandulifera*) and Japanese knotweed (Fallopia japonica)) (GBNNSS, 2011e; Tokarska-Guzik, B. and Pisarczyk, E., 2015) are identified as a pressure for 'water courses of plain to montane levels with the *Ranunculion fluitantis* and Callitricho-Batrachion vegetation'. A heat map that shows the distribution of INNS that have the potential to impact freshwater ecosystems is available on the Wales Environmental Portal (Natural Resources Wales, 2024).
INNS cause structural instability in riverbanks, increase localised flood risk by blocking channels, interfere with navigation, water supply and water quality in the freshwater ecosystem. Confidence: High	There has been no significant new evidence since 2020 however below is a review which provides links to sources of evidence which supports the current statement. Risk assessments produced by the GB Non-Native Species Secretariat or the EU provide a useful overview of the likely impacts of INNS on freshwater habitats in GB/EU and these have been referenced below where they support the statement above. The INNS targeted by the Four Rivers for LIFE project in Wales (2022-2027) include: Himalayan balsam, (*Impatiens glandulifera*), Skunk Cabbage (*Lysichiton americanus*), Japanese knotweed (Fallopia japonica)and Giant hogweed (*Heracleum mantegazzianum*). They have been selected due to the impact that they are currently having on the condition of 4 riverine SACs in Wales. The Article 17 (JNCC, 2019a) report identifies in detail which non-native species affect protected freshwater habitats in Wales and highlights that riparian non-native vegetation (e.g. Himalayan balsam (*Impatiens glandulifera*) and Japanese knotweed (*Fallopia japonica*)) (GBNNSS, 2011c; Tokarska-Guzik, B. and Pisarczyk, E., 2015) are a pressure on 'water courses of plain to montane levels with the Ranunculion fluitantis and Callitricho-Batrachion vegetation'. Himalayan balsam

Effects on freshwater ecosystem, ecosystem service and benefits	Key changes or new evidence since 2020
	(*Impatiens glandulifera*) can cause issues relating to bank instability in the winter and can cause increased sedimentation/reduced water quality (Greenwood, Gange and Kuhn, 2020). Other species such as Signal crayfish (*Pacifastacus leniusculus*) and Chinese mitten crab *(Eriocheir sinensis*) can also contribute to bank instability (GBNNSS, 2011d, 2011g). Live Chinese mitten crab (*Eriocheir sinensis*) have been reported for the first time in the river Conwy in 2024 when they have only previously been reported in the river Dee in Wales (Falkingham et al, 2016). Some plant INNS that have established in Wales have been shown to cause issues with navigation, access and localised flooding as they form thick mats and clog up channels (e.g. Floating pennywort (*Hydrocotyle ranunculoides*), *Elodea spp*., and *Lagarosiphon major*) (GBNNSS, 2011f, 2017a, 2017b). While other species that have recently arrived in Wales have caused significant issues in clogging pipes elsewhere in GB which has had localised impacts on water supplies (e.g. zebra mussel)(Elliott et al., 2005; Bukontaite and Zaiko, 2008). Article 17 (JNCC, 2019a) habitat report identified that Canada goose (*Branta canadensis*) (GBNNSS, 2011a) are causing nutrient problems at some 'hard oligo-mesotrophic waters with benthic vegetation of Chara Spp' sites in Wales. Concern was also raised about killer shrimp (*Dikerogammarus villosus*) being a risk to this habitat (GBNNSS, 2010) (e.g. they can cause localised extinctions of native invertebrates and can also disrupt nutrient cycling).

Table 58 Effects on Ecosystems and Ecosystem Services – Marine

Effects on marine ecosystem, ecosystem service and benefits	**Key changes or new evidence since 2020**
Marine INNS can affect the biodiversity and structure of native habitats, especially as they are often fast growing. There is often a corresponding impact to ecosystems, where native species can be outcompeted or smothered. In some cases, invasive species can spread new diseases. Confidence: High	There has not been a lot of new evidence since 2020, however, a report which assesses the impact of INNS on habitat features, fisheries and aquaculture relevant to Wales has been produced which does provide some relevant information (Tilbury *et al.*, 2020). Biogenic habitats (e.g. molluscs) were noted in this report as especially high risk from INNS. American lobster (*Homarus americanus*) are highlighted in the report as potentially spreading diseases. The Article 17 (JNCC, 2019a) habitats report identifies which non-native species affect protected marine habitats in Wales. American slipper limpet (*Crepidula fornicata)* was of particular relevance to 'sandbanks'. American slipper limpet (*Crepidula fornicata),* Pacific oyster *(Crassostrea gigas)* and *Wireweed (Sargassum muticum)* (Bohn K., 2014) were identified as being a significant pressure on 'estuaries', 'reefs' and 'shallow inlets and bays'. American slipper limpet (*Crepidula fornicata)* (GBNNSS, 2011c) can alter the availability of habitat and its function and they can compete for food, their attachment to other species can reduce their hosts survival, growth and reproduction. *Crassostrea gigas* (GBNNSS, 2010a) can form reefs, modify habitats and negatively affect native filter feeding populations and have knock on impacts on ecosystems. *Sargassum muticum* (GBNNSS, 2011i) forms dense stands, outcompeting native seaweed, it can reduce light penetration (e.g. in the Menai Strait), increase sedimentation and can alter the temperature of rockpools. *Didemnum vexillum* (a carpet sea squirt) has recently been reported in Milford Haven (2023). This species smothers and outcompetes native species for habitat and can affect shellfisheries (GBNNSS, 2011a). American slipper limpet *(Crepidula fornicata)* has been reported around Anglesey (first reported in the Menai Strait in October 2020), this is a significant increase in range as it had only previously been found in south Wales (Bohn K., 2014). There are concerns about it's impact on the important shellfish industry in this area as it is known to affect native mussel growth rates and survival (Thieltges, 2005).

Effects on marine ecosystem, ecosystem service and benefits	Key changes or new evidence since 2020
	A heat map that shows the distribution of INNS that have the potential to impact marine ecosystems is available on the Wales Environmental Portal (Natural Resources Wales, 2024).

Table 59 Effects on Ecosystems and Ecosystem Services – Mountains moorland and heath (MMH)

Effects on MMH ecosystem, ecosystem service and benefits	Key changes or new evidence since 2020
INNS threaten the condition, extent and connectivity of mountain, moorland and heath ecosystems and the ecosystem services they deliver. Confidence: High	There has been no significant new evidence since 2020, however below is a review which provides links to sources of evidence that support the current statement. Examples of INNS that have been targeted by the LIFE Quaking Bogs project to improve the condition of bog habitat on Special Areas of Conservation include Himalayan balsam (*Impatiens glandulifera*). Species targeted by the LIFE Welsh Raised Bogs project to restore raised bog habitat include non-native conifers and Rhododendron (*Rhododendron ponticum*). The Article 17 habitat report identifies in detail which non-native species are affecting protected habitats included in this ecosystem in Wales. For example Rhododendron (*Rhododendron ponticum*)(GBNNSS, 2013) and non-native conifer (e.g. Sitka spruce (*Picea sitchensis*)(GBNNSS, 2022b)) regeneration is identified as a significant impact on 'European dry heaths' in upland areas while *Cotoneaster Spp*. (GBNNSS, 2019c, 2022a), Japanese Knotweed (*Fallopia japonica*) (GBNNSS, 2011e) and Himalayan balsam (*Impatiens glandulifera*) (Tokarska-Guzik, B. and Pisarczyk, E., 2015) are identified as more of a significant issue in lowland locations. The Article 17 report identified that non-native *Cotoneaster Spp.* are a particular problem for '*Juniperus communis* formations on heaths or calcareous grasslands'. Non-native conifer Spp. and Rhododendron (*Rhododendron ponticum*) are identified as issues for 'active raised bogs', 'blanket bog' and 'depressions on peat substrates of the Rhynchosporion' habitats, while non-native conifer Spp., Rhododendron(*Rhododendron ponticum*) and Japanese knotweed (*Fallopia japonica*) were highlighted as species affecting 'degraded raised bogs still capable of natural

Effects on MMH ecosystem, ecosystem service and benefits	Key changes or new evidence since 2020
	regeneration'. Rhododendron (*Rhododendron ponticum*) was identified as an issue for transition mires and quaking bogs. Non-native plants listed in Article 17 as affecting mountain moor and heath habitats will out compete, shade or alter the chemistry of the soil (e.g. Rhododendron *(Rhododendron ponticum*) and non-native conifers) which will affect the diversity and abundance of native species thereby affecting the condition of these habitats. They may also affect peat formation by drying out or shading areas and thereby affect the ecosystem services that the peatland provides (Sloan *et al.*, 2018). Grazing pressure was also highlighted by the Article 17 report as an issue on habitats included in the mountain moor and heath ecosystem, grazing from non-native deer Spp. and feral goat is likely to contribute to this pressure (GBNNSS, 2015a). A heat map that shows the distribution of INNS that have the potential to impact mountain, moor and heath ecosystems is available on the Wales Environmental Portal (Natural Resources Wales, 2024).

Table 60 Effects on Ecosystems and Ecosystem Services – Woodlands

Effects on woodland ecosystem, ecosystem service and benefits	**Key changes or new evidence since 2020**
INNS outcompete or adversely impact native species affecting their abundance and diversity. INNS can impact the condition and function of woodland ecosystems. Confidence: High	There has been no significant new evidence since 2020 however below is a review which provides links to sources of evidence which supports the statement above. INNS targeted by the LIFE Celtic Rainforest project include Rhododendron (*Rhododendron ponticum*) (GBNNSS, 2013), Montbretia (*Crocosmia pottsii x aurea = C. x crocosmiiflora*) (GBNNSS, 2011j) and American skunk cabbage (*Lysichiton americanus*) (GBNNSS, 2015b) due to the impact that these species are having on the condition of oak woodland located within Special Areas of Conservation in north west Wales. Recent research about the reported impact of INNS on habitats in the UK identifies that INNS are most commonly reported as impacting on woodland habitats (Dehnen-Schmutz *et al.*, 2022). Grey squirrel (*Sciurus carolinensis*) have been estimated to cause significant damage to woodland in Wales, in particular on broadleaf tree species (the range of the cost annually to Wales of Grey squirrel depends on the predicted damage level (low (£0.2 million), medium (£4.1 million) or high (£7 million)) (Royal Forestry Society, 2021). The GB risk assessments produced by the GB Non-Native Species Secretariat and output from the NNSIP Portal provide a useful overview of the likely impacts of INNS on woodland habitats in GB, these have been referenced below where they support the statement above. The Article 17 (JNCC, 2019a) habitat report identifies in detail which non-native species affect protected woodland habitats in Wales for example 'Atlantic acidophilous beech forests with Ilex and sometimes also Taxus in the shrub layer (*Quercion robori-petraeae* or *Ilici-Fagenion'* are affected by Cotoneaster Spp. in Wales (GBNNSS, 2022a). The Article 17 report also identified that invasive non-native species are widespread in '*Asperulo-Fagetum* beech forests' and include cherry laurel (*Prunus laurocerasus*) (GBNNSS, 2019a).

Effects on woodland ecosystem, ecosystem service and benefits	Key changes or new evidence since 2020
	INNS are also a widespread problem in ‘Tilio-Acerion habitat’, involving a wide-range of species such as cherry laurel (*Prunus laurocerasus*), a variety of non-native conifer species, and ground flora, (e.g. periwinkle (*Vinca minor*) (GBNNSS, 2024a) and Himalayan balsam (*Impatiens glandulifera*) (Tokarska-Guzik, B. and Pisarczyk, E., 2015). *Rhododendron ponticum* and non-native trees (e.g. western hemlock (*Tsuga heterophylla*) (GBNNSS, 2024b)) are identified as issues in the Article 17 report for ‘old sessile oak woods with Ilex and Blechnum in the British Isles’ located in Wales. The Article 17 report states that ‘Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior (Alno-Padion, Alnion incanae, Salicion albae*)’ are vulnerable to colonisation by water borne dispersal of INNS (e.g. of Himalayan balsam (*Impatiens glandulifera*), Japanese knotweed (*Fallopia japonica*) (GBNNSS, 2011e; Tokarska-Guzik, B. and Pisarczyk, E., 2015) and non-native trees. Cherry laurel (*Prunus laurocerasus*) is an issue for ‘Taxus baccata woods of the British Isles’ located in Wales. The Article 17 report also highlighted that non-native deer grazing pressure is an increasing issue for all protected woodland habitat in Wales and that muntjac (*Muntiacus reevesi*) are an increasing issue (GBNNSS, 2011l). Grey squirrel (*Sciurus carolinensis*) were only highlighted by the Article 17 report as an issue for ‘Alluvial forests’ in Wales however their impact is likely to be more widespread (Welsh Government, 2018). Non-native deer, Grey squirrel (*Sciurus carolinensis*) and some of the non-native plants highlighted above can affect one or more aspect of woodland habitat: establishment, structure, rate of growth and quality of woodland habitat and timber (Dolman *et al.*, 2010; Symmons, J, 2010; GBNNSS, 2011l, 2013; European Environment Agency, 2016).

Effects on woodland ecosystem, ecosystem service and benefits	Key changes or new evidence since 2020
	A heat map that shows the distribution of INNS that have the potential to impact on woodland ecosystems is available on the Wales Environmental Portal (Natural Resources Wales, 2024).

Table 61 Effects on Ecosystems and Ecosystem Services – semi-natural grassland (SNG)

Effects on SNG ecosystem, ecosystem service and benefits	Key changes or new evidence since 2020
INNS outcompete or adversely impact native species affecting their abundance and diversity. INNS can impact the condition and function of semi-natural grassland ecosystems. Confidence: High	There has been no significant new evidence since 2020 however below is a review which provides links to sources of evidence which supports the statement above. Since SoNaRR 2020 the Limestone Grassland Restoration Project in north Wales has targeted the control of Cotoneaster Spp. which are a significant threat to this habitat. As well as the Article 17 report, risk assessments produced by the GB Non-Native Species Secretariat and output from the NNSIP Portal provide a useful overview of the likely impacts of INNS on semi-natural grassland habitats in GB and these have been referenced below where they support the statement above. The Article 17 (JNCC, 2019a) habitat report identifies in detail which non-native species affect protected semi-natural grassland habitats in Wales for example invasive non-native species (mainly non-native conifer (GBNNSS, 2022b)) affect 38% of units where ‘Calaminarian grasslands of the Violetalia Calaminariae’ is present. While New Zealand Willowherb (*Epilobium brunnescens*)(GBNNSS, 2011k) is an issue for ‘Alpine and subalpine calcareous grasslands’ and for ‘Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels’. The Article 17 habitat report also highlights that INNS are impacting ‘semi-natural dry grasslands and scrubland facies: on calcareous substrates (*Festuco-Brometalia*)’ however it did not specify which species are an issue though this is likely to include *Cotoneaster Spp.* (GBNNSS, 2022a).

Effects on SNG ecosystem, ecosystem service and benefits	Key changes or new evidence since 2020
	INNS were identified as an issue in some units where ‘Molinia meadows on calcareous, peaty or clayey-silt-laden soils (*Molinion caeruleae*)’are present but that it was not enough of an issue for INNS to be highlighted as a pressure in the report for this habitat. Non-native conifers (GBNNSS, 2022b), *Rhododendron ponticum* (GBNNSS, 2013) and feral goat (GBNNSS, 2015a) were all highlighted as species in need of management to protect ‘Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels’. A heat map that shows the distribution of INNS that have the potential to impact semi natural grassland ecosystems is available on the Wales Environmental Portal (Natural Resources Wales, 2024).

Table 62 Effects on Ecosystems and Ecosystem Services – Urban

Effects on Urban ecosystem, ecosystem service and benefits	**Key changes or new evidence since 2020**
INNS can impact on built structures, human health and environmental systems in the urban environment. Confidence: Medium	There is limited new evidence since 2020 about the impact of INNS on the urban ecosystem, below is a review which provides links to sources of evidence which support the current statement above. The current estimates of the cost of INNS to the urban environment are likely to underestimate the actual cost (Heringer *et al.*, 2024). The recently updated assessment of the economic impact of INNS in Great Britain undertaken by CABI and commissioned by Defra (Eschen *et al.*, 2023) highlighted that INNS are estimated to cost the construction, development and infrastructure sector £13 million annually in Wales and cost the transport sector £9 million annually in Wales and the utilities sector £1 million annually. The cost of INNS to human health in Wales was estimated to be 8 million annually (Cuthbert *et al.*, 2021; Eschen *et al.*, 2023). This new report updates the CABI report undertaken in 2010 about the economic impact of INNS in GB (Williams et al. 2010). The CABI report undertaken in 2010 (Williams et al., 2010) about the economic impact of INNS highlighted specific species that affect the urban environment, for example it highlighted the impact that Japanese knotweed (*Fallopia japonica*) and Buddleia (*Buddleja davidii*) have on the built environment including housing and transport infrastructure. The 2010 CABI report also highlighted the damage that Grey squirrels (Sciurus carolinensis) do to lofts in urban areas. The 2010 CABI report also identified that the presence of certain non-native plants can cost the construction industry money in management and delays (e.g. Japanese knotweed *(Fallopia japonica*), Himalayan balsam (*Impatiens glandulifera*) and Giant hogweed (*Heracleum mantegazzianum*)). The 2010 CABI report (Williams et al., 2010) also highlighted the cost of non-native plant (e.g. Japanese knotweed (*Fallopia japonica*), Giant hogweed (*Heracleum mantegazzianum*), Himalayan balsam (*Impatiens glandulifera*) and Buddleia (*Buddleja davidii*)) control across the rail network.

Effects on Urban ecosystem, ecosystem service and benefits	Key changes or new evidence since 2020
	Non-native water plants, burrowing and fouling invertebrates where highlighted as affecting canal infrastructure (e.g. Chinese mitten crab (*Eriocheir sinensis*) and Signal crayfish (*Pacifastacus leniusculus*)) (Williams e*t al.*, 2010). Collisions caused by deer on the road network and collisions/delays caused by non-native birds (e.g. Canada geese) at airports were highlighted as an issue (Williams *et al.,* 2010). The annual costs in 2010 of INNS to the transport sector in Wales was (approx.): roads £0.7 million, railways £5.1 million, aviation £0.25 million and shipping £2.9 million) (Williams *et al*., 2010). In 2010 the cost to water companies of INNS in Wales was estimated to be £0.2 million and for power stations the cost was estimated to be £0.26 million annually (Williams et al., 2010). Data on the impact of INNS to human health in Wales is limited, the 2010 CABI report identified that certain species can directly affect human health (e.g. Giant hogweed (*Heracleum mantegazzianum*)), while others are known to be potential vectors for diseases (e.g. non-native deer can contribute to the spread of Lyme disease) (Williams et al., 2010). Only a fraction of INNS have been assessed to give an estimate of the overall cost of INNS to the economy of the UK and therefore the actual costs are likely to be higher (Cuthbert *et al.*, 2021). A heat map that shows the distribution of INNS that have the potential to impact urban ecosystems is available on the Wales Environmental Portal (Natural Resources Wales, 2024).

Table 63 *Effects on Ecosystems and Ecosystem Services – Enclosed farmland*

Effects on enclosed farmland ecosystem, ecosystem service and benefits	Key changes or new evidence since 2020
INNS outcompete or adversely impact native species affecting their abundance and diversity. INNS can affect crops and productivity; this can impact the condition and function of enclosed farmland. Confidence: Medium	There has been some limited new evidence since 2020 below is a review which provides links to sources of evidence which supports the statement above. An analysis of pathways of arrival to GB of INNS (Booy, 2019; GBNNSS, 2019b) concluded that two of the top five pathways relate to horticulture (contaminants of plants and horticultural escapes). The rate of the establishment and spread of INNS and trends in the pathways of arrival have been predicted to continue to remain the same in the short term as the historic trends (NNSIP, 2020). Over the last century the introduction of non-native species has been largely driven by human activities. Invasion trends and trends in human socio-economic activities (e.g. increasing trade, and increasing land use/cropland) are closely corelated (IPBES, 2023). Climate change is also likely to affect the introduction and spread of INNS in future (IPBES, 2023). The CCRA3 Technical Report (Climate Change Committee, 2021a) identifies that INNS alongside pests and diseases present a serious risk to agricultural productivity, crops and livestock. Since SoNaRR 2020 Glastir (the sustainable land management scheme in Wales launched in 2012), has continued to provide payments to land managers for delivering environmental goods and services this included some actions to manage INNS. It's aims were to address climate change, improve water management, and enhance biodiversity. The scheme was replaced in 2024 by a new interim scheme and will eventually be replaced by the Sustainable Farming Scheme (SFS). Efforts to address INNS through Glastir have not had a measurable benefit. The recently published Environment and Rural Affairs Monitoring & Modelling Programme (ERAMPP) report (Emmett *et al.*, 2025) about Wales national trends and Glastir evaluation concluded that between 2013/16 – 2021/23: • There has been a two-fold increase in the percentage of ponds with invasive species from 9% to 19%.

Effects on enclosed farmland ecosystem, ecosystem service and benefits	Key changes or new evidence since 2020
	• There has been an increase from 58.9% to 66% of headwater streams having invasive invertebrates. • There has been an 8% decrease in plant species richness across all habitats and 22% increase in non-native plant richness. • Land which came into the Glastir scheme had lower levels of non-native plant species compared to land outside of the scheme however the rate of increase in the number of non-native plants is identical in both the land in Glastir and the national trend meaning there has been no benefit of the Glastir management options in relation to non-native plants. A recent study under taken to estimate the cost of INNS to the UK economy (Eschen *et al.*, 2023) has refreshed a study undertaken in 2010 (Williams (Williams F, and Eschen R, Harris A, D Djeddour, C Pratt, RS Shaw, S Varia, J Lamontagne-Godwin, SE Thomas, ST Murphy, 2010). The new study is a partial update and provides broad summary data about cost to sectors including agriculture and horticulture and also some comparable data about the estimated cost of certain species including some that impact on the agricultural sector (i.e. non-native deer, non-native geese/swans, American mink (*Neovison vison*) etc). The estimated cost of INNS to the agriculture sector in Wales has increased from £71 million per annum in 2010 to approximately £124 million per annum in 2023 (52 million excluding fungi) (Williams F, and Eschen R, Harris A, D Djeddour, C Pratt, RS Shaw, S Varia, J Lamontagne-Godwin, SE Thomas, ST Murphy, 2010, p. 20; Eschen *et al.*, 2023). A heat map that shows the distribution of INNS that have the potential to impact enclosed farmland is available on the Wales Environmental Portal (Natural Resources Wales, 2024).

Responses and Opportunities for action

Responses to SoNaRR2020 Opportunities

This section provides a summary of the responses (actions that have been taken in relation) to the main opportunities identified in SoNaRR 2020 for improving action to tackle INNS in Wales.

Collaboration

SoNaRR 2020 opportunity 1. Establish and develop a collaborative framework to address INNS issues more effectively within Wales to maintain or enhance the resilience of ecosystems.

- A collaborative framework to address INNS issues more effectively within Wales that aims to maintain or enhance the resilience of ecosystems and builds on the work of the Welsh Biodiversity Partnership INNS Group was established, through the Wales Ecosystem Resilience Network (WaREN) project.

- The WaREN has had several phases (phase one 2019-21, two 2022-23, three 2023-2024 and four 2024-2025). Phase 1 was a collaborative effort between members of the Wales Biodiversity Partnership INNS Group including the South and West Wales Wildlife Trust, North Wales Wildlife Trust, Dŵr Cymru, Natural Resources Wales and Welsh Government. The North Wales Wildlife Trust as continued to lead on the later phases of the WaREN project.

- The WaREN has provided opportunities to increase stakeholder and public participation in decision making and has increased opportunities for collaboration through the development of a collaborative framework (e.g. engagement and mapping of stakeholders, improving communication through events and news letters, facilitating information gathering through events, questionnaires and workshops etc).

- The WaREN project has developed Wales level tools (e.g. a Local Action Group Toolkit and video resources) and has also supported the development of GB tools (e.g. the INNS Mapper/Mapiwr INNS recording tool and introductory videos). This has supported work to gather the evidence needed to drive collaborative action to tackle INNS and work towards improving the strategic steer in relation to addressing INNS issues in Wales.

- The project has also engaged with funders to provide information to help guide decision making about which INNS projects align with the strategic needs in Wales. This has helped to increase confidence about which projects are likely to contribute to strategic INNS delivery in Wales.

- The project also engaged in a large amount of awareness raising about INNS, their impacts and biosecurity in Wales through their Ecosystem Invaders Campaign which included the development of a set of resources and campaign materials (e.g. leaflets for various stakeholder groups, games, colouring books, videos etc). The WaREN also helped to support, develop and advise local action groups. Thereby helping to facilitate action to tackle INNS issues on the ground and to prevent INNS from arriving and establishing in the first instance.

- The WaREN project has clear deliverables that meet INNS policy objectives and to date each phase of the WaREN has been successfully delivered.

- The WaREN project has contributed to several of the key actions in the renewed GB INNS Strategy 2023-2030 (GBNNSS, 2023) including (action 5.1) supporting national and regional scale co-ordination projects for managing INNS, that bring together local action groups, industry and government bodies and another key action (5.2) that relates to improving ways of supporting strategic local action including improving funding mechanisms, improving links between local action groups and INNS experts and supporting the development of recording tools. They have also contributed to several of the actions relating to building awareness and understanding (actions 8.1, 8.4 and 8.5) through the development of the Ecosystem Invaders Campaign which links to existing GB INNS campaigns, and by assessing the impact of the Ecosystem Invaders Campaign.

- In the marine environment, a UK Marine INNS Group was established in 2023, to discuss and input to national marine INNS issues, greatly increasing collaboration between nations. The NRW Nature Networks Marine Invasive Non-Natives Species (INNS) Biosecurity Planning Across the Marine Protected Area (MPA) Network Project contains strong elements of cross border collaboration with England. Pathway Action Plans and Species Action Plans have been produced for marine MPAs in Wales and NRW is working closely with Natural England to produce biosecurity plans for the cross-border sites (i.e. the Severn and Dee estuaries).

Address INNS through land management schemes

SoNaRR 2020 opportunity 2. There is the potential to include action to address INNS as a public good within any future land management scheme to maintain or enhance the resilience of ecosystems.

- The renewed GB INNS Strategy 2023-2030 (GBNNSS, 2023) highlights that much of the cost of INNS to the economy of GB is borne by the agriculture and forestry sectors. Recent research about the economic impacts of INNS has estimated that INNS cost the forestry sector in Wales £167 million per annum and the agriculture sector in Wales approximately £124 million per annum (Eschen *et al.*, 2023). A key action (5.3) of the renewed GB INNS strategy 2023-2030 is to *'seek ways to ensure that INNS management is included in relevant new initiatives where possible, including new agricultural and land management schemes'*. This key action provides a policy driver for the inclusion of INNS into land management schemes in Wales.

- The Climate Change Committee (CCC)'s 2021 assessment of climate risks to the UK (Climate Change Committee, 2021b) highlighted INNS as a priority risk facing terrestrial, freshwater, and marine habitats and species, as well as agriculture and forestry, further emphasising the current and future risk that INNS pose to the agriculture and forestry sectors in Wales.

- There has been a considerable amount of engagement about INNS in relation to the proposed Sustainable Farm Scheme (SFS), however it is not clear yet how INNS will be addressed by the SFS. Currently the SFS is likely to be divided into three layers and will be phased in over time, the proposed layers are universal, optional and collaborative (Welsh Government, 2023b). Currently adherence to INNS legislation by entrants to the universal layer of the scheme is being considered as a condition of payment alongside a suite of other legislation (Welsh Government, 2023b).

- It is hoped that the prevention of the introduction and spread of INNS will also be communicated as part of the advice and training provided (e.g. continuous personal development modules) to entrants to the universal layer of the SFS and work is ongoing to support this.

- Work is ongoing to develop INNS management options for the optional layer of the scheme to enable entrants to this layer of the scheme to tackle certain INNS on the land they own or manage under the scheme.

- Given the scale of INNS, the collaborative layer of the scheme has been highlighted as offering potential to tackle INNS at appropriate spatial scales and potentially provide more effective and sustainable control or eradication. Work on developing the collaborative layer of the scheme is ongoing.

Promote biosecurity

SoNaRR 2020 opportunity 3. The promotion of biosecurity using the renewed GB biosecurity campaigns and current and future biosecurity initiatives to improve biosecurity at sensitive sites, on priority pathways, amongst the public, and within businesses and organisations.

- Biosecurity is key to preventing the introduction and spread of INNS, pests, and diseases and is the most cost-effective way to address INNS issues, especially in the marine environment.

- Action has been taken to raise awareness through more active promotion of the renewed GB biosecurity campaigns in Wales (i.e. Check clean Dry and Be Plant Wise). Bilingual campaign materials have been produced annually and distributed through key stakeholders (e.g. Canoe Wales, GB INNS Inspectorate) and projects (e.g. WaREN).

- Action is taken annually amongst bodies, projects and stakeholders in Wales to support and promote the GB Invasive Species Week in Wales and to work collaboratively with other countries to increase awareness of INNS and biosecurity. The Invasive Species Week campaign continues to grow year on year. In 2023 over 260 organisations across England, Wales, Scotland, Northern Ireland, Ireland, Jersey, Guernsey, and the Isle of Man took part in Invasive Species Week and 62 tweets from the official GB Invasive Species Week account reached over 94,000 timelines and received 13,000 video views.

- Work was undertaken to assess and identify the main marine INNS pathways in Wales (Dewey, N., Pack, K., Williamson, D, Walsh, A., 2021), to establish where best to target biosecurity measures.

- Action has also been undertaken to improve biosecurity in marine protected areas. For example, a project to develop a biosecurity plan for Pen Llŷn a'r Sarnau (PLAS) Special Area of Conservation (2019-2022) was delivered which raised awareness of marine INNS and biosecurity (e.g. through events, factsheets, social media and other stakeholder engagement), produced resources (e.g. a INNS workshop kit and INNS ID guide for Wales in English and Welsh) and gathered evidence (e.g. undertook an INNS pathways assessment for Wales and an assessment of the impact of key marine INNS on MPA features). This project also trialled the use of eDNA to monitor for key marine INNS and installed advanced mooring systems to reduce the spread of an INNS at the site.
- The Nature Networks Marine Invasive Non-Natives Species (INNS) Biosecurity Planning Across the Marine Protected Area (MPA) Network Project builds on the PLAS Biosecurity Plan Project. It is a three-year programme (2022-2025) which will work with key stakeholders, through a series of online and in-person workshops and engagement sessions, to create and implement four biosecurity plans for fully Welsh marine sites:

  - Menai Strait and Conwy Bay SAC
  - Cardigan Bay SAC
  - Pembrokeshire Marine SAC
  - Carmarthen Bay and Estuaries SAC

  And work collaboratively with Natural England to develop cross border biosecurity plans for two further sites:

  - Dee Estuary SAC
  - Severn Estuary SAC

  Species and pathway action plans will also be produced as part of this project. In addition to this the project will look at novel solutions to marine INNS management, which includes Chinese mitten crab (*Eriocheir sinensis*) traps on the Dee and the use of ultrasound to control a carpet sea squirt (Didemnum vexillum).

- Biosecurity has also improved within organisations, for example since 2020 work has been ongoing to make NRW an exemplar in biosecurity by improving the provision of advice, training and equipment within NRW. NRW also promote biosecurity externally by sharing information and tools.

Driving Action

SoNaRR 2020 opportunity 4. Implement INNS policy and legislative drivers to facilitate and drive action to tackle INNS issues to maintain or enhance the resilience of ecosystems in Wales

- Work is ongoing to support the actions associated with INNS legislation and policy drivers in Wales. The main INNS legislation and policy in Wales is the Invasive Alien Species Regulation (retained Regulation (EU) 1143/2014) (IAS Reg), the Invasive Alien Species (Enforcement and Permitting) Order 2019 and the GB INNS Strategy which was renewed in 2023 (2023-2030) and its implementation plan which was drafted in 2024.

- Action is ongoing to continue to support the embedding of the IAS Reg in Wales and to ensure that Wales is contributing to GB actions associated with the IAS Reg, for example by updating the Wales draft contingency plans and implementing them when required and by commenting on GB risk assessments and decisions relating to the listing of new species of special concern.

- The IAS Order has largely been embedded in Wales, processes and procedures have been established or amended to enable relevant bodies (e.g., NRW) to regulate and enforce the IAS Order. Welsh Government have authorised officers from the Fish Health Inspectorate and the Non-Native Species Inspectorate as enforcement officers in Wales. There continues to be liaison between regulation and enforcement bodies in Wales and England to ensure a consistency of approach in applying the IAS Order.

- The pilot GB Non- Native Species Inspectorate (NNSI) was established in 2021. The aim of the NNSI is to help protect GB from the introduction and establishment of invasive non-native species. The NNSI has mainly been concentrating on awareness raising and inspection activities in Wales. As the inspectorate becomes fully operational their role and powers may be strengthened.

- Considerable progress has been made in supporting actions relating to the GB INNS Strategy and implementation plan in Wales, including by:

    - Welsh Government and NRW contributing to and supporting the GB working groups from a Welsh perspective (e.g. training, research, media and communications, Non-native Species Information Portal (NNSIP) etc.) and inputting to and commenting on outputs (e.g. GB INNS risk assessments) and supporting and promoting plans (e.g. GB Evidence Strategic Plan).

    - Since April 2011, Defra, Welsh Government and Natural England, has funded CABI to investigate the scope for biological control (biocontrol) of invasive non-native plants. Since 2021 Welsh Government funding has focused on trials on Himalayan balsam and Australian stone swampcrop at a number of sites across Wales. Biocontrol has the potential to play an important role in protecting aquatic and riparian habitats where chemical and mechanical control options are impractical or prove to be prohibitively expensive.

- Welsh Government have funded rapid eradication work (i.e. Topmouth gudgeon (*Pseudorasbora parva*)), this work has been supported by NRW.

- Work is ongoing to support the development and implementation of draft GB Pathway Action Plans which target action (including promoting biosecurity) on priority pathways to prevent the introduction and spread of INNS. Priority pathways include zoos, recreational angling and boating, horticulture and pets.

- An example of a project in Wales that targets one of the priority pathways and focuses on prevention is the Garden Escapers project. The project involves engaging with gardeners and other key stakeholders (e.g. garden centres) to prevent invasive and potentially invasive plants escaping gardens into the wild. This project links to Plant Alert which enables information about plants demonstrating invasive tendencies to be more widely reported. The Garden Escapers project could support actions (4, 6 and 8) in the draft GB Horticulture Pathway Action Plan and may also help to inform future GB INNS horizon scanning exercises and which species may need to undergo risk assessment in future.

- The establishment of the WaREN project and its work (e.g. supporting the development of INNS Mapper which is a tool to gather information about the distribution and management of INNS in Wales and improving strategic coordination) has contributed towards several of the actions in the GB INNS Strategy.

- Welsh Government have also renewed their guidance relating to Himalayan balsam (*Impatiens glandulifera*), Giant hogweed (*Heracleum mantegazzianum*) and Japanese knotweed (*Fallopia japonica*) and have created new Japanese knotweed guidance for voluntary groups.

- NRW and Welsh Ministers have powers to make species control provisions (SCP) under Section 14 and Schedule 9A of the Wildlife & Countryside Act 1981. SCP can require owners of premises to eradicate or control INNS or formerly resident native species or allow NRW and Welsh Ministers to do so in certain circumstances. A significant area of work since 2020 has been establishing processes which enable SCP to be issued in Wales. Work is ongoing to update the Welsh Government Code of Practice for SCP in Wales.
- The Habitats directive and the LIFE Natura 2000 Thematic Action Plan have also been drivers to tackle widely spread INNS that are affecting special sites (e.g. Special Areas of Conservation (SAC)). This has been achieved through a Welsh Government funded pilot project targeting the control of INNS on National Nature Reserves that are also designated as SACs in south west

Wales and through large scale nature projects that involve INNS management on SACs:

- **Sands of LIFE**
  Sands of LIFE has restored over 2400 hectares of sand dunes, across four SACs. It involved the removal of scrub and invasive non-native species which were smothering and stabilising the dunes.
- **LIFE Quaking Bogs**
  This project involves conserving and restoring quaking bogs at Crymlyn Bog on the outskirts of Swansea, St David's in Pembrokeshire and on the Llŷn Peninsula in Gwynedd, this has included the removal of invasive plants (e.g. Himalayan balsam (*Impatiens glandulifera)*).
- **Four Rivers for LIFE.**
  This project is led by Natural Resources Wales (NRW) and aims to protect, enhance and help restore the Teifi, Tywi, Cleddau and Usk riverine SACs by undertaking management action including controlling invasive non-native plants (i.e. direct management and trialling the CABI Himalayan balsam biocontrol at several locations).
- **LIFE Welsh Raised Bogs**
  This project involves restoring raised bogs at 7 SACs across Wales. The project has worked in partnership with local communities, landowners and contractors and has included improving the conditions of the peatland at these sites by removing invasive species (e.g. Rhododendron (*Rhododendron ponticum*)).
- **LIFE Celtic Rainforest**
  Is a £7 million project that aims to protect and restore Snowdonia's Celtic rainforests and has included controlling invasive species such as Rhododendron (*Rhododendron ponticum*).
- **The Upper Wye Catchment Restoration Project** is a Welsh Government funded project that aims to restore the health of the upper reaches of the river Wye and includes the removal of invasive non-native plant species.

Opportunities for SoNaRR2025

Below is a list of the main opportunities that need to be considered in the updated version for SoNaRR2025. The SoNaRR2020 opportunities have been reviewed, and all of the existing opportunities have been retained, however the emphasis of some of them have changed due to the work that has been undertaken since 2020.

Collaboration

SoNaRR 2025 opportunity 1. Continue to develop a collaborative framework to address INNS issues more effectively within Wales to maintain or enhance the resilience of ecosystems

- A collaborative framework for addressing INNS across Wales that built on the work of the Welsh Biodiversity Partnership INNS Group has been established through the Wales Ecosystem Resilience Network (WaREN) project. Funding has been secured for an additional phase of the WaREN which has provided an opportunity to further develop and embed the collaborative framework.

- The next phase of the WaREN project provides an opportunity to contribute to two of the key actions in the renewed GB INNS strategy 2023-2030 (GBNNSS, 2023). It will mainly contribute to key action 5.1 which involves supporting national and regional scale co-ordination projects for managing INNS that bring together local action groups, industry and government bodies. It will also partially contribute to key action 5.2 by continuing to improve links between local action groups and INNS experts.

- Evidence for the third UK Climate Change Risk Assessment (CCRA3) (Climate Change Committee, 2021a) identified WaREN as an important mechanism for addressing the threat of INNS in Wales.

- The WaREN needs to continue to be supported to:

    - Grow the membership of the collaborative framework to address INNS issues more effectively within Wales by engaging more widely with stakeholders involved in INNS control (e.g. local authorities, Network Rail, trunk road agencies, utilities, agricultural sector, companies involved in INNS control).

    - Continue to encourage and support the reporting of INNS records and INNS management action which will help to inform strategic action to tackle INNS in Wales and will help to facilitate collaborative action at appropriate spatial scales.

    - Develop a strategic steer in collaboration with members of the WaREN that will inform decision making about tackling INNS in Wales.

    - Increase communication and collaboration within and across the membership of the framework and encourage and facilitate more coordinated action on the ground.

    - Support the establishment of projects at appropriate spatial scales (e.g. landscape scale projects) focusing on specific species (e.g. American mink (*Neovison vison*)) or geographical areas (e.g. catchments).

    - Continue to develop tools and fully embed the collaborative framework so that it can continue to function in the long term.

- The Nature Networks Marine Invasive Non-Natives Species (INNS) Biosecurity Planning Across the Marine Protected Area (MPA) Network Project is a three-year programme (2022-2025) which will work collaboratively with key stakeholders to develop species action plans and four biosecurity plans for sites in Wales. It will also work collaboratively with Natural England and other stakeholders to create biosecurity plans for two cross border sites (Dee Estuary SAC and the Severn Estuary SAC). Continued collaboration with partners to implement actions from these species and biosecurity plans will be crucial to their success.

- NRW's Corporate Plan to 2030 includes an objective that involves preventing the introduction and spread of invasive non-native species, pests and diseases through coordinated action with strategic partners and is a driver for NRW to support this type of work.

Address INNS through land management schemes

SoNaRR 2025 opportunity 2. There is the potential to include action to address INNS as a public good within any future land management scheme to maintain or enhance the resilience of ecosystems

- Recent research about the economic impacts of INNS has estimated that INNS cost the forestry sector in Wales £167 million per annum and the agriculture sector in Wales approximately £124 million per annum (Eschen *et al.*, 2023). This research emphasises the significant impact that INNS have on the forestry and agriculture sectors in Wales.

- The renewed GB INNS Strategy 2023-2030 includes a key action to *'seek ways to ensure that INNS management is included in relevant new initiatives where possible, including new agricultural and land management schemes'*, which acts as a policy driver to try to ensure that INNS are addressed by the SFS.

- Widely spread INNS need to be tackled at appropriate spatial scales to ensure that action is effective and sustainable in the long term (Larson *et al.*, 2011). This may involve the engagement and coordination of multiple landowners in a catchment or landscape. The proposed collaborative layer of the SFS offers an opportunity to facilitate action to tackle INNS at appropriate spatial scales.

- The effective eradication of INNS, often necessitates long term action, including monitoring and long term funding (GBNNSS, 2023). Complete eradication often takes longer than current project funding cycles which are usually only 1-3 years. Land management schemes like the SFS often have longer funding cycles which offers an opportunity to tackle INNS over a longer time period which would be more likely to lead to effective control/eradication of INNS.

- The SFS is currently being developed and there is still an opportunity to incorporate INNS into the proposed SFS or any other land management schemes in future.

- Work will continue to try to ensure that INNS are addressed by the SFS. It is hoped that INNS will be accommodated in the optional and collaborative layer where additional payments, technical support and advice will facilitate collaborative strategic, effective and sustainable action to reduce the impact of INNS.

- There is a potential opportunity (subject to funding) for the Wales INNS strategic steer that the WaREN project may develop during its next phase to be used to help inform the collaborative layer of the SFS in relation to INNS management.

Promote biosecurity

SoNaRR 2025 opportunity 3. The promotion of biosecurity using the renewed GB biosecurity campaigns and current and future biosecurity initiatives to improve biosecurity at sensitive sites, on priority pathways, amongst the public, and within businesses and organisations to prevent the introduction and spread of INNS

- The extension of the WaREN provides an opportunity for the project to continue to promote biosecurity in general and to promote their INNS campaign and national biosecurity campaigns (e.g. Check Clean Dry) to members of the collaborative framework and to the general public.

- There are plans (subject to funding) to extend the membership of the collaborative framework established by the WaREN project to include a wider range of INNS related stakeholders. This offers an opportunity to promote biosecurity and national biosecurity campaigns through these new stakeholders. Certain stakeholders are likely to have considerable reach (e.g. to their members or customers) and promoting the national campaigns through them offers an opportunity to extend the reach of these campaigns in Wales.

- The Garden Escapers project provides an opportunity to promote the national Be Plant Wise campaign to key stakeholders.
- The Nature Networks Marine Invasive Non-Natives Species (INNS) Biosecurity Planning Across the Marine Protected Area (MPA) Network Project is currently working with key stakeholders to create and implement biosecurity plans for six marine protected areas in Wales (4 wholly within Wales and 2 cross border) and this project will end in 2025. This project will establish a tested approach to biosecurity risk management in the marine environment in Wales. This provides an opportunity for the approach to be rolled out to other marine areas within Wales (subject to the provision of resources to continue with this work). Funding is being sought to implement the actions in the marine biosecurity plans across Wales.

- Biosecurity related projects in Wales (i.e. the Marine Invasive Non-Natives Species (INNS) Biosecurity Planning Across the Marine Protected Area (MPA) Network Project and the WaREN project) provide an opportunity to share information, tools, and lessons learnt so that the approaches can be adopted elsewhere.

- The newly formed GB NNSI provides an opportunity to raise awareness about biosecurity and to promote national campaigns as part of their work in Wales (e.g. while undertaking inspections or attending events).

- GB working groups that support the delivery of aspects of the GB INNS strategy offer an opportunity to develop tools which can be used to improve biosecurity in Wales e.g. the development of biosecurity training for different sectors and the development of new national campaigns that target priority pathways (i.e. a pet pathway campaign developed to address pet releases/escapes).

- The renewed GB INNS Strategy 2023-2030 (GBNNSS, 2023) is an opportunity as it acts as a policy driver to ensure work is prioritised, for example the promotion of biosecurity through GB biosecurity campaigns will contribute to key action 8.1 of the strategy, while improving the provision of biosecurity training for different sectors will contribute to key action 8.3 in the strategy.

- The Wales Biodiversity Partnership INNS Group includes a wide range of stakeholders interested in addressing INNS in Wales and they could take a greater role in increasing awareness of the impact of INNS and the importance of implementing biosecurity as well as promote biosecurity best practice and related national campaigns through their organisations and/or membership.

Driving Action

SoNaRR 2025 opportunity 4. Implement INNS policy and legislative drivers to facilitate and drive action to tackle INNS issues particularly in relation to prevention in order to maintain or enhance the resilience of ecosystems in Wales

- While significant progress has been made, ongoing work is needed to support and facilitate actions associated with the retained Regulation (EU) 1143/2014 Invasive Alien Species Regulation (IAS Reg). GB working groups and task and finish groups offer an opportunity to progress this work particularly in relation to action relating to prevention including the development and implementation of Pathway Action Plans (PAP groups) and the updating, adoption and implementation of the draft contingency plans (GB Rapid Response Group) in Wales.

- The IAS (Enforcement and Permitting) Order 2019 (IAS Order) is largely embedded in Wales however more work will be needed to ensure that processes are operating effectively and that there is a consistency of approach in interpreting, regulating and enforcing the IAS Order in both England and Wales. Groups like the licencing and further enforcement group offer an opportunity to NRW to continue to work with other bodies (e.g. NNSI, Natural England, Police, Welsh Government and Defra) to ensure a consistent approach is adopted.

- There is an opportunity for the pilot GB INNS Inspectorate to take on a broader role in supporting the IAS Reg and IAS Order in Wales in future, if this occurs then existing procedures and processes will need to be amended, and new ways of working will need to be agreed.

- The renewed GB INNS Strategy 2023-2030 and implementation plan is one of the key policy drivers relating to INNS and offers an opportunity to continue to progress INNS work in a strategic, collaborative and coordinated way across GB. The GB INNS Strategy aligns with the Convention on Biological Diversity hierarchy of focusing on prevention followed by rapid response and then long-term management.

- Other legislative and policy drivers in Wales (e.g. Water Framework Directive, Marine Strategy Framework Directive, Habitats Directive, Woodlands for Wales Strategy and Grey Squirrel Management Action Plan) offer opportunities to drive forward action to address INNS issues targeting specific species or ecosystems in Wales.
- The Global Biodiversity Framework (GBF) is an opportunity as it is likely to become a significant new driver for INNS action in Wales in particular Target 6 which specifically relates to INNS and focuses on prevention. Significant action will be needed to enable Wales to meet this target particularly in relation to tackling newly arrived species which are not listed in current contingency plans, eradicating recently established INNS and monitoring the establishment of INNS in Wales.

Evidence needs

Globally and nationally, new trend data confirm that INNS introductions continue to be driven by increased movement of people and goods, and climate change. However, comprehensive trend data to describe INNS impacts across Welsh ecosystems remains limited, highlighting a continued evidence gap.

Progress made with the SoNaRR2020 evidence needs

Broad evidence need 1: What is the impact of invasive non-native species of Priority to Wales on SoNaRR ecosystems, their resilience and the ecosystem services they provide in Wales, currently and in the future?

Specific evidence needs and progress that has been made to fill them:

a) **What is the impact of invasive non-native species of Priority to Wales on multiple ecosystems and the ecosystem services they provide in Wales currently?**

   Progress: As part of SoNaRR2025 a review of the impact caused by INNS identified as being of priority to Wales was undertaken that considered their impact across multiple SoNaRR ecosystems and ecosystem services (current and future). This included producing a log of links to relevant, reputable data sources (including the Non-Native Species Information Portal, risk assessments (GB and EU), CABI compendium, research papers and databases (e.g. WorMS). A full literature review has not been undertaken and could be considered in future if resources allow.

   The heat maps that show the distribution of INNS that affect each SoNaRR ecosystem in Wales has been improved. An existing GIS layer of the extent of the ecosystems selected for SoNaRR (with the exception of wetlands) has been identified and this has been applied to enable the records of INNS in each ecosystem to be isolated. This refreshed INNS data is available through the Wales Environmental Portal.

   Ongoing evidence need: The review has revealed a lack of information on certain listed species. A more comprehensive review of literature about the ecology and impact of each species that takes into account the current and likely climate conditions in Wales and could be undertaken in future that would improve understanding of the likely establishment, spread and impact of priority species in Wales (this could be in the form of a risk assessment and/or literature review).

Having this information would allow further assessment of the impact that each INNS of priority to Wales has across all ecosystem services to be undertaken, which is also a key evidence need. It would be prudent to identify what information may be needed to inform a framework for measuring the impact of INNS before data is gathered about their ecology and impacts (e.g. Environmental Impact Classification for Alien Taxa (EICAT).

Quantifying the impact of INNS on multiple ecosystems and the ecosystems services they provide could be used to help prioritise species and action needed to tackle them in Wales.

b) What is the trend in distribution and impact of invasive non-native species of priority to Wales?

Progress: The identification of the impact that INNS have on each type of SoNaRR ecosystem and the identification of an ecosystem layer which largely aligns with the SoNaRR ecosystems (excluding wetlands which are encompassed by the freshwater part of the GIS layer rather than the mountain, moor and heath section of the GIS layer) have the potential to provide a much more accurate understanding of the distribution of INNS that affect each SoNaRR ecosystem. This could now form a baseline from which it may be possible to analyse future trends over time. However further work is needed to develop an approach to assess spatial data and impact information to indicate potential trends in impacts to SoNaRR ecosystems in Wales over time, to fully meet the evidence gap needed to determine trends.

Ongoing evidence need: Wetlands are currently included in the mountain, moorland and heath SoNaRR ecosystem and not the freshwater SoNaRR ecosystem. A new GIS layer of SoNaRR ecosystems needs to be created, this could be done by modifying the current Wales ecosystem layer by removing the wetland habitat from the freshwater part of the layer and adding it to the mountain, moor and heath part of the GIS layer. The GIS layer could then be used to identify existing INNS records in each SoNaRR ecosystem that are likely to affect that ecosystem and enable this data to be extracted and analysed.

c) It would be useful to quantify/rank the likely impact that each INNS of priority to Wales may have on the different ecosystems. A procedure for doing this would need to be created so that there was a consistent robust approach. The output of this work could be used in conjunction with distribution data to model and quantify the potential impact of INNS of priority to Wales on each SoNaRR ecosystem**. What are the barriers to improving the existing invasive non-native species records data and how can we overcome these?**

Progress: The Global Biodiversity Framework and the GB INNS Strategy are both drivers to reduce the rate of the establishment of certain INNS in GB by 50%. In order to achieve this target, it will be necessary to establish a baseline rate and to have accurate levels of reporting. Since 2020 the GB NNSS have identified the need to improve the rates of reporting INNS and to also target the reporting of under reported INNS (e.g. freshwater plants, invertebrates and widely spread species etc). Work is ongoing at a GB level to improve these rates of reporting.

The INNS mapper tool for recording distribution and management action has been developed to try to improve the rate of reporting of widely spread species which are often under reported. Work is ongoing to further develop and promote INNS Mapper alongside other reporting routes (e.g. iRecord and Local Record Centres), through national campaigns (e.g. Invasive Species Week) and projects (e.g. the WaREN).

Ongoing evidence need: More action is needed to increase the level of reporting of INNS records in Wales. The speed at which INNS data flows to and through national repository (e.g. National Biodiversity Network Atlas) needs to be improved in order to improve awareness of the introduction and spread of INNS. More work is needed to further develop and promote reporting routes to national databases (e.g. INNS Mapper). Monitoring programmes are lacking for marine INNS and would benefit from further prioritisation, funding and resources.

An INNS data set that amalgamates all INNS data sets in Wales would improve the current data set used for SoNaRR (i.e. amalgamate the Local Record Centre/NBN Atlas and the Biological Society of Britain and Ireland’s data sets together to create a comprehensive INNS dataset for Wales).

d) How do we quantify the impact of invasive non-native species of Priority to Wales on each SoNaRR ecosystems' resilience, and on ecosystem services, now and in the future?

Progress: A rapid assessment has been undertaken based on existing evidence about the potential impacts that INNS can have on SoNaRR ecosystems and ecosystem services in Wales. However, the level of current and likely future impacts on ecosystems their resilience and ecosystem services has not been estimated.

Ongoing evidence need: In order to address this evidence gap, it would be necessary to develop a process to quantify the current impacts of species of priority to Wales on the different SoNaRR ecosystems, their resilience and on ecosystem services. In addition, it would be necessary to develop models that can predict likely impacts in future, of species of priority to Wales on the different SoNaRR ecosystems, their resilience and on ecosystem services. Established frameworks for measuring impacts such as the Environmental Impact Classification for Alien Taxa (EICAT) which is the IUCN global standard for measuring the severity of environmental impacts caused by animals, fungi and plants living outside their natural range could be used or adapted and applied at a Wales level to help to address this evidence gap.

e) What is the impact of invasive non-native species on the Welsh economy and provisioning ecosystem services?

Progress: Defra funded an update to the study on the economic impact of INNS on GB (Eschen *et al.*, 2023) which provides information about the financial impact of INNS on the economy of GB and each devolved administration including Wales.

Ongoing evidence need: This evidence gap has been filled for the 2025 SoNaRR, however the study will need to be repeated for future iterations of SoNaRR.

Broad evidence need 2: How effective is invasive non-native species management including national campaigns at helping to achieve the sustainable management of natural resources?

a) **What is the current level of awareness of invasive non-native species, biosecurity, and Great Britain biosecurity campaigns in the 1) general public and 2) key target stakeholders?**

Progress: A report commissioned by Welsh Government about Public Views on Plant Health and Invasive Non-Native Species, summarised the findings of a survey which included questions about the general public's awareness of INNS, their impacts and what action they have taken to address INNS (Welsh Government, 2023a). The survey undertaken in England about the awareness of INNS, biosecurity and GB biosecurity campaigns amongst the general public and key groups of stakeholders provides an indication of awareness in England however it did not include Wales. The WaREN project commissioned a report (unpublished 2023) to assess the impact of the Ecosystem Invaders campaign, this included a YouGov survey (2022 and 2023) that assessed awareness amongst the general public of INNS, biosecurity and national campaigns.

Ongoing evidence need: If resources are available, including Wales in the next iteration of the survey undertaken in England about awareness of and attitudes towards INNS, biosecurity and GB INNS campaigns amongst the general public and key stakeholders would address this evidence gap. Alternatively (subject to funding) the part of the report commissioned by the WaREN that assessed awareness amongst the general public in Wales of invasive species, INNS, biosecurity and national campaigns could be repeated and extended to collect information about attitudes/behaviour and to target key stakeholders.

Broad evidence need 3: How are invasive non-native species of priority to Wales being tackled in Wales?

a) **What action is being taken in Wales to address invasive non-native species issues on the ground and how effective and cost effective is this action?**

Progress: A summary of information about what action has been undertaken to address INNS issues in Wales is captured in the opportunities section of SoNaRR 2025.

There is no comprehensive dataset of all INNS management and costs in Wales, work is ongoing to capture more of this data. Currently NRW collect information on a voluntary basis about INNS actions that NRW undertake or fund annually. NRW have also estimated NRW's annual spend on INNS related action. WaREN have undertaken a survey of local action groups to ascertain which INNS they are targeting through an annual questionnaire. The INNS mapper tool has been developed to enable INNS management actions data to be mapped spatially and is starting to be populated.

Ongoing evidence need: Action is needed to improve the current data set about INNS actions and costs in Wales, by capturing more records and ensuring that similar types of data are collected so that the data sets can be amalgamated. INNS actions and costs also need to be analysed to determine how effective and cost effective the actions are, this may necessitate a general review of different management options for INNS and how appropriate, effective and cost effective they are in different circumstances.

What are the priority evidence needs for INNS (relating to SoNaRR)?

- What impact do invasive non-native species of Priority to Wales have on all SoNaRR ecosystems and ecosystem services in Wales currently?
- What is the trend in distribution and impact of invasive non-native species of priority to Wales?
- How do we quantify the impact of invasive non-native species of priority to Wales on each SoNaRR ecosystem, its resilience, and on ecosystem services in Wales, now and in the future?
- What are the barriers to improving the existing invasive non-native species records data and how can we overcome these?
- What is the current impact of invasive non-native species on the Welsh economy and provisioning ecosystem services?
- What is the current level of awareness of and attitudes towards invasive non-native species, biosecurity, and national INNS/biosecurity campaigns amongst the 1) general public and 2) key target stakeholders?
- What action is being taken in Wales to address invasive non-native species issues on the ground and how effective and cost effective is this action?

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Annex 3: Land use and management change evidence

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Current situation and past trends

A summary of evidence about this driver of change and associated pressures at a Wales level. This includes evidence of past trends and evidence about the indirect drivers (social, cultural, economic, governance, technological) and other direct drivers which interact with land use change.

The evidence to describe Sea use and management change is included within the SoNaRR 2025 Marine ecosystem assessment.

The evidence below updates the relevant trends set out in the SoNaRR 2020 Land use and soils chapter (NRW, 2021b) (particularly the non-soils parts of section 4).

Land Use and management Change

ONS Natural Capital Accounts data on habitat extent in Wales show changes to land use between 1990 and 2021. Urban increased the most, followed by woodland and farmland outside Enclosed Farmland (which includes Mountain Moor and Heath, Semi-Natural Grassland, Neutral Grassland, Coastal Margins, Freshwater, wetlands and floodplains). Enclosed farmland decreased in area. (Office for National Statistics, 2023a). Enclosed Farmland in the ONS Natural Capital Accounts is defined differently to SoNaRR (NRW, 2021a).

Figure 10 Changes in Farmland, Woodland and Urban land use between 1990 and 2021(Source: Office for National Statistics, 2023)

This excludes out of map areas. Definitions are contained in UK natural capital accounts methodology guide (Office for National Statistics, 2023b). Within Wales, 1229 km2 of productive land is on a flood plain, with 4-9% of this area being arable land and 50-51% improved grassland (NRW, 2021a).

Other data sources in each of the land uses are considered in more detail below:

Woodlands

Between 2010 and 2021 satellite data reported in ERAMMP indicates 6.8% of land use changed. In relation to trees, there is an important distinction between woodland, which is taken to mean the National Forest Inventory (NFI) definition (>0.5ha) in the Woodland ecosystem assessment in SoNaRR, and 'woody presence' as recorded through ERAMMP.

ERAMMP reported that woodland cover increased by 23,600 ha’s between 2010 and 2021 and represented 16.9% of Wales in 2021, however this includes all land where 10m pixels were dominated by a signal representing 'woody presence' (Emmett *et al.*, 2025). In contrast, NFI data reported that woodland cover increased by 7,000 ha’s between 2010 and 2021 and represented 15% of Wales in 2021 (Forest Research, 2024c).

The two data sets are measuring different things. The current Welsh Government target, as articulated in the Woodland for Wales Strategy 2018, is to increase woodland cover by 2000 ha/year from 2020-2030 and beyond and this is based on the NFI definition of a woodland. Published forestry statistics (2024) on woodland creation show that planting rates in Wales have not reached the 2,000 ha per annum ambition since 2020 (Forest Research, 2024a). See SoNaRR 2025 woodland assessment.

By way of comparison, ERAMMP reported that as woodland cover increased by 23,700 ha between 2010 and 2021, it was more than the 2,000 ha per year planting ambition (Emmett *et al.*, 2025). Given the raft of benefits provided by smaller areas of woodland/trees outside of woodland, we understand that Welsh Government is reviewing how these trees might contribute to future targets for increasing woodland in Wales.

As reported in SoNaRR2020, the area of land in Wales used for trees outside Woodlands according to NFI in 2016 was 92,700ha (Forestry Commission, 2017). Recent analysis of the extent of Urban trees shows very little change (Living Wales and The canopy cover Web map of the United Kingdom’s towns and cities). See SoNaRR 2025 Urban and Enclosed farmland assessments.

An increase in woodland and tree cover is needed to help build ecosystem resilience, to secure the delivery of climate change and decarbonisation, to provide places for recreation and well-being and to ensure that the productive potential of Welsh woodlands is maintained (NRW, 2021b).

Agricultural land

90% of land area in Wales is used for agricultural purposes (includes farm woodlands and other uses). Permanent grassland is still the main component of agricultural land in Wales, it accounts for nearly two-thirds (63%) of agricultural land and can be improved, semi-improved or unimproved (semi-natural) depending on the management practices. Improved grasslands are subject to more intensive management practices compared to semi-improved grasslands as they receive more inputs. The remaining land comprises new grassland (9%), sole rights rough grazing (excluding common land)(14%), arable crops (includes horticulture) (6%) and other land uses (9%)(Welsh Government, 2024g). .

Between 2010 and 2021 there has been no net change in the area of semi-natural land (which includes semi-natural grassland, heathland and wetland) (Emmett *et al.*, 2025).

There was a slight increase in the arable area between 2020 and 2024 from 5% to 6%, the area of new grasslands remained fairly stable at 9% (155,205ha in 2020 to 155,791ha in 2024). There was more maize, spring barley and oilseed rape (OSR) in 2024 compared to SoNaRR2020 (2019 data)(Figure 2),whilst the area of other grasslands fell. The significance of these short-term changes is unknown. The total arable area in 2024 is similar to the area of arable land in ~mid 70s and is higher than it was 20 years ago (about 70,000 ha) (NRW, 2021a). The area has been much higher in the past (Welsh Government, 2023f). Land managed for arable cropping increases the pressures on soils from pesticide usage, changes to land cover and tillage (NRW, 2021b).

Figure 2 Area of land under different crops in 2019 and 2024 Source: (Welsh Government, 2024g) (Welsh Government, 2023f)

There is contradictory evidence on the longer term changes in arable land extent which are likely to be due to differences in data collection methods. Whilst arable and horticultural land reported a decrease by ERAMMP between 2010 and 2021 (24%) and loss of the most productive agricultural land (Arable and Improved Grassland by 5%); the Agricultural Survey reported an increase in arable land and new grasslands during these periods. (Welsh Government, 2024g; Emmett *et al.*, 2025).

Urban land use

There is approximately 35,100 km total road length in Wales in 2022, an increase of 0.3% on the previous financial year (2020-21). Total road lengths in Wales change relatively little from year to year. Some of the annual increase is due to an improvement in the quality of the data rather than an actual increase. (Welsh Government, 2022d). Road verges and amenity grasslands can be managed to support nature (Welsh Government, 2024f). The extent of road verges managed for nature across Wales is an evidence gap.

Urban cover increased by 28% (28,200ha) between 2010 and 2021. This is an area greater than the increase in woodland area and the majority has come from improved grassland (Emmett *et al.*, 2025).

These land use changes are broadly similar to changes seen across Great Britain over the same 11 year time period (Emmett *et al.*, 2025)

Renewable Energy Land use

Land use demand for renewable energy has, and is expected to, increase to meet decarbonisation and Net Zero policy ambitions. SoNaRR2020 reported on the increasing pressures within the Enclosed Farmland Ecosystem from competing land use (NRW, 2021a). This also increases the challenge to manage Section 7 habitats and soils sustainably, including peatland habitats and to maintain and increase the extent of woodlands.

Across the UK the area of maize grown for bioenergy increased between 2015 and 2020. In 2020 this was mainly for anaerobic digestion (DEFRA, 2021). Crops grown specifically as an energy crop for anaerobic digestion (AD) are considered a non-waste feedstock. As a result, the current permitting regulations do not require that AD plants be permitted. The number of AD plants can't be fully quantified and is an evidence gap. The digestate from energy crop AD has to compete with other materials to land for landbank availability. See Annex 5: Aim 4 Waste evidence for further information.

In 2022, solar energy in the UK had a combined capacity of around 14GW (UK Government, 2022b), 9.6GW of this capacity comes from ground-mounted solar panels (Solar Energy UK, no date). According to Solar Energy UK, existing projects require approximately 1.6 ha of land for every megawatt (MW) of power (previously it was approximately 2.4 ha)., it is estimated that current ground-mounted solar covers 230 square kilometres (km2) (23,000ha). The Department for Business, Energy and Industrial Strategy proposes that future solar power will need between 0.8 and 1.6 ha of land to produce 1MW of power (Department for Energy Security & Net Zero, 2024). See Annex 6: Aim 4 Energy evidence for further information.

Future Wales, the National Plan 2040, identifies Best and Most Versatile land (BMV) agricultural land as a national natural resource under Policy. Considerable weight is given to protecting Best and most versatile land in the planning system (Welsh Government, 2021c). Since SoNaRR2020 further guidance has been issued on BMV and solar array PV developments (Welsh Government, 2022a). See SoNaRR 2025 Soils assessment for further evidence and SoNaRR2020 Land Use and Soils for the extent of BMV area in Wales (NRW, 2021b).

In July 2023, an estimate of developments of national significance (DNS), existing and proposed wind and solar farms on land showed there were 62 DNS, of which 26 were Wind Farms (3 or more turbines), covering over 20,000 hectares and 36 were Solar Farms (15MW+), covering over 2,650 hectares. In addition, there were 64 Wind and Solar Farms in planning (non-DNS) of which 8 were Wind Farms and 56 were Solar Farms and 24 Other Proposed Wind Farm Developments. There were estimated to be 44 Operational Wind Farms (3 or more turbines) and 123 Operational Solar Farms (1MW+) in Wales (Campaign for the Protection of Rural Wales, 2023). The definition of wind and solar farms used to derive these figures are not fully known. The full range, types and generating capacity of all Renewable Energy projects across Wales can be found in the SoNaRR 2025 Annex to Aim 4.

A 2023 assessment by Renewable UK Cymru estimated there were 30 windfarm sites in planning or under development which included peaty soils or peatlands within their development boundaries. NRW estimates that 22 windfarm sites already developed in Wales have some peat within their development boundaries, with 22 showing an apparent overlap of constructed windfarm infrastructure on peat (NRW pers com, 2023).

Greenhouse Gas Emissions from Agriculture, Land Use and Land Use Change and Forestry Sector

Emissions of Greenhouse gases from Agriculture increased by 0.33 Mt CO_2eq/yr in 2010 to a total of 5.7Mt CO_2eq/yr in 2021 . There was a reduction in the sink within the Land Use, Land Use Change and Forestry (LULUCF) sector from -0.774Mt CO_2eq/yr in 2010 to -0.752 Mt CO_2eq/yr in 2021 with a reduction of 0.022 Mt CO_2eq/yr over the decade (Emmett *et al.*, 2025).

Over the longer term, emissions from the sectors together reduced by 18% between 1990 and 2020. The Climate Change Committee reported in 2023, that there had been little recent progress in reducing emissions. (Climate Change Committee, 2023). Welsh Government have responded to the Climate Change Committee's 2023 progress report (Welsh Government, 2023d)

The emissions sink from LULUCF reduced in size between 1990 and 2021 (Climate Change Committee, 2023). The ability of the LULUCF sector to act as a carbon sink has shown a declining trend over the last decade (Climate Change Committee, 2023). The variation in the net sink is due to afforestation in earlier decades and the effect on the age structure of the present forest area, particularly conifer plantation (Forest Research, 2024b; Brown *et al.*, 2025). The net sink increased in size slightly between 2020 and 2021 (Welsh Government, 2024c).

In 2019, the largest emission sinks in the LULUCF sector was existing woodland remaining as woodlands (-72%) and the largest emission sources were grasslands converted to croplands (33%). In the Agriculture sector the largest emissions in 2019 was enteric fermentation (dairy 15%, non-dairy 22%, sheep 20%) (Welsh Government, 2021e). See the Climate Change evidence for information on the overall emission contributions across all sectors.

Livestock Management

Livestock influenced habitat condition, are the main source of ammonia emissions (which also contribute to particulate formation (PM2.5)), and ruminants (sheep and cattle) are the main sources of agricultural sector greenhouse gas emissions in Wales (Emmett *et al.*, 2025).

Sheep and lambs:

In 2024, the total number of sheep and lambs in Wales was 8.75 million, up 0.6% on the previous year's figure and down 8% on 2019 and SoNaRR2020 (Welsh Government, 2023f, 2024g). The number of sheep and lambs in Wales began to increase during the 1970s, reaching a peak of 11.8 million in 1999. There was a gradual drop in numbers over the following 10 years, possibly reflecting changes to the operation of the EU Common Agricultural Policy (CAP) when schemes based on the number of livestock kept where phased out (Welsh Government, 2023f). Between 2010 and 2023 there was an increase of 5% with no consistent trends and are lower than the historical highs of 1998 (Emmett *et al.*, 2025).

Cattle and Calves:

In 2024, the total number of cattle and calves in Wales was 1,089,800 – this represents a decrease of 2.4% from the figure for June 2023 and 3% compared to 2020(Welsh Government, 2024g). The contraction of the breeding herd continues to be primarily driven by the suckler herd (AHDB, 2023). The number of dairy holdings has declined and the number of dairy females aged 2+ years that had calved fell by 1.3% to 251,300 between 2023 and 2024 . This definition is generally accepted as a measure of the dairy herd. (Welsh Government, 2024g)

Across the UK, over the short term (2021-2023) annual average milk yields per dairy cow has fluctuated but over the longer-term (2004 to 2023) annual average milk yields have grown despite a decline in annual average dairy herd (DEFRA, 2024).

Over longer term periods (2004 and 2024), the size of Welsh dairy herd increased by 3% and the size of the beef herd fell by 33%(Welsh Government, 2024g). Between 2010 and 2023, there was a decrease from historical highs in 1974 for cattle and calves (Emmett *et al.*, 2025).

Pigs and Poultry:

In June 2024 the total poultry in Wales was 11,842,400 up from 9,840,150 in 2020. Poultry production is concentrated in relatively few large units. The numbers kept by other, non-commercial keepers will be relatively small. With this structure, a large increase or decrease in numbers on a handful of units can have a significant effect on the overall estimates. Over 90% of these were either table chicken/broilers (6.3 million) or chicken kept for laying eggs (4.4 million). In the early 2000s broiler chickens made up a large majority of the total poultry (Welsh Government, 2024g). The number of chickens for egg production has been increasing for a number of years and is now similar to the number of broilers (Welsh Government, 2023f). Poultry numbers have fluctuated over the last 20 years and are similar to numbers in 1999-2001(Welsh Government, 2024g).

In June 2024 the total number of pigs was 27,900 down from 28,430 in 2020. The numbers are lower then they were 20years ago. The majority (90%) are kept for fattening (meat production) with the remainder used for breeding (Welsh Government, 2023f, 2024g).

See the SoNaRR 2025 Annex to Aim 3: Cultural wellbeing evidence for gamebird management

Fertiliser Management

Overall application rates of artificial fertilisers, excluding nutrients from organic manures, in England and Wales, and Great Britain as a whole decreased between 2018 and 2022 (DEFRA, 2023a). The trend is for nitrogen, phosphate, and potash (NPK) on both the cropping and grass categories. The decrease in 2022 is thought to be largely attributable to price, which recorded sharp increases during 2021 and 2022 due to supply restrictions. The temporary closure of one of the main UK ammonium nitrate manufacturers in September 2021 caused initial supply issues in the domestic market compounded by global supply disruption by the conflict in Ukraine. The resulting price increase is thought to have been more problematic for livestock producers than arable farmers due to the timing of purchases (DEFRA, 2023a).

The long-term trend is shown below in Figure 4

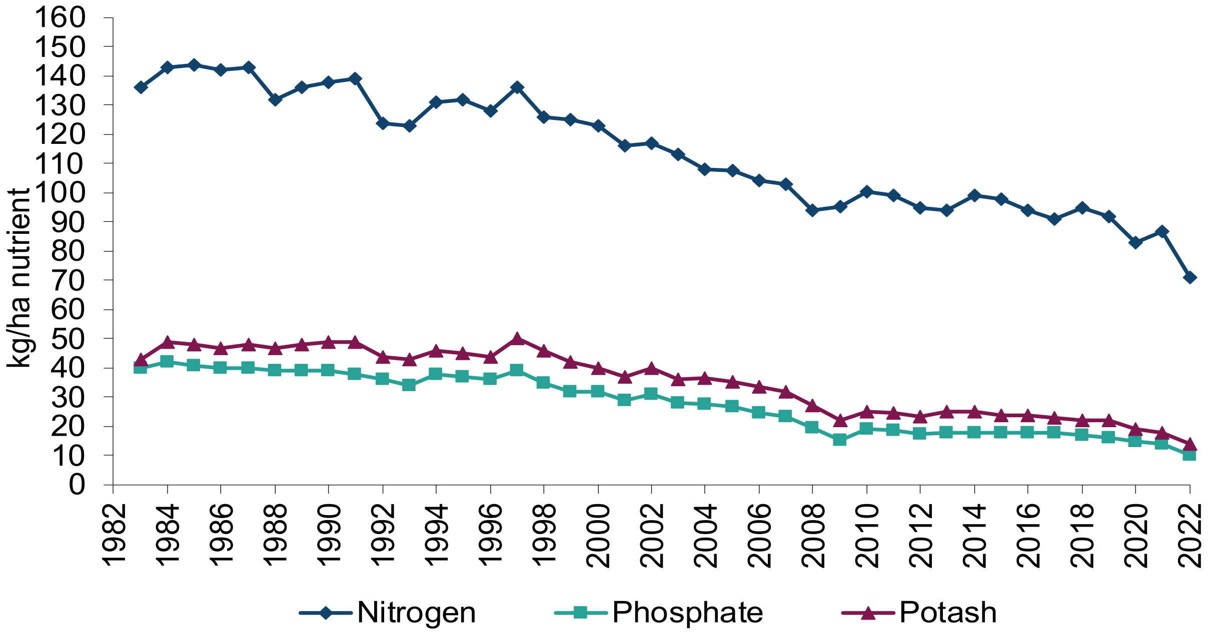

Figure 11 Long-term trends in GB fertiliser Practices (Source:: British survey of fertiliser practice 2022 (DEFRA, 2023a)

Inorganic fertiliser use in Wales

Using information from the Farm Business Survey on the amount purchased to estimate the amount used on different farm types (Dairy, Cereals and General cropping, Mixed, Lowland grazing, Less favourable area (LFA) grazing) :

- In 2022-23, Dairy farms make up the largest proportion of nitrogen use (48%) and output (47%) in Wales whilst accounting for a much smaller proportion of land (13%) and farms (15%) (Welsh Government, 2024b).
- In 2022-23, LFA grazing livestock farms make up the largest proportion of farms (66%), land (73%), with a considerable proportion of NPK use (32%, 44% and 39%). SDA Sheep farms make up the largest proportion of output (41%), land (55%) and farms (40%) out of all LFA farms in Wales (Welsh Government, 2024b).
- Fertiliser application rates (kg/ha) in all farm types showed an overall decline in inorganic fertiliser (NPK) between 2020-21 and 2022-23 (Welsh Government, 2024b).
- Dairy farms have a considerably larger average application rates of nitrogen (132 Kg/Ha in 2022-23), higher than all other farm types across the timeseries (2017-18 to 2022-23) with the exception of mixed farms in 2019-20, followed by cereals and general cropping (70 Kg/Ha in 2022-23), mixed (59 Kg/Ha in 2022-23), lowland grazing (44 Kg/Ha in 2022-23) and LFA grazing (16 Kg/Ha in 2022-23) (Welsh Government, 2024b).
- Cereals and General Cropping farms have a considerably larger average application rates of phosphorous (25 Kg/Ha in 2022-23), higher than all other farm types across the timeseries (with the exception of mixed farms in 2019-20), followed by mixed farms (16 Kg/Ha in 2022-23), dairy (10 Kg/Ha in 2022-23), lowland grazing (9 Kg/Ha in 2022-23) and LFA grazing (3 Kg/Ha in 2022-23) (Welsh Government, 2024b).
- The 2023-24 year saw a small increase in Nitrogen and Phosphorus (mainly for cereals and general cropping) application, but this is still lower than all farm total levels reported in 2021-22 and earlier (StatsWales, 2025)

Landbank Availability

SoNaRR2020 reported on the increasing concerns regarding the impact of pollution to water from the use and management of organic manures and identified better evidence was required to assess what landbank is available in Wales (NRW, 2021a, 2021b).

It is estimated that 10 million tonnes of organic manures are applied to the agricultural landbank in Wales each year (Rollett and Williams, 2022a). Organic manures (livestock manures/slurries, waste, sewage sludge and end of waste materials) when managed and utilised appropriately have a valuable role in improving soil health, contributing to a circular economy, and improved food sustainability and security. However, where organic manures are not managed properly, for example over applied to soil, this activity has the potential to cause harm to the environment. Organic manures should be seen as a useful resource and any over application a disposal activity.(NRW, 2024c).

Modelling has been used to estimate the distribution and size of the landbank that is available for recycling new organic materials containing nitrogen. The landbank available for organic materials is larger than that currently estimated to be used by livestock manures and organic materials. However, in some parts of the country (South Wales, North Wales, and Pembrokeshire) the landbank is already under pressure and transport of any future 'new' sources of organic materials away from these areas may be required. In comparison, parts of Carmarthenshire and Powys are under less pressure. Restricting applications to soils below P Index 3 showed the landbank was reduced further. The modelling and data limitations along with assumptions used are identified.(Rollett and Williams, 2022b, 2022a). However, other reports suggest there are pressures in other areas, such as the Wye Catchment (The RePhoKUs Project, 2021a, 2021b).

The Water Industry are undertaking a landbank availability assessment for England and Wales. This report will focus on biosolids applications to the landbank.

An Evidence Assessment of the Impacts of Organic Manures on the Water Quality has recently been published (Vallack, Hargreaves and Gibbs, 2025; no date)

Pesticide Practices

SoNaRR2020 Enclosed Farmland Chapter reported the weight of pesticide active ingredients applied to land had decreased over the past 25 years, whilst the number of hectares treated with pesticides, along with the frequency of treatments, had increased, impacting soil biodiversity (NRW, 2021a).

More recent data for arable, grassland and fodder crops grown in Wales since SoNaRR2020 show the weight of pesticides and the number of hectares treated on arable land has fluctuated whilst the weight of pesticides and number of hectares treated on grassland and fodder crops has decreased (Fera, 2022). Between 2020 and 2022, there has been a 20% increase in the total area treated and an 18% increase in the total weight of pesticides applied on arable land across the UK. The increase in area grown and the switch back to winter cropping in 2022 is likely to be the main reason for this increase in usage (Ridley *et al.*, 2022). On grassland and forage land across the UK, there was an increase in the pesticide-treated area of 25% since 2017, and 43% since 2009 corresponding to an increase in the area of fodder crops grown (turnips and swedes, fodder beet, maize and other crops for stock feeding). The weight of pesticides applied increased by 14% since 2017 and by 48% since 2009 (Ridley *et al.*, 2021). Over the longer term across the UK there was a 60% decrease in the total weight of pesticide active ingredients applied in agriculture between 1990 and 2020. (DEFRA, 2025).

Agricultural Productivity

Productivity provides a measure of how well inputs are converted into outputs. Recent UK trends for Total Factor Productivity (TFP) show an increase in productivity compared to SoNaRR2020:

- Productivity rose by 3.4% between 2021 and 2022 but declined 5.1% between 2022-2023 due to changes in input/output volumes, whereas SoNaRR2020 showed a decrease of 2.1% between 2017 and 2018.

- Between 2021-2022 there was a decrease in the volume of all inputs (3.3 %) and an increase (0.1%) between 2022-2023. The largest percentage decreases in inputs between 2021-2022 were fertilisers (-12.8%), seeds (-12.0%) and animal feed (-6.7%), whereas the largest increase in inputs between 2022-23 was fertilisers (15.3%).
- The volume of all outputs decreased by <0.1% (2021-2022) and 5% (2022-23). Total crop output increased by 1.7% between 2021-2022 and 7.9% between 2022-23, whilst total livestock output decreased by 1.7% (2021-2022) and 3.6% (2022-2023). The notable changes in crop output between 2021-2022 were an increase in oilseed rape (38.8%) and barley (11.5%), with decreases in sugar beet (-18.3%) and in 'vegetables and horticultural products' (-4.9%) whilst in 2022-2023 the largest decrease was in cereals (15.6%). All livestock outputs in 2022 changed by less than 4% up or down except for the output of eggs which fell by 21.4%.
- Since the series began in 1973, TFP increased by 67.3%, driven by an increase in the volume of all outputs by 37.9% and a decrease in the volume of all inputs by 17.6% (DEFRA, 2023b).

Indirect drivers of change

Governance

The most significant policy change on land used for agriculture since SoNaRR2020 is The Agriculture Act (Wales) 2023. This provides powers to amend legislation derived from the European Union (EU) and establishes Sustainable Land Management as the framework for future agricultural support and regulation within Wales, helping to contribute to the well-being goals and the Environment (Wales) Act 2016. The Act has four objectives:

- Sustainable Production of Food and other Goods
- Mitigating and adapting to climate change
- Maintain and enhance the resilience of ecosystems and the benefits they provide
- Conserve and enhance the countryside and cultural resources and promote public access to and engagement with them, and to sustain the Welsh language and promote and facilitate its use (Senedd Cymru, 2023).

This places the Sustainable Land Management duty on all Ministers and will contribute towards delivery of the many policy ambitions below and the following outcomes (Senedd Cymru, 2023).

- Encouraging the production of food in an environmentally sustainable manner.
- Helping rural communities to thrive and strengthening links between agricultural businesses and their communities
- Improving the resilience of agricultural businesses
- Sustaining the Welsh language and promoting and facilitating its use
- Reducing emissions of GHGs
- Maximising carbon sequestration and storage
- Maintaining and enhancing the resilience of ecosystems
- Conserving and enhancing landscapes and the historic environment

- Improving air quality.
- Improving water quality.
- Maintaining and enhancing public access to and engagement with the countryside and the historic environment.
- Mitigating flood and drought risks
- Achieving and promoting high standards of animal health and welfare
- Maximising resource efficiency - Taking a circular approach by keeping resources and materials in use for us as long as possible and avoiding waste.
- Encouraging agricultural businesses to manage energy effectively (including by adopting energy efficiency and energy saving practices and generating renewable energy on their land).

The Basic Payment Scheme payments continue in Wales whilst the replacement Sustainable Farming Scheme (SFS) is being developed. Glastir agreements expired at the end of 2023 and have been partially replaced by an interim scheme (Cynllun Cynefin Cymru/Habitat Wales Scheme) to provide an opportunity to continue management activities on statutory sites that held Glastir contracts.

All farmers participating in the SFS would be required to carry out a suite of 'Universal Actions' for which they would receive the 'Universal Baseline Payment'. Building on this, non-compulsory 'Optional' and 'Collaborative' actions would then be available for additional support (Welsh Government, 2023g)

A number of other policy targets and recommendations for climate adaptation and mitigation, commitments for nature and biodiversity, for Future Planning and for the Circular Economy have influenced and continue to influence the future direction of land use and management in Wales. The main changes since SoNaRR2020 are an increase in ambitions in sustainable land management, renewable energy, tree and woodland creation, housing and peatland restoration (Welsh Government, 2021d; Climate Change Committee, 2023).

- Net Zero Wales is the latest emissions reduction plan, following on from Prosperity for all: A Low Carbon Wales covering the first carbon budget (2016-20). This contains ambitions for land use change to meet decarbonisation ambitions such as more renewable energy, more tree planting and more peatland restoration that will affect current and future land use and management (Welsh Government, 2021d).
- The Water Resources (Control of Agricultural Pollution) Regulations were introduced in April 2021 and set out an all-Wales approach to reducing the impacts of pollution from agricultural activities on our environment, including rivers.
- The Environmental Impact Assessment (Agriculture) (Wales) (Amendment) Regulations 2020 amend the Environmental Impact Assessment (Agriculture) (Wales) Regulations 2017. The 2017 Regulations require agricultural projects on uncultivated or semi-natural areas and/or large scale restructuring projects on rural land holdings to apply to the Welsh Government for a decision on whether the project is likely to have a significant effect on the environment, known as a screening decision. EIA consent is required where the screening decision identifies significant effects (Welsh Government, 2017).

- A target for the equivalent of 70% of electricity consumption in Wales to come from renewable sources by 2030 with an additional aim to meet 100% of its electricity needs from renewable sources by 2035 (Senedd Cymru, 2023; Welsh Government, 2023h, 2023h)
- The UK government's energy security strategy, published in April 2022, contained various measures to deal with the UK's energy crisis and achieve its net-zero targets, including a pledge to ramp up solar power capacity from 14 gigawatts (GW) to 70GW by 2035 (UK Government, 2021, 2022a). This includes other energy measures which have impact on land use such as driving the growth of low carbon hydrogen, delivering new and advanced nuclear power, investing in CCUS, 50GW offshore wind by 2030 which will have impact on land use through transmission and other supporting infrastructure.
- The Climate Change Committee advised that to reach net zero, in Wales we need to plant 43,000 hectares of new trees by 2030, rising to 180,000 hectares by 2050. That means planting around 86 million trees over the next nine years (Welsh Government, 2021b). This exceeds commitments made in the Woodlands for Wales Strategy 2018.
- Peatland restoration targets will significantly ramp up and reach 1800 hectares of peatland restoration action per year by 2031(Welsh Government, 2022b; NRW, 2023a).
- Greenhouse gas removal (GGR) including carbon dioxide removal (CDR) is increasingly recognised as necessary for achievement of net zero emissions (Climate Change Committee, no date). Different removal methods and technologies hold different implications for land use. Current Welsh Government policy focus has been around carbon capture, utilisation and storage (CCUS) of industrial plant and power generation emissions , with no current plans to issue licences for permanent storage of CO2 onshore in Wales (Welsh Government, 2024k). However, recent Welsh Government consultation (May-August 2024) on Integrating greenhouse gas removals in the UK Emissions Trading Scheme includes consideration of high quality nature-based removals (Welsh Government, 2024d). New and novel land based greenhouse gas removal (GGR) methods such as biochar and enhanced rock weathering, are gaining increasing commercial interest as potential contributors to net zero emissions but commercial interest is running ahead of development of an adequate evidence base and appropriate regulation (Tresise, Wentworth and Parliamentary Office of Science and Technology, 2022; Beerling *et al.*, 2023; Forrest and Wentworth, 2024). There are many outstanding policy considerations and uncertainties which require further research to overcome the risks and impacts that may arise from inappropriate implementation (Tresise, Wentworth and Parliamentary Office of Science and Technology, 2022; Forrest and Wentworth, 2024).
- Wales is accelerating progress to go Beyond Recycling to achieve a zero waste, net zero carbon Wales (Welsh Government, 2021a). This includes halving avoidable food waste by 2025 and reduce it by 60% by 2030. Where we continue to generate waste, it requires land to manage it, highlighting importance of waste prevention (for all material types, not just food) for easing competing pressures on our land use. More food waste is expected to be collected separately in Wales following new regulations (i.e. The Waste Separation Requirements (Wales) Regulations 2023) and more initiatives to restrict food from being disposed in mixed residual waste.

- More housing through Strategic and Local Development plans (Future Wales). During 2019-20 to 2023-24 on average 7,400 additional homes are required annually (Welsh Government, 2021c)with a policy commitment to build 20,000 new, low carbon social homes over the Government term (Welsh Government, 2021e)
- Global target of 30 by 30 to protect and manage 30 per cent of our land, freshwaters and seas for biodiversity and cut food waste by half by 2030. Adoption of the COP15 4 goals and 23 targets. (Convention on Biological Diversity, 2022; Welsh Government, 2022c).
- Nutrient Neutrality to manage new development and water discharge permit proposals to prevent them from causing a net increase in nutrients for the duration of the authorisation within SAC River Catchment areas. This is applicable in Wales to developments with phosphorus discharges into Special Areas of Conservation (SAC) rivers. (NRW, 2022).
- River Pollution Action Plan for relieving pressures on Special Areas of Conservation (SAC) to support delivery of affordable housing. (Welsh Government, 2023e)
- Climate Change Committee recommendation to plant trees on 2% of farmland by 2025 while maintaining its primary use, rising to 5% by 2035, and extend hedgerows by 20% by 2035 and better manage existing hedgerows.(Climate Change Committee, 2023).
- Updated Planning Policy Wales to provide further clarity on securing net benefit for biodiversity through the application of the step-wise approach, a stronger emphasis on taking a proactive approach to green infrastructure and strengthened the protection of SSSIs (Welsh Government, 2024e).
- In 2023 Defra announced supermarket essentials will no longer be linked to illegal deforestation to protect the habitats of some of the world's most precious and endangered species. Palm oil, cocoa, beef, leather and soy are to be included in new legislation aimed at helping ensure the products we buy do not harm the world's forests. (DEFRA, Natural England and Steve, 2023)
- Agricultural Soil Policy Statement sets out the vision for protection and sustainable management of soils in Wales and acknowledges the crucial functions and services soils provide (Welsh Government, 2025a)
- In Wales, since 2019 all development 100 m² or more in size, is required to have Sustainable Drainage Systems (SuDS) to manage on-site surface water. These SuDS must be designed and constructed in accordance with the Welsh Government Standards for Sustainable Drainage. SuDS has benefits for both water quality and surface water management.
- Welsh Government have asked NRW to examine the case for new National Park in Wales. The area of search is based on the existing Clwydian Range and Dee Valley National Landscape but also takes in adjoining areas that meet the qualifying criteria for a National Park. Evidence has been compiled, and landscape evaluations have established the nature of the pressures and opportunities a new National Park might address. NRW Board have approved the evidence, and a full public consultation will now follow. If designation is found to be appropriate a Designation Order will be submitted to Welsh Government for consideration early in 2026.If the area does become a National Park, it's purposes will be to conserve and enhance natural beauty and promote opportunities for enjoyment and understanding of the special qualities of the area. National Parks will increasingly be expected to support farmers and landowners, implement policies to speed up nature recovery and mitigate and adapt to

climate change. Examples of projects include peatland restoration at scale and supporting appropriate small scale renewable energy projects or enhancing the management and extent of nature sites.

Economics

Farmers across Wales have been experiencing a challenging economic environment since 2020 from Brexit, Covid-19, increasing costs, consumer influences, world market trends, TB issues and extreme weather events. Wet winters had delayed livestock turnout and dry weather affected grass growth and potato yields, whilst a mixed autumn affected tilling. More recent challenges have been around the conflict in Ukraine, inflation, higher input costs, livestock disease, changes to farm support, changes in the political landscape, and extreme weather events (Meat Promotion Wales, 2021, 2024; Farmlytics, 2024; Aberystwyth University, no date).

The farm accounts data derived from the annual Farm Business Survey (FBS) in Wales showed :

- Dairy farms consistently account for the largest proportion of agricultural Farm Business Income (FBI) and output in Wales (between 2012-13 and 2022-23). Dairy FBI has varied greatly over the past 11 years largely due to farm gate milk prices which has a direct effect on income on dairy farms. There is wide variation in milk price paid to farmers in Wales. Over the same period Less Favoured Areas (LFA) farm FBI showed considerable variation, but all had seen a decrease in farm business income in 2022-23 compared to the previous year. Grazing farms (Disadvantage Areas) accounted for the smallest proportion of agricultural output in Wales, whilst DA Grazing is technically the lowest contributing farm type, this is closely followed by Sheep (Severely Disadvantaged Areas) and SDA Grazing farm types. In terms of relative FBI (profit) the trends for each farm type have varied considerably throughout the years with no single farm type being the overall highest or lowest earner. In 2022-23, Dairy farms have the highest percentage of farms in the Profit band whereas DA Grazing farms have the highest percentage making a loss (Welsh Government, 2024a).
- The contribution of the Basic Payment Scheme, other subsidies, miscellaneous and diversified income to the bottom line contributed around 25-28% of the total income (outputs) and 108-190% of profits, on average, for the upland cattle and sheep farms.
- The Farm Business Survey throughout the period highlighted large profit differences between the top third and bottom third of producers. For example, the top third hill cattle and sheep farms' £ per effective hectare profit was over double the average achieved. However, these don't take account of labour costs which may be misleading, especially in the dairy sector. (Aberystwyth University, no date)

The economic evidence doesn't include the recent changes to agri-environment schemes.

More evidence on modelled trade scenarios and the impacts are contained in SoNaRR2020 Land Use and Soils (NRW, 2021b) and Welsh Government's published Evidence and Scenario Sub-group products (Welsh Government, 2019), which includes the Summary from their EU exit scenario planning workshops (Welsh Government, 2018).

See SoNaRR 2025 Woodland assessment for evidence on Timber provision. The Trees and Timber Taskforce made a recommendation for a Timber Industrial Strategy (Welsh Government, 2021g) and this was published by Welsh Government in July 2025.

Farmer Motivations

SoNaRR2020 reported the average farm size in Wales is generally small in comparison to most other parts of the UK and are predominately made up of very small (59%)(standard output <£25k) and small farms (28%) (standard output £25-125k) in terms of turnover they influence just over half the land area of Wales (15% and 45% respectively). As such, these are numerically important in terms of people and land management area (NRW, 2021b). Both farm types share similar overall motivational rankings with intrinsic and expressive factors the most important reasoning given for farming and that lifestyle was more important than income maximisation. Small farm operators tend to view their farm primarily as a business (83%) and, place importance on carrying on a family tradition (48%), working with other family members and feeling strongly connected to the farming community as their main motivations. Both farm types show openness to Environmental Conservation with very small farms slightly more enthusiastic about enjoying environmental improvement activities (Bradley *et al.*, 2021).

SoNaRR2020 reported on the motivations for sustainable land use change.

Covid-19

Studies on the impact of COVID-19 provide information about a shift towards modified eating behaviours and shifts towards online food purchases. The restrictions on hospitality meant a large shift to more home consumption and less consumption away from home, with substantial impacts on supply chains and producers.(González-Monroy *et al.*, 2021; Dicken *et al.*, 2022; Welsh Government, 2022e).

Almost **half of Welsh Dairy producers** have been **highly affected** by COVID-19. This is due to the higher occurrence of farmers affected by reductions to milk prices and requests to reduce production volumes. With such a considerable proportion of Welsh producers affected, the Welsh Government introduced funding support.

Food and Food Consumption

The food and drink supply chain in Wales (primary production, manufacturing, retail, wholesale, and non-residential catering) contributed a total Gross Value Added (GVA) of £6.11bn in 2021 up from £4.7bn in 2016 and SoNaRR2020. It employed 233,500 people in 2023 up from 217,000 (2017) people and SoNaRR2020. The sector employed 37,000 people in 2021, a 2.8% increase from the 36,000 in 2020 (Food and Drink Wales, 2024).

Studies into food consumption and trends in the UK showed:

- That what people consume still falls short of dietary guidelines. There have been reductions in salt, sugar, and red and processed meat consumption in the last 10 years, but consumption of fruit, vegetables and fibre has shown little or no change.

There are socio-demographic differences in the consumption of a healthy diet. Low socio-economic status (in terms of education level, work status and income) is the single most consistent risk factor for an unhealthy diet (d'Angelo *et al.*, 2020).

- The channels through which consumers purchase food are diversifying, especially from the expansion of online food delivery platforms (d'Angelo *et al.*, 2020; Food, Farming and Countryside Commission, 2023)
- *Consumer trust in British agriculture remains strong* and are the most trusted sector in the whole food supply chain. *The environment is important and a concern to consumers when choosing food* (Adamson, 2023; Food, Farming and Countryside Commission, 2023)
- **T**he public are more concerned now about environmental issues than in 2020 and SoNaRR2020, with particular interest in water issues relating to water pollution, plastic in food packaging, rainforest and habitat destruction. Methane from livestock, water usage in British crop production and food miles were the major concerns for all respondents. (Adamson, 2023; Food, Farming and Countryside Commission, 2023)
- There has been an increase in the sale of ethical and sustainable produce, but this represent a small proportion of household food purchases. There is often a value-action gap between a stated preference for sustainable and ethical food and translation into action if other needs are satisfied (e.g. price, availability and perceived quality). Many consumers remain unaware of social and environmental consequences of their consumption practices. The most important barrier to purchasing sustainable and ethical food stated to be in the literature is cost, with other barriers including perceived quality and habit (d'Angelo *et al.*, 2020).
- A survey and research into the value of the "Value of Welshness" to shoppers and guests in Wales and across GB found that shoppers and guests desire more Welsh Food and Drink in retail and out of home venues (*The Value of "Welshness"*, no date).

Food Waste in Annex 5: Aim 4 Waste evidence**.**

Environmental Schemes and Support

SoNaRR2020 reported on the lessons learnt from previous Rural Development agri-environment schemes. Updated evaluations suggested the following recommendations for these schemes: Enabling Natural Resources and Well-being Grant (ENRaW), Sustainable Management Scheme (SMS) and Local Places for Nature (LPfN). Areas to build upon included:

- Sharing of experiences and good practices and using established good practices.
- Build on sustainable partnerships and collaborative approaches using innovative and flexible approaches.
- Explore opportunities for greater involvement of NRW in the SMS.
- More long-term approaches (ENRaW andLPfN).
- More support and dedicated Team or individuals to projects and a facilitator support role (SMS).
- More focus on outcomes, rather than inputs, and develop greater mechanisms for monitoring and illustrating the outcomes against programme (LPfN and ENRaW).

- Using monitoring data to support optimisation and identifying opportunities for improvements (LPfN).
- More project pipeline (LPfN).
- The Expression of Interest process to be shorter, a six-to-12-month development phase prior to a full three-year delivery phase (SMS)
- An assessment process that assesses the whole application rather than individual sections (SMS)
- Alignment with regional priorities, dates for funding windows to be outlined from the outset and adhered and swift turnaround (SMS)

  (Welsh Government, 2021f, 2023b; Johnson and Vousden, 2023)

A 2021 survey regarding the support offered by Farming Connect showed soil sampling or nutrient management planning and animal health monitoring were the most popular single activities carried out by farmers and land managers, and that a combination of activities were mainly carried out. (Cutress, 2021)

In the same survey, 43% of respondents aimed to plant trees in the future, with 29% not intending to, and 27% being unsure. Of those who answered no to planting trees in the last 10 years, around 25% of respondents overall had a definite lack of any desire to plant trees. The main reasons for not planting trees was the consideration that enough trees had already been planted on their farms (34%), the land was either considered too good for trees, required for grazing livestock or that there wasn't enough land in general (19%). Another key barrier likely due to the ending of the Glastir support was that there was a lack of desire without funding or policy to indicate benefits to farmers for doing so (9%). (Cutress, 2021)

Advances in Technology

Remote sensing and artificial intelligence developments can be used for land use and management decisions, modelling of future scenarios, monitor future change in landscapes and habitats (van der Plas *et al.*, 2023) and for making land management decisions such as precision farming (Farming Connect, 2020; Sishodia, Ray and Singh, 2020)

The level of uptake and types of technology used for land use and management decisions in Wales is an evidence gap.

Farmers across Wales will have maps and information of their farms from LiDAR, providing information on habitats and tree cover.

Future outlook

The future outlook is likely to be more pressure on the limited supply of land to:

- meet the demand for food and timber (Meat Promotion Wales, 2024) (Confor, 2022),(Welsh Government, 2022f),(Future Generations Commissioner for Wales, 2020; Jones *et al.*, 2023)

- provide more renewable energy and housing,
- store and sequester carbon
- more organic materials for recovery to land
- to mitigate and adapt to climate change
- maintain and restore habitats for biodiversity
- improve resilience to extreme weather and global economic shocks.

The biggest change in a generation is the Agriculture (Wales) Act 2023 which replaces the long standing Common Agricultural Policy. The Sustainable Farming Scheme proposals align with the Act's Sustainable Land Management objectives and have been met with a strong reaction from the farming sector (British Broadcasting Corporation (BBC), 2024) with concerns about the payment method, budget and the feasibility of the scheme rules (Senedd Research, 2024). Using feedback on the Sustainable Farming Scheme (SFS) consultation – Keeping Farmers Farming, Welsh Government have worked closely with the farming unions and other stakeholders and have established an SFS Ministerial Roundtable supported by two sub-groups to make changes to the proposed Scheme to several key areas balancing the evidence, stakeholder views and other considerations (Welsh Government, 2024h).

The Sustainable Farming Scheme sets the pathway towards a transition to more sustainable land management as required by the Agriculture (Wales) Act. The success of the scheme in achieving the objectives and outcomes for climate, nature, people and pollution reduction will depend on the level of uptake, speed of transition and effective implementation. Agriculture covers the majority of land use and management in Wales. Evolution of the scheme over time will be important to support progress towards sustainable land management.

Responses and Opportunities for action

Responses to SoNaRR2020 Opportunities

Evolution of 'public goods'-based schemes, initiatives and incentives

Nature Investment Standards: The British Standards Institute (BSI) has been tasked with developing a new, consensus-based, UK-wide standards' framework and is looking to establish an overarching standard, setting out the principles for high-integrity nature markets (British Standards Institute, no date). This standard will be applicable across nature markets and establish common principles that provide a benchmark for existing and emerging schemes to be recognised as sufficiently robust and credible. This work is currently undergoing a discovery phase, which will conclude with the publication of a roadmap identifying a set of formal standards to be developed to establish the framework and address other key gaps in the current landscape. This BSI standard is intended to:

- establish an overarching framework to drive actions to create the conditions for consistency and high integrity across all nature markets.
- support high integrity of units traded in nature markets.
- support nature markets to deliver positive environmental outcomes.
- protect against the risks of activity in nature markets leading to negative, unintended consequences for the environment.
- act as a specification, and a basis for standards on specific aspects of nature markets, against which market participants can seek certification to signal their high integrity; and

support the provision of information from nature markets that deters, and/or helps detect, greenwashing.

Sustainable Investment Principles: The Welsh Government is developing an approach to sustainable finance for natures recovery (Welsh Government, 2024i). The principles intended to ensure funding in Nature Markets and environmental services are of high integrity, benefits and engage local communities and avoid inappropriate land use change and green washing.

Woodland Water Code: Forest Research, funded by Defra, has embarked on a project to develop a UK Woodland Water Code (WWC) as a crediting mechanism to support private investment in woodland creation as a nature-based solution to help tackle diffuse pollution, flooding and rising water temperatures. The WWC will look to align with other incentives for private investment in nature markets including potentially integrating with the existing Woodland Carbon Code. The code may also support work on achieving nutrient neutrality (Brook *et al.*, 2024).

Nutrient Trading: Welsh Government convened a Nutrient Trading Task and Finish Group during 2023 representing a range of stakeholders, including NRW, to look at the feasibility for potential nutrient trading as a tool for improving freshwater quality. The subsequent group report provides a series of recommendations for further action, whilst recognising the opportunities, challenges and risks involved for all. Links have been established to wider work from across the UK that would also benefit from this work, including the development of BSI Nature Investment Standards and the Woodland Water Code project led by DEFRA.

Sustainable Urban Drainage: Sustainable drainage systems (SuDS) are designed to mimic natural drainage by managing surface water run-off as close to source as possible taking into account the benefits such as water quantity, water quality, biodiversity and amenity by providing green infrastructure. All new developments of more than one dwelling or where the area covered by construction work equals or exceeds 100 square metres require approval before construction can commence from the SuDS Approval Body (SAB) (CIRIA and susdrain, 2025).

Soil Carbon: Various work is ongoing in the area of soil carbon bringing together research into development and practice, such as the Welsh Governments Carbon Sequestration Panel work (report in preparation). Across the UK a group of stakeholders are also feeding into a BSI guidance development which consider the parameters of carbon markets (including soil) and the application of principles as well as technical challenges around the Monitoring, Reporting and Verification (MRV) of Farm Soil Carbon projects.

Hedgerow Carbon Code: The Game and Wildlife Conservation Trust (GWCT) has begun piloting a new Hedgerow Carbon Code funded from the government's Natural Environment Investment Readiness Fund to evaluate the practicality of the code and the carbon calculation tool. The code will encourage hedgerow habitat improvements to increase the amount of carbon stored by hedges, contributing to farming's net-zero target and biodiversity. The intention is to allow land managers to calculate and verify the carbon capture potential of their hedgerows, enabling them to trade carbon credits (The Game & Wildlife Conservation Trust, 2022).

Protect Wales' network of special places for nature and landscape

Biodiversity Deep Dive: Implementing recommendations from the biodiversity deep dive that focussed on Wales' response to the global target known as 30 by 30 to protect and manage 30 per cent of our land, freshwaters and seas for nature by 2030.

Nature Networks Programme: this aims to improve the condition and connectivity of our protected sites network contributing to our international commitments such as 30x30. This programme also encourages community engagement whilst also increasing capacity to develop a range of projects to enable our most precious habitats and species to thrive.

National Peatlands Action Programme: Welsh peats occupy approximately 4% of the land area. Semi natural peatlands, which occur primarily in the uplands account for 97% of all peats in Wales (NRW, 2020). The National Peatland Action Programme has six priorities:

6. Peatland erosion
7. Peatland drainage
8. Sustainable management of blanket peats
9. Sustainable management of lowland peats
10. The restoration of afforested peatlands
11. The gradual restoration of our highest carbon-peatlands

Restoration action on over 3,000 hectares in the first four years (2020-24) means the programme surpassed its restoration targets of public and private land (NRW, 2024d; Welsh Government, 2024j).

Local Places for Nature: (LPfN) promotes a bottom-up approach and community led activities to:

- create areas that support nature within communities, in particular urban and peri-urban areas
- encourage a greater appreciation and value of nature
- create more green spaces, honouring our commitment to do so
- support wider biodiversity objectives

National Forest: The National Forest for Wales programme was launched by Welsh Government in Spring 2020 with the aim of creating a National Forest the length and breadth of Wales (Welsh Government, no date). It aims to support the improved management of existing woodlands (including those not previously in planned management) and new woodland creation. The Woodland Investment Grant (TWIG) and Status Scheme both support bringing woodlands into planned management and the programme has included initiatives such as Tiny Forest (Welsh Government, 2023a) and Plant a Tree. See SoNaRR 2025 Woodland assessment.

Celtic Rainforest: A report on the State of Wales' Rainforests was published on 26th November 2024. The report is the first major output of the Alliance for Wales' Rainforests. It establishes an ecological baseline for rainforest condition in Wales, shining a spotlight on the multiple threats that the habitat faces and outlining the actions required to restore Wales' temperate rainforest and create a healthier, better connected and more resilient rainforest landscape. The Celtic Rainforest LIFE project has improved woodland condition within the Eryri National Park and also on three woodland SACs outside through a systematic programme of Rhododendron removal, halo thinning and the re-instatement of appropriate grazing (Eryri National Park, no date). See SoNaRR 2025 Woodland assessment

Nutrient Neutrality: the principles are for managing new development and water discharge permit proposals to prevent them from causing any net increase in nutrients for the duration of the authorisation within failing SAC River Catchment areas (NRW, 2022)..

The Natur am Byth: this partnership is Wales' flagship Green Recovery project. It unites nine environmental charities with Natural Resources Wales (NRW) to deliver the country's largest natural heritage and outreach programme to save species from extinction and reconnect people to nature (NRW, 2023b).

The River Teifi Catchment area Demonstrator Project: this is seeking to find innovative solutions to pollution problems. A recent event (NRW, 2024b) identified the following themes:

- Farmer led projects.
- Data Integration and Visualisation.
- Water quality awareness.
- Collaborative Long-term Funding.
- Rainfall/catchment management.
- Behaviour change.

Four Rivers for LIFE: this is an ambitious, large-scale river restoration project to improve the condition of four major rivers in Wales: Teifi, Cleddau, Tywi and Usk. These four rivers are classed as Special Areas of Conservation (SAC) which means they are of international importance for their wildlife and plants such as Atlantic salmon, lamprey, shad, otter and water crowfoot (NRW, 2023c). All four rivers are currently in an unfavourable condition as a result of multiple pressures (NRW, 2024a).

Sands of LIFE: Sands of LIFE was a major conservation project to rejuvenate sand dunes across Wales which runs to June 2024. It recreated the natural movement in the dunes and revitalised habitats which are home to some of our rarest wildlife.

This major project, led by Natural Resources Wales, restored over 2400 hectares of sand dunes, across four Special Areas of Conservation, on 10 separate Welsh sites. Natural Resources Wales / Sands of LIFE

River Dee LIFE: LIFE Dee River is a £6.8m project to transform the River Dee and its catchment by restoring the river and its surroundings back to their natural state. This will bring many benefits to the environment, most notably improving the numbers of salmon, lamprey and freshwater pearl mussels to help them become more sustainable in future. Natural Resources Wales / LIFE Dee River

New LIFE for Raised Bogs: The LIFE Welsh Raised Bogs project is the first national restoration programme for raised bogs and for any peatland habitat in Wales. The 4-year pioneering and ambitious project aims to restore seven of the very best examples of raised bogs in Wales. Almost 4 square miles (over 900 hectares) will be restored to a better condition. This represents 50% of this habitat in Wales and 5% in the UK. Natural Resources Wales / New LIFE for Welsh Raised Bogs

Opportunity Catchments: For the third cycle of River Basin Planning, NRW has identified Opportunity Catchments. These will be integrated as a priority work area for both NRW and external partners across the public and private sector Natural Resources Wales / Dee and Western Wales river basin management plans 2021-2027

A better land use change decision-making framework

It has been estimated that if existing land-based policy commitments are added together, the UK's land already risks being 'overpromised' (The Royal Society, 2023).

Since SoNaRR2020 there are continued calls for more consideration of future land use changes required to meet policy commitments. Some are calling for a land use framework (*A Land Use Framework for Northern Ireland*, no date; *Land use framework*, no date), others are calling for more consideration of multi-functional land uses (UK Climate Risk, 2021; The Royal Society, 2023) and a more spatially targeted strategy for land-use change initiatives with more integration of the mitigation and adaptation policy ambitions (UK Climate Risk, 2021).

The Department for Environment, Food and Rural Affairs (Defra) has published a consultation to inform the development of a Land Use Framework for England Land use in England - GOV.UK. Key findings of the assessment into integrating data for better land use decision found gaps and areas to improve on :

- A shared spatially explicit integrated evidence base to help understand the opportunities for multifunctional land use.
- Land use model to help decision makers think holistically.
- Applying land valuation (economic and non-economic) in decision making.

- Improvements to some datasets.
- No agreed taxonomy for land use that meets the need for land use decision making and no clear definition of what is ‘urban’ and what is ‘rural’
- Inefficiencies in development from a lack of information on land ownership.

(*Finding common ground: Integrating data, science and innovation for better use of land*, 2023).

Future land use scenarios have been explored in a Welsh context including land sparing and sharing scenarios for sustainable land use and food systems in Wales. It found in order to achieve this goal and create habitat for biodiversity it would be necessary to stipulate that 86% of all new forest should be planned and managed to deliver benefits for biodiversity (i.e. it should use a diverse mix of native species (and/or natural regeneration) and be sensitively managed to maintain good ground cover flora, open areas and a shrub understorey layer). Modelling and evidence gaps remain in relation to agroforestry land use scenarios (Smith *et al.*, 2022).

Implement the National Peatland Restoration Programme

See above.

Increase the rate of new woodland creation and plant more trees

Woodland creation is taking place in Wales, but the scale and pace continues to fall well short of Welsh Government policy aspirations. There is currently no additional incentives to spatially target tree planting, for example to improve connectivity. Data on Priority Ecological Networks (PENS, including covering woodland was published in August 2023. The Timber and Trees Deep Dive, announced by the Deputy Minister for Climate Change in June 2021, sought to identify and prioritise a set of actions to increase tree planting; and overcome barriers related to woodland creation, taking account of the challenging levels of tree planting needed to address climate change; use Welsh timber in construction and the need to de-carbonise Welsh housing; and encourage community tree planting . Following the Deep Dive, there has been a revamp of the woodland creation grant offering in Wales, and work has been undertaken to streamline NRW's verification of woodland creation applications and improve woodland creation content on its website. Organisations such as the Woodland Trust continue to support a range of tree planting and woodland creation initiatives such as MOREwoods, MOREhedges, and trees for schools and community groups. Welsh Government has also developed the Sustainable Farming Scheme which will incorporate actions to plant more trees on farms. See SoNaRR 2025 Woodland assessment.

More Sustainable Land Management Systems and Practices

Overall, 40% of agricultural land (38% of Wales) participated in the agri-environment Glastir scheme with 54% of the previous Tir Gofal and/or Tir Cynnal schemes land area entering the Glastir schemes. Specific management actions on particular land parcels to improve the status of the natural resources covered 25% of agricultural land in Glastir. The difference between these two areas represents land covered by the Whole Farm Code (WFC), which required farm managers to adhere to a series of rules across their entire land holdings. Most of the land use change across Wales was unconnected to Glastir. Glastir management options will have contributed an additional ca. 1% of future land use change due to woodland creation which is not yet detectable by satellites. A small number of land management options incentivised land use and management changes (categories as defined by UKCEH Land Cover Map between 2010-2021), such as woodland creation (3,780ha of which 5ha was agroforestry), hedgerow creation and restoration (2,200km), peatland restoration (992ha or 1.2% of peatland area) and habitat creation (3890 ha) (Emmett *et al.*, 2025).

Of the many options offered in the Glastir scheme, five options represented 62% of land area in the scheme. The majority of Glastir management options focussed on limiting grazing pressure and fertiliser use by area. The Farm Practice Survey indicated this has supported the maintenance of current practices as there was no evidence animal numbers and fertiliser use were different in scheme compared to outside of the Glastir Entry and Advanced schemes (Emmett *et al.*, 2025).

The Habitat Wales Scheme (HWS) is a replacement scheme. Farmers could enter this from Glastir Advanced and Commons when their contracts came to an end on 31 December 2023. The aims of the scheme was to maintain support for the management of habitat land in 2025 before the introduction of the Sustainable Farming Scheme (SFS) Universal Layer in 2026 and bring additional habitat land, not currently under paid management, into sustainable land management practices (Welsh Government, 2023c)

Using a decision train approach to tackle issues at source

Source apportionment modelling of the contribution that different sectors make to phosphate levels in catchments designated as Special Areas of Conservation (SAC) showed Rural Land Management to be the primary contributor of phosphates in the Wye, Usk, Tywi and Cleddau and a smaller contribution in the Glaslyn and Teifi, where the contributions from the Water Industry are higher (Dŵr Cymru Welsh Water, no date).

Opportunities for SoNaRR2025

There are five main areas, where policy, systems and practice can help to improve the sustainable use and sustainable management of natural resources based on land capability and suitability opportunities:

- Protect and conserve the current land cover.
- Alter land management regime (systems and practices).
- Provide ‘nudges’ to change use or management such as standards or incentives.
- Change the land use.
- Innovate the provision of well-being benefits.

There needs to be alignment between the five types of intervention if the challenges of the climate and nature emergencies, decarbonisation targets, and well-being benefits.

From the evidence in the chapter and in SoNaRR2020 the following are considered to be top priorities to address through a combination of the five main types of intervention:

Evolution of ‘public goods’-based schemes, initiatives and incentives.

More sustainable agricultural and forestry land management must be supported as part of an integrated approach to increase SMNR, the provision of ecosystem benefits, and enhance future well-being. The ability of land managers to work collaboratively, and at scale, to share and build knowledge and skills and deliver shared outcomes is needed - this is essential for landscape or catchment scale outcomes. In addition, incentives to adopt systematic approaches, profitability and business resilience go hand in hand with sustainability and ecosystem resilience. Sustainable production can only take place when there is the right balance between private and public sector initiatives, as well as accountability, equity, transparency, and regulations. Farmers and land managers need to be provided with the right incentives that support the adoption of appropriate practices on the ground (NRW, 2021b;Welsh Government, 2022c).

Protect Wales’ network of special places for nature and landscape

The network of terrestrial and freshwater SSSIs provides a haven of wild diversity alongside Wales’ treasured landscapes. Considerations should be made to giving soils more of a prominent role in existing terrestrial SSSI site descriptions. It has been long known that protecting these patches and taking action to restore habitat ‘stepping stones’ between these special sites increases the resilience of all of Welsh ecosystems. Some of these sites will be impacted by the changing climate but taking action to better connect Wales’ special sites will help some species and habitats adapt and move (NRW, 2021b; Welsh Government, 2022c; *State of Nature Wales*, 2023). See SoNaRR 2025 Aim 2 assessment.

A better land use change decision-making framework

Clear direction on land use change and sustainable land management priorities at a national, regional, and local level could support better delivery of SMNR through Area Statements, RENs and other place-based delivery mechanisms. Wales’ policy frameworks for natural infrastructure and long-term climate change mitigation and adaptation requires land use change (NRW, 2021b). Land use change based on sustainable management of the soils resource as part of the Environment Act (Wales) 2016 are crucial to the climate and nature agendas (UK Climate Risk, 2021).

A land use decision framework could help bring together all the interests, from environment and farming, town planning and housing, public services, transport and infrastructure, and business investment. People and communities should be involved in shaping a national framework and be informed by it. More co-operative approaches between landowners and managers could support the shifts we know are required. A new coherent and integrated framework may help such complex decisions to be made in the context of SMNR, the climate and nature emergencies (NRW, 2021b).

Implement the National Peatland Restoration Programme

Bringing upland and lowland semi-natural deep peat into favourable condition and bringing more tree covered, grassland, and arable deep peat into sustainable management would help meet Wales' nature and decarbonisation targets. This would increase sustainable drainage across peaty soils, contributing to catchment-based flood and drought risk management strategies. Peatlands in good condition support a characteristic and significant suite of habitat types and animal and plant species, as well as performing a range of critical ecosystem service functions: carbon accumulation, carbon storage, the regulation of greenhouse gas emissions, and other hydrological and hydrochemical processes (NRW, 2021b; *Regulating Water Flow | IUCN UK Peatland Programme*, no date).

Increase the rate of new woodland creation and plant more trees.

Wales must tackle the climate and nature emergencies to improve ecosystem resilience and generate future well-being benefits. SoNaRR2016 identified that planting 'the right tree in the right place' can provide multiple benefits for SMNR and well-being. Challenges remain.

There are opportunities for natural catchment management to reduce flood and drought risk, and to slow down surface water flow by creating or restoring riparian and/or flood plain trees and woodlands. This would provide land for upstream winter overflow and improve riparian habitats throughout water catchments to collectively reduce the risk of flooding and drought to downstream communities. Tree shelterbelts established at Nant Pontbren catchment in pastures of land used for sheep grazing showed water infiltration rates were up to 60 times higher in areas planted with young trees than in adjacent grazed pastures. This demonstrates that farm trees could represent a key landscape feature, reducing run-off even when only present as a small proportion of the land cover (Carroll *et al.*, 2004; Woodland Trust & Coed Cymru, 2013; DEFRA *et al.*, 2025).

Trees and hedgerows along farm boundaries and integrated throughout the farm can provide biosecurity barriers, provide shade and shelter benefits for livestock and crops as shelterbelts or interspersed throughout pasture in a silvospasture or silvoarable agroforestry system. They provide a habitat for wildlife, especially when linked to areas of fragmented existing habitats intercept overland water flow and diffuse pollutants before they reach watercourses and intercept airborne pollutants such as ammonia (DEFRA *et* *al.*, 2025; Soil Association, 2025; Centre for Ecology and Hydrology and the Forest Research, no date). Woodland and trees grown as a crop for timber can help diversify the farm business (Soil Association, 2025).

One of the most important measures to improve river health in Wales is to establish good tree lined riparian zone habitat and management wherever possible, especially at protected and designated waterbodies (DEFRA *et al.*, 2025). There are opportunities for riparian habitat establishment and maintenance in the SFS (Welsh Government, 2025b) .

Trees in towns and villages can significantly help society adapt to the predicted impacts of the changing climate through shade, cooling, and air quality improvements. Woodland creation on suitable derelict brownfield sites can bring them back into beneficial use (See Spirit of Llynfi Woodland, near Bridgend).(NRW, 2021b)

More integrated Sustainable Land Management Systems and Practices

Land underpins the supply chain, and if it becomes degraded, the business is at risk. Continuing professional development and compliance with regularly updated best practice frameworks, such as the Code of Good Agricultural Practice, UK Forestry Standard, and Planning Policy Wales, and Sustainable Farming Scheme is key.

Precise and appropriate application methods of organic manures will minimise the risk of causing diffuse pollution (air and water), soil erosion, promote soil biodiversity and whilst reducing emission of greenhouse gases. Encouraging more agroecological and low impact silvicultural principles, practices and systems as part of agronomic and forestry decision-making and nutrient management can replace or minimise the use of inputs (NRW, 2021b).

Using a decision train approach to tackle issues at source

A major failing within resource management is trying to tackle problems at the point where the impact is felt. This is simply too late; there is a need instead to look at the root cause of problems and develop approaches which can tackle them at source. The “decision train” approach can be used to consider additional or complementary solutions in a sequential manner as shown in the diagram below.

In the case of erosion, for example, it is very difficult to tackle surface run-off across a catchment. However, it is possible, through legislation or other motivations, to tackle the sources of the issue. Modified vehicle emission standards improve air quality and with cleaner air there is less pollution deposited over the countryside. This in turn reduces the amount of polluted run-off.

The following four-step approach provides a framework for solving problems as close to their source as possible (Figure 3)

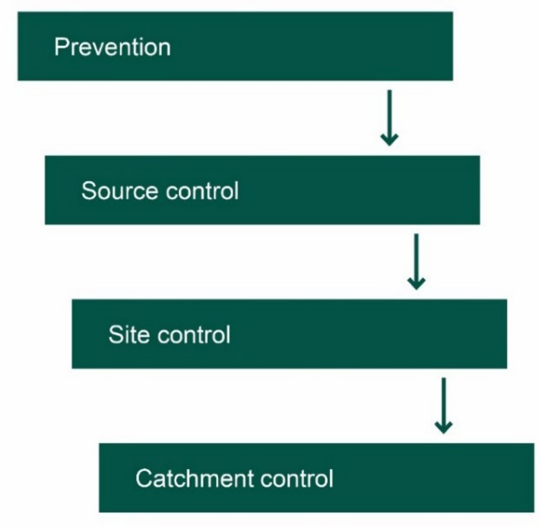

Figure 12 Four-step decision train approach (Source: NRW)

When seeking to address issues such as catchment erosion, the nature of the existing challenges must be looked at. All too often prevention or dealing with the source of the issue is ignored, and solutions are applied at the very last stage where the impact is most heavily felt. Such late stage interventions are important, however ignoring “upstream” solutions can end up being more costly and inflexible (NRW, 2021b).

See also Annex 5: Aim 4 Waste evidence

Evidence needs

Existing Evidence Needs

Progress on evidence needs identified in SoNaRR2020 were for combined Land Use and soils. Progress was undertaken in relation to Nutrient Loadings to Land. An assessment of the current landbank in Wales (gov.wales) Constraints to nutrient recovery and recycling to agricultural land in Wales (gov.wales).

New and existing evidence needs:

1. Spatial distribution of livestock numbers and densities across Wales.
2. Further research to estimate total cereal needs for animal feeds in Wales, in particular to find the breakdown of cereal type and use by each livestock sector in Wales. Current reports provide estimates for the UK but not for Wales. 69 ERAMMP Feasibility of increasing cultivated crops on farms in Wales as a GHG mitigation measure and for delivery of public goods.pdf.
3. The extent and type of crops grown for bioenergy in Wales.
4. The extent of roadside verges managed for nature.

5. Published trends in fertiliser practices (organic and inorganic fertilisers) in Wales. Historical evidence exists for inorganic fertilisers for GB, England and Wales combined with more recent evidence published for Wales on inorganic fertiliser use.

6. Uptake of innovative sustainable land management practices in Wales such as precision farming and innovative horticulture

7. Trends in sustainable land management practices in Wales and the outcomes they provide for climate, nature and people and their contribution to pollution reduction.

8. Agricultural productivity (Total Productivity Factor) for Wales (an estimate of inputs and outputs). Estimates are published for the UK regularly but not Wales.

9. Above and below ground carbon sequestration rates of different agroforestry systems and the benefits and trade-offs for nature and people relevant to the Welsh context.

10. Update statistics and analysis of food consumption trends. These have not been updated since 2017 [National Diet and Nutrition Survey: results for years 1 to 9 | GOV.WALES]

11. Spatial Land Use changes in Wales and trends over time to better understand the type and extent of changes to inform SoNaRR pressures. Where land use change data and evidence is collected it is not easily shared or combined. A better understanding and monitoring of shared land uses would also be useful where primary use is for woodland or agriculture but also may support renewable energy development for example.

12. Updated statistics on the area of Trees outside woodlands.

13. Barriers and enablers to sustainable land management and sustainable land use change across all farm types and sizes in Wales.

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Annex 4: Aim 3 Cultural well-being evidence

Evidence lead: Jill Bullen

Summary

The State of Natural Resources Report (SoNaRR) highlights the vital role of landscapes in delivering cultural ecosystem services that support well-being, identity, and nature recovery. Landscapes are not only physical spaces but also cultural settings that shape how people experience life, connect with nature, and engage with heritage.

The landscape evidence pack contributes to our understanding of cultural well-being and is supporting evidence for SoNaRR2025. New national evidence is reported through three Cultural Ecosystem Services, including key messages, insightful summaries, and key opportunities for action.

Continue reading to understand the importance of landscapes in delivering cultural well-being and the importance of integrating landscape considerations into planning, design, and management. Opportunities for action include:

- Enhancing resilience through place-based planning.
- Improving green infrastructure in urban areas.
- Promoting dark sky-friendly lighting.
- Conserving landscape character and quality.
- Using landscape character to guide climate and nature recovery responses.

"The Landscape Institute welcomes the State of Natural Resources Report, and the evidence-based connections made between landscape, wellbeing, and nature. This demonstrates that protecting, conserving, managing and enhancing landscapes is vital. Our chartered landscape professionals have the skills to do this, providing life-enhancing solutions for people, place and nature". Carolin Göhler, Landscape Institute President, 9 January 2025.

Cultural Ecosystem Service: Visual and sensory amenity services (Experiential)

Overview for landscape

Landscapes are the settings in which we live, work, study and experience life, they reflect the interrelationships between natural resources, culture and economy. Landscape characteristics and qualities deliver multiple benefits and contribute to cultural well-being, a sense of place, identity and quality of life, as well as wildlife benefits. Landscapes are an effective communication tool to raise public awareness and understanding of the climate and nature emergencies which can help inform and influence positive changes (Clwydian Range & Dee Valley AONB and Natural Resources Wales, 2022).

Key messages

- Over half of Wales is evaluated as outstanding or high for its visual and sensory character, qualities and scenic quality, a nationally important landscape resource [H].
- The full Tranquillity & Place resource (Theme 6) shows tranquillity to be an important national resource for Wales, its people and nature. 70% of Wales (14,917km2) is in the top three tranquillity categories of the combined Theme 6 dataset, indicating that large areas of Wales are associated with multiple contributors to tranquillity [H].
- 81% of Wales is in the top 3 most visually tranquil national categories where the perception of nature and natural landscapes is greater than that of human influence and light pollution [H].
- Only 10% of urban areas are in the top 3 visually tranquil national categories, green infrastructure could enhance tranquillity [H].
- 41% of our landscapes are evaluated as moderate, locally important, for their landscape character [H].
- More than 2/3rds of Wales is within the darkest skies national category, but light pollution is prevalent around built-up areas [H].
- 86% of Wales is in the top five (out of ten) combined sound environment national categories where natural sounds are expected to be more prominent than noise [H].
- The changing climate of Wales is likely to have significant direct (e.g. changing land cover) and indirect (e.g. by influencing land use decisions) impacts on landscape character, quality and local distinctiveness [H].
- 20% of adults visited green and natural spaces every day in Wales, these places can enrich our experiences of life [H].

Key opportunities for action

- **Enhancing resilience and sensitive place-based planning in locally valued landscapes** - this can also improve their landscape quality and character.
- **Increasing quality green infrastructure** - this can enhance visually tranquil places where people live, providing an important contrast and benefits to quality of life.
- **Promoting dark sky lighting retrofits and policies** - to reduce light pollution, and can bring positive changes for communities, nature recovery and climate mitigation.
- **Following the advice in the Noise and Soundscape Plan for Wales 2023 to 2028** – particularly when planning new development that may impact on the relative balance between noise and natural sounds where people live.

- **Conserving and enhancing landscape character and quality** - including nature recovery actions and broadleaf woodland planting are likely to contribute to an improving trend and condition.
- **Landscape character can help plan and guide change at scale** – contributing to our responses to climate and nature recovery actions.

State and impacts on benefits.

Tranquillity can be described as a relative abundance, perception or experience of nature, natural landscapes, and features and/or a relative freedom from unwanted visual disturbance, signs of human influence and artificial noise. Tranquillity is highly valued and contributes to landscape value, health, well-being and spiritual benefits, and can support local economic opportunities associated with activities that satisfy demand for tranquillity from visitors and tourists. You can view information and data relating to the Tranquillity and Place themes on the Tranquillity and Place Story Map.

The new Tranquillity & Place resource has been developed using mapped 'themes' that merge to produce an overall relative Tranquillity & Place map identifying the strategic and local resource for use as an evidence base to inform policy intent, practice and provision for well-being benefits. The themes are as follows:

Theme 1 - relative abundance, perception or experience of nature, natural landscapes and greenspaces.

Theme 2 - relative freedom from intrusive visual disturbance and human influence.

Theme 3 - relative dark skies.

Theme 4 – sound environments where natural sounds are more prominent than noise and are appropriate to context. Theme 4 is further subdivided into:

- Part 1. Sounds other than road and railway noise.
- Part 2. Road and rail noise
- Part 2 Combined. Joining Theme 4 part 1 and part 2.

These themes are collated to develop the combined themes:

Theme 5 - visually tranquil places (Themes 1, 2 and 3)

Theme 6 – the full tranquillity and place resource (Themes 1, 2, 3 and 4).

The Tranquillity & Place Theme 6 full resource connects sound and visually tranquil places. 70% of Wales (14,917km2) is in the top three tranquillity categories of the combined Theme 6 dataset (Figure 1), indicating that large areas of Wales are associated with multiple contributors to tranquillity [H]. All National Parks and National Landscapes (Areas of Outstanding Natural Beauty) have more than 97% of their area within the top four tranquillity national categories, reflecting their importance for tranquillity and their contribution to visual and sensory amenity services. (Green *et al.*, 2025).

81% of Wales is in the top 3 (30%) most visually tranquil categories (5,398.15 km2 is in the top 20%) (Figure 2) where the perception of nature and natural landscapes is greater than that of human influence and light pollution (Green, Manson and Chamberlain, 2022 version 2) [H]. The predominantly rural and visually tranquil landscape of Wales is reflected in over half of Wales (51%) being evaluated as outstanding or high in LANDMAP Visual and Sensory, including for its character and scenic quality (White Consultants, 2018) [H]. Most of the areas evaluated as Outstanding are Upland. 73% of Wales is associated with attractive views both into and out from landscape areas [H].

Eryri National Park has the highest percentage of land area within the top 3 visually tranquil categories at 97%, all three National Parks in Wales are above 92%. Llŷn and Gower AONB have the highest proportion of land in the top 3 visually tranquil categories, both at 98% (Green, Manson and Chamberlain, 2022 version 2) [H]. Evidence that supports tranquillity being an important Special Quality of designated landscapes.

A ‘word cloud’ generated using the collective Special Qualities of the eight designated National Parks and National Landscapes in Wales shows the prominence and importance of tranquillity to their designation and in conserving and enhancing Natural Beauty (Tirweddau Cymru, 2025).

27% of the National Parks and National Landscapes in Wales are evaluated as outstanding, and 49% is evaluated as high in the national LANDMAP Visual & Sensory dataset [H]. The three top LANDMAP Visual & Sensory landscape classifications for the designated landscapes in Wales include 31% (1,584km²) upland moorland, 9% (446.9km²) open rolling lowland, and 6.7% (344.7km²) is open or wooded mosaic upland valley (Nolan *et al.*, 2020) [H].

Relative tranquillity and accessibility by urban standards where people live is important, in addition to provision within the rural landscape. Of the 214 urban areas assessed in Wales, only 10% are in the top 3 (out of 10) visually tranquil categories (Green, Manson and Chamberlain, 2022) [H]. Urban areas were defined using the extent of the study areas mapped in the Urban Tree Cover data from the Tree Cover in Wales’ Towns and Cities project (NRW, 2016). This suggests a significant potentially unmet demand for visually tranquil places in urban areas. As tranquillity has limited resilience, subtle changes may have marked effects on natural settings and tranquillity. Conversely, subtle positive changes, such as from green infrastructure, may help to realise fuller benefits from visually tranquil places where people live providing an important contrast and break from the built environment with benefits to quality of life. Exposure to green space, particularly urban, is associated with improved psychological well-being, physical activity and linked health outcomes. There is evidence for the psychological benefits of nature-based interventions, in particular reduced depression and improved mood (Lamont and Hinson, 2024).

The People and Nature Survey for Wales (NRW and Natural England, 2024) showed that 20% of adults visited green and natural spaces every day, with 40% visiting twice a week or more. 24% were visiting urban green spaces, with the importance of the wider landscape evident through visits recorded to the open countryside (19%), beaches, sea and coastline (16%) and woodlands & forests (15%). Landscapes as settings in which we can enrich our experiences of life 81% visited places for walking, 30% wildlife watching, 12% children's play and for 16% picnics and eating outside. 96% said it was good for their physical and mental wellbeing and 85% felt that being in nature made them happy [H]. Eryri National Park visitor monitoring figures (2022) for the mountainous areas indicate that over 540,000 people visited Yr Wyddfa and 75,500 visited Cader Idris (Eryri National Park, 2023).

Welsh policy aims to conserve and enhance outstanding and high landscapes with characteristics and qualities of national and regional/county importance to deliver current cultural benefits now and in the future.

However, 41% (8,609.04km2) of Wales in the LANDMAP Visual and Sensory dataset is evaluated as moderate for character and 40% for scenic quality [H]. Landscapes with distinctive characteristics and patterns of elements and features can contribute to a local sense of place. Enhancing environmental resilience and sensitive place-based planning in these locally valued (moderate evaluation) landscapes can improve their quality and character and contribution to cultural well-being.

Dark skies are an important natural resource for people now, and future generations, enabling views of stars, major constellations, meteor showers and the Milky Way in our darkest places. More than 2/3rds of Wales falls into the darkest skies category (Figure 3), with mid Wales being the darkest region (90%) and 95% of the designated landscapes being within the darkest two categories (Green, Manson and Chamberlain, 2021) [H]. Astrotourism in these localities is increasing with the third Welsh Dark Skies Week in the Designated Landscapes in 2024 to the astro-tourism trail in the Cambrian Mountains featuring in the National Geographic. Since SoNaRR 2020 Ynys Enlli, Presteigne and Norton and Gower have gained dark sky area status, the Clwydian Range and Dee Valley National Landscape is in application.

You can [view information and data relating to dark skies on the Tranquillity and Place Dark Skies Story Map] and on the [Dark Sky and Light Pollution web map].

Light pollution, however, can impact our visual, amenity and experiential services from landscapes and greenspaces and the cultural and economic benefits they provide. There are indications that the amount of light emitted around the edge of major built up areas is increasing, data also suggests the amount of light within the built-up areas is decreasing (Green, Manson and Chamberlain, 2021) [H]. Reducing prevalent light pollution and using dark sky friendly lighting can make a difference for our communities’ health and wellbeing, as well as the breeding cycles and foraging behaviour of nocturnal wildlife.

Environmental noise is an important public health issue, a top environmental risk to health with negative impacts on human health and wellbeing. The National Survey for Wales stated that a quarter of the people in Wales are regularly bothered by noise from outside their homes (World Health Organization, 2018; Welsh Government, 2022b) [H]. Tranquillity and relatively tranquil sound environments are an important resource in Wales with health and well-being benefits for people and the wider economy. Tourism may benefit from associations with valued sound marks and iconic sounds (Welsh Government, 2023) where prominent and distinctive sounds are associated with specific places, species or land uses creating a strong sense of identity linking to place.

Outdoor noise can be an environmental stressor, where the environment exerts pressure on a person or population, which is beyond the control of those experiencing the noise. Some landscapes and places include prolonged, man-made mechanical sounds. Positive soundscapes and high quality acoustic environments have been linked to health and can help us avoid or mask the aggravation and stress response evoked by unwanted noise(Irene van Kamp and Fred Woudenberg, 2025).

The Tranquillity & Place sound environment theme incorporates certain man-made sounds as environmental stressors as well as sounds from nature which may be more beneficial, restorative sounds. “Islands of tranquillity” such as urban parks and green spaces are regarded as beneficial and health-promoting, this should equally apply in the built environment where people live outside of urban areas. Identifying and mapping the Tranquillity & Place sound environment brings new evidence to Wales and contributes to the intent of the Environment (Air Quality and Soundscapes) (Wales) Act 2024 to tackle unwanted noise and protect sounds that matter to people.

At a national scale 86% of Wales is in the top five (out of ten) combined sound environment categories where natural sounds are expected to be more prominent than noise in outdoor places (Figure 4). Whereas 69% of Wales (14,600 km^2) is in the top three national tranquillity categories for the sound environment where natural sounds are more prominent than noise when considering solely road and rail (Gibbs and Sims, 2024) [H]. This indicates that large areas of Wales are affected by sounds other than road and rail. With the cessation of all major road building projects in Wales in 2023, consideration of the sound environment when planning new development that may impact on the relative balance between noise and natural sounds where people live is important for the outlook and retention of associated tranquillity and sound benefits.

More than 77% of all National Parks in Wales are in the top three tranquillity categories for the sound environment in relation to road and rail (with Eryri being greater than 84%), reflective of the general absence of these networks in Welsh National Parks. However, for the combined sound environment 14% of National Parks in Wales are in the top three tranquillity categories confirming that sounds other than road and rail detract from tranquillity associated with sound, for example low flying aircraft, ports, quarries and industrial sites. National Parks do exceed the national statistic (9%) for combined sound environment at 14% (Gibbs and Sims,

2024) [H], supporting their relative importance within the Welsh landscape in still delivering tranquil sound environments as an integral part of people's experience of protected landscapes.

The increased road and rail network within, and near to, National Landscapes (AONB's) is reflected in the reduced percentage of top three tranquillity categories for the sound environment in relation to road and rail, in comparison to National Parks (>77%), with the lowest National landscape (Wye Valley) at 59% and Anglesey, Llŷn and Gower all exceeding 74%. For the combined sound environment in National Landscapes, the average is 17%, higher than for National Parks, with the Gower and Anglesey particularly delivering well on the sound environment at 36% and 26% respectively, and the Wye Valley and Clwydian Range and Dee Valley much reduced with both at 4%.

Wales Natural Beauty and Landscape Mapping indicates that large areas of Wales' landscapes have a potential for high or moderate contribution to natural beauty (on a 7-point scale of high contributor to high detractor). The mapping also shows a correlation between areas of high contribution to natural beauty and high contribution to wellbeing. The most popular motivation for UK staying visitors to Wales is to enjoy the country's natural landscape (79%) (McAllister, Blunt and Davies, 2021), up from 67% in 2016. It is seen as a particular strength and something that sets Wales apart as a holiday destination. Many came to relax from the stresses of life and for the sense of peacefulness (74%).

The three National Parks in Wales are legally recognised for their Natural Beauty and for the opportunities they provide for the enjoyment of the special qualities through outdoor recreation. Scottish National Parks regularly generate over £700million of economic impact per annum in their visitor economies alone, more than 30 times the £22m invested in them by the Scottish Government each year (Watson, 2024). Whilst not all economic impact will be directly associated with National Park status, studies in the USA and Finland have shown that funding for National Parks has generated a 10 to 1 economic return on investment (Mayhew, 2024). Studies suggest the return on investment for National Parks is between 1 to 10, and 1 to 30. The Anholt-Ipsos Nation Brands Index (Ipsos, 2022) identifies natural beauty as a strong key driver (16% and in top 3 drivers) for visitors to many countries.

Key drivers and pressures

Previously identified landscape pressures reported in SoNaRR include how climate change impacts may influence to a greater or lesser degree landscape character and quality, expansion of the built environment, onshore wind renewable energy, woodland expansion replanting choices. These pressures remain valid and are supported by the SoNaRR 2025 ecosystem chapters [H].

Nationally evident changes – mixed picture

The Environment and Rural Affairs Monitoring & Modelling Programme (ERAMMP) for Wales report National Trends between 2010 and 2021 identifies a 7% increase in

Woodland cover, a 4% increase in new and restored Hedgerow and an expansion of Urban cover of 28,200ha, now representing 6% of Wales in 2021

Th assessment reported that 12 (63%) Broad Habitats and Landscape Features were in a state of concern or had declined; 6 were stable (32%) and 1 had improved (Hedgerows), representing a doubling of Broad Habitats and Landscape Features which are now of concern or had declined in the last 10 years (Emmett *et al.*, 2025) [H].

Cumulative change across the Welsh landscape is intensifying with a broad trend towards increased woodland cover and diversity, undermanaged marginal land, and intensification of agriculture in lowland areas. The visibility of onshore and offshore wind and solar renewable energy developments is increasing, as are the increasing impacts of climate change from disease affecting character, species and seasonal diversity e.g. ash, larch. A positive trend in peatland restoration improving landscape scale habitats.

Locally evident changes – mixed picture

The ERAMMP report acknowledges the positive local impact of the increased Woodland cover, and local negative impact of increased Urban cover, changes that will have been important for local landscape visual quality, as well as impacting on many other services and benefits. The age of individual trees in the landscape is progressing, but overall numbers have not increased. No change was reported in the condition of Historic Environment Assets (HEAs) with 54% in excellent or sound condition (Emmett *et al.*, 2025) [H].

Wider local changes are evident from urban expansion, impacts of climate change from flooding, wildfires, erosion and landslip affecting built and natural environments. Agricultural intensification e.g. larger dairy and intensive poultry units in the rural landscape. Undermanagement of habitats and woodlands, unmanaged sport, recreation and access affecting landscape quality, and biodiversity, expansion of game bird shoots and visual effects of vegetation management. INNS including edges of watercourses, pollution and fly tipping. An NRW survey of local authorities in 2021 and 2024 showed a positive trend in improving dark skies in towns and villages by improving street lighting units and implementing local authority night time lighting policies (NRW, 2021).

Registered historic landscape (RHL) changes

Medium to larger developments are generally located outside of Registered Historic Landscapes, or outside of the character areas most sensitive to change. Development trends remain continuous in type and distribution. Regionally, North Wales RHL's have seen an increase in residential and mixed-use development applications within the Registered Historic Landscapes. Small-scale development, tourism, camping pods and extensions to caravan sites and increased renewables are evident in West Wales. Within South Wales, most applications were for agricultural building/poultry/slurry store followed by commercial and industrial development or redevelopment (NRW, 2024a).

Trends and outlook

The changing climate of Wales is likely to have significant direct (e.g., changing land cover) and indirect (e.g., by influencing land use decisions) impacts on landscape (Berry *et al.*, 2019) including landscape character, historic buildings, local distinctiveness and quality (Welsh Government, 2024b) [H].

Risks and opportunities from climate change for landscape character are assessed as increasing in magnitude from medium at present to high in the future (Netherwood, 2021). Flooding (Figure 5), wildfire and extreme weather events can affect our wellbeing, interaction with landscape and accrued recreation benefits.

You can view areas threatened by sea level rise and coastal flooding in Wales and the United Kingdom on the Climate Central Coastal Risk Screening Tool interactive map. Projections for future flood levels can be viewed under different scenarios.

Pests and diseases, such as ash dieback can affect our long-term benefits. Ash trees are culturally significant, valued for heritage, spiritual, recreation and landscape contributions (Hall *et al.*, 2021). Ash is a key component of our Welsh landscape, in woodlands (17,500 ha of ash dominant woodland), along roadsides and hedgerows or as individual trees in fields, parks and gardens. The Welsh Government long term aims for ash dieback include minimising the social, economic, environmental and cultural impacts of ash dieback (Welsh Government, 2024a).

The loss of seasonal colour in the countryside due to large-scale removal of larch plantations has brought opportunities for increasing colourful mixes of broadleaves and introducing low impact silvicultural systems (LISS), with multiple benefits for landscape, nature recovery and climate adaptation.

Low-level benefits arising from warmer mean temperatures may include changes in crops and vegetation growth, or the discovery of new historic assets visible as parch and crop marks (Historic Environment Group, 2020), but overall impacts will be negative for the landscape (Berry *et al.*, 2019).

You can view case studies of how climate change will alter our landscapes and our historic places on the Historic Environment and Climate Change in Wales Story Map.

18% of all LANDMAP Visual & Sensory landscape areas in Wales are considered to be in good condition, 45% fair, 3 % poor in relation to the component elements, features and management, although 34% are unassessed it does give some insight (White Consultants, 2018). 57% of all Visual & Sensory landscape areas in Wales are regarded as in constant condition, only 9% improving and 34% declining, the overall outlook for significantly improving landscape condition is unlikely to change without positive interventions that enhance landscape character and quality [H].

The publication in 2025 of Good Practice Guidance: Planning for the Conservation and Enhancement of Dark Skies in Wales enables developers and planners to design, submit and assess lighting schemes that are appropriate and support the implementation of national planning policy for lighting. The Dark Skies Working Group in Wales has evidence that since publication, more lights have been switched off to benefit nature and communities.

Wales Natural Beauty and Landscape Mapping includes mapping of the potential of landscape features to contribute to/detract from resilience to climate change. Landscapes of high scenic quality and good condition tend to have potential to contribute to biodiversity and resilience to climate change. The Welsh Government's Biodiversity Deep Dive recognised the opportunities for the Designated Landscapes to contribute to nature recovery in their areas, recommending that prioritised nature restoration plans are developed and delivered, supported by evidence and mapping tools (Welsh Government, 2022a). Landscape enhancing universal actions from the Sustainable Farming Scheme, nature recovery actions and broadleaf woodland planting to balance losses from ash dieback and larch are likely to contribute to an improving trend and condition.

Landscape visualisations can effectively convey changes to landscape character as we respond to a changing climate and nature emergency, facilitating understanding and landscape planning (Clwydian Range & Dee Valley AONB and Natural Resources Wales, 2022). Figure 7 illustrates a range of desirable future landscape examples.

Evidence gaps

- Monitoring landscape change through LANDMAP
- Visual impact of renewable energy
- Changes in ffridd / coed cae vegetation character and landscape quality
- Changing light pollution and impact on relative dark skies and tranquillity
- Registered Historic Landscape change.

Cultural ecosystem service: Spiritual, artistic and symbolic services

Overview for landscape

Landscapes characteristics and qualities can be associated with spiritual, artistic and symbolic meaning, contributing to language, cultural identity, and sense of being and place. Planning Policy Wales recognises that the intrinsic value of a place to people or communities as being particularly important, and that this may relate to aesthetic, cultural, spiritual and/or historical associations.

Key messages

- Landscape characteristics and qualities associated with spiritual, artistic and symbolic services contribute to Wales' distinctive cultural identity and sense of place.
- Spiritual, artistic and symbolic landscape associations can enhance quality of life and are important economic and social assets, as recognised in Planning Policy Wales (Welsh Government, 2024b).
- The legacy of prehistoric religious, ritual and funerary sites evident in the landscape today are tangible records of the spiritual and symbolic activity of

past generations, they need to be maintained for the benefit of present and future generations.
- More than 2/3rds of Wales is within the darkest skies category [H] where there is improved visibility of astronomical features in the night sky, contributing to nighttime sense of place, tranquillity and spirituality. Light pollution around built up areas results in limited or no visibility of astronomical features.
- Natural nocturnal sounds from night time wildlife experiences can enrich spiritual services, including listening for birds such as nightjar, owls and Manx shearwaters, badger watching, bat detection and glow-worm spotting, and the wildlife tours that offer these experiences.

Key opportunities for action

- Placemaking is a holistic approach to the planning and design of development and spaces, focused on positive outcomes (Welsh Government, 2024b). A holistic placemaking approach can recognise that spiritual, artistic and symbolic services are not limited to the rural environment but can be integrated where people live through Placemaking (Design Commission for Wales, 2020).
- Recognition and consideration of the visibility, and its vulnerability, of spiritual sites and their associations with local topography and views when potentially impacted by landscape change.
- Implementing night lighting policies and installing dark sky friendly lighting units can have marked positive effects for the visibility of the night sky and its astronomical features.

State and impacts on benefits.

Landscapes that are associated with the perceptual qualities wild and/or spiritual are recorded and mapped in the LANDMAP Visual and Sensory dataset, it is not exhaustive at a local landscape level (question 24).

New mapping (2024) of Prehistoric Funerary and Ritual sites (Figure 6) shows the density of designated sites across Wales, indicative of their landscape and archaeological significance and contribution to spiritual and symbolic services. Associating the density of Prehistoric Funerary and Ritual sites with landscape character areas enables a landscape perspective to our past and present cultural and ideological associations.

These features and sites are frequently, and strongly, connected to the natural environment and often landscape intervisibility. The contributions of ecosystems to cultural and spiritual identity and as a source of inspiration for expression (e.g., through art) can provide well-being benefits and enjoyment.

Meaningful connections may be made with more accessible places such as through community identity, as places to ‘escape to’, through nature-based spiritual, cultural and arts-based activities perhaps linked to myths and legends or experienced through the lens of the film industry using Welsh landscapes.

Key drivers and pressures

- The lack of intensive farming in upland and marginal areas has enabled buried archaeological features and earthworks, and especially prehistoric ritual monuments to remain well preserved. However, the effects of climate change on these areas will be numerous, the effects may be gradual or severe in the short to medium term and significant over time, potentially detrimentally affecting their cultural services from impacts such as wildfires, destabilisation. Increasing visitors and heritage tourism may lead to opportunities for conservation-led site management but may also result in adverse increased visitor pressure on popular historic sites (Historic Environment Group, 2020) [H].
- Wildness is the quality of an area which appears to be uninhabited, often relatively inaccessible and where the influence of human activity on the character and quality of the environment appears to have been minimal. Land that is perceived to be undermanaged, e.g. marginal land, may add to a sense of wildness, the visibility of onshore and offshore wind and solar renewable energy developments is likely to detract from the perception of wildness, and perhaps spirituality.

Evidence gaps

- More detailed landscape evidence relating to spiritual, artistic and symbolic services.

Cultural ecosystem service: Education, scientific and research services

Overview for landscape

The biophysical characteristics and qualities of ecosystems that can contribute to education and research by enabling people to use the geological landscape environment mapped, classified and recorded from a landscape perspective facilitating intellectual interactions with the environment.

Half of Wales (50%) is highly valued in LANDMAP for its Geological Landscapes, based upon an assessment of their research, educational and historical values, rarity or uniqueness and as a classic example. 33% of Geological Landscape areas include features or sites with clear key geological or geomorphological features as classic examples. 19% of the Geological Landscape areas (landscape area polygons) are recognised as outstanding, being of exceptional scientific importance and nationally or internationally rare or unique, a further 19% are regarded as scientifically rare or regionally exceptional, an exceptional offering for education, scientific and research services (NRW, 2024b) [H]. The dataset can also be interrogated specifically for its value to research and education (questions 29 and 29a).

Figures

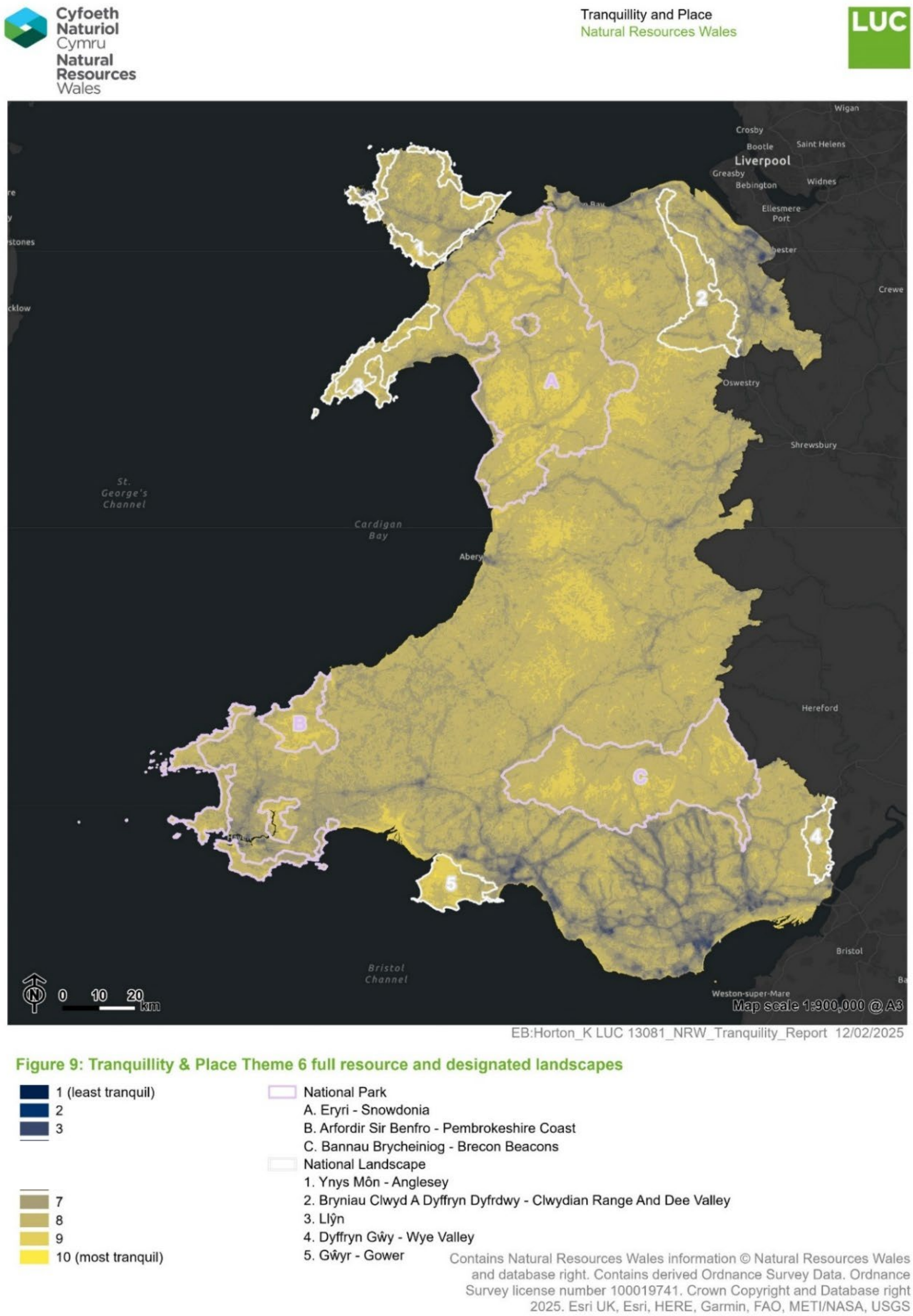

Figure 13 Tranquillity & Place Theme 6 Full Resource

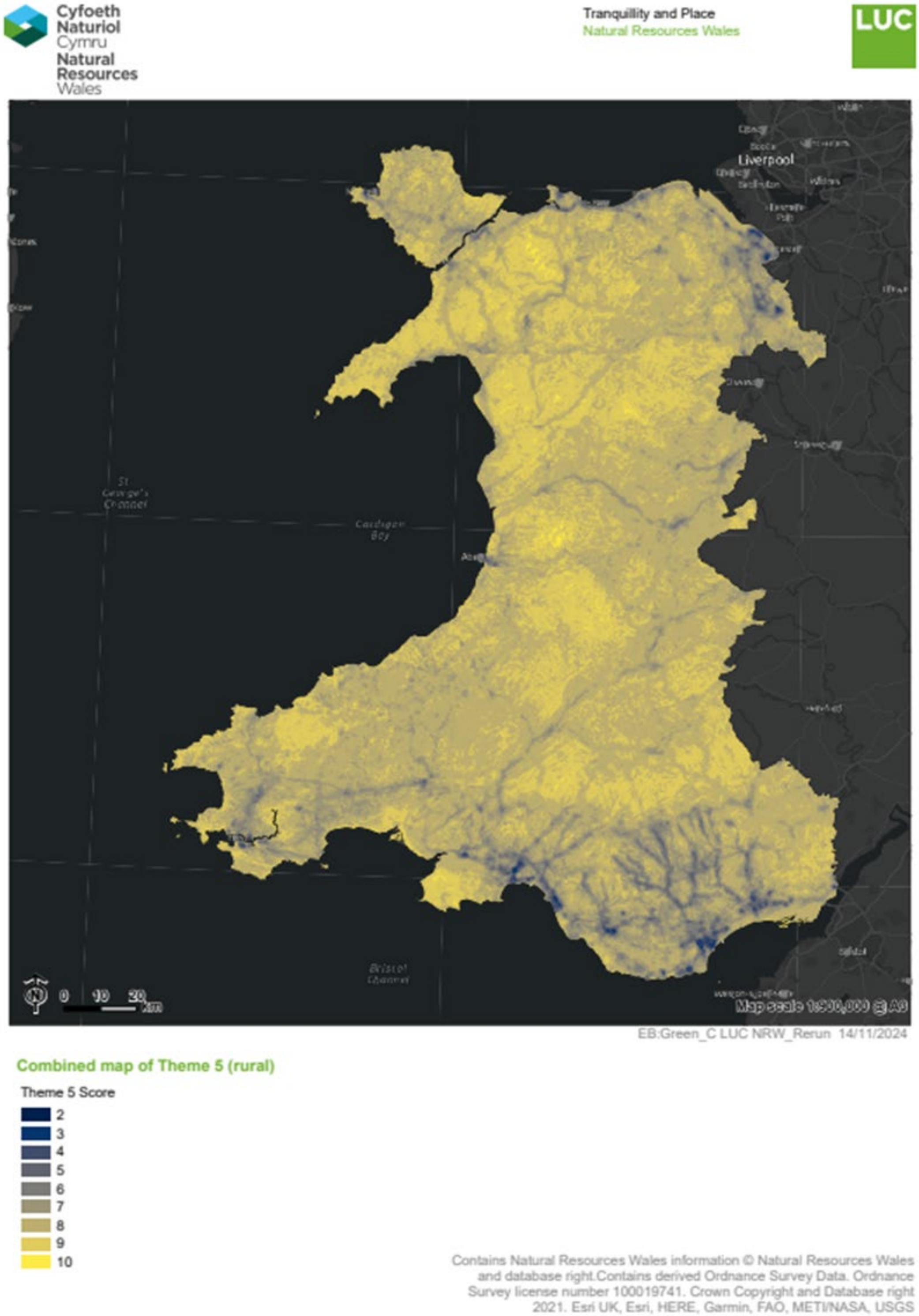

Figure 14 Tranquillity & Place Theme 5 Visually Tranquil Areas

Cyfoeth Naturiol Cymru
Natural Resources Wales

Tranquillity and Place - Dark Skies
Natural Resources Wales

LUC

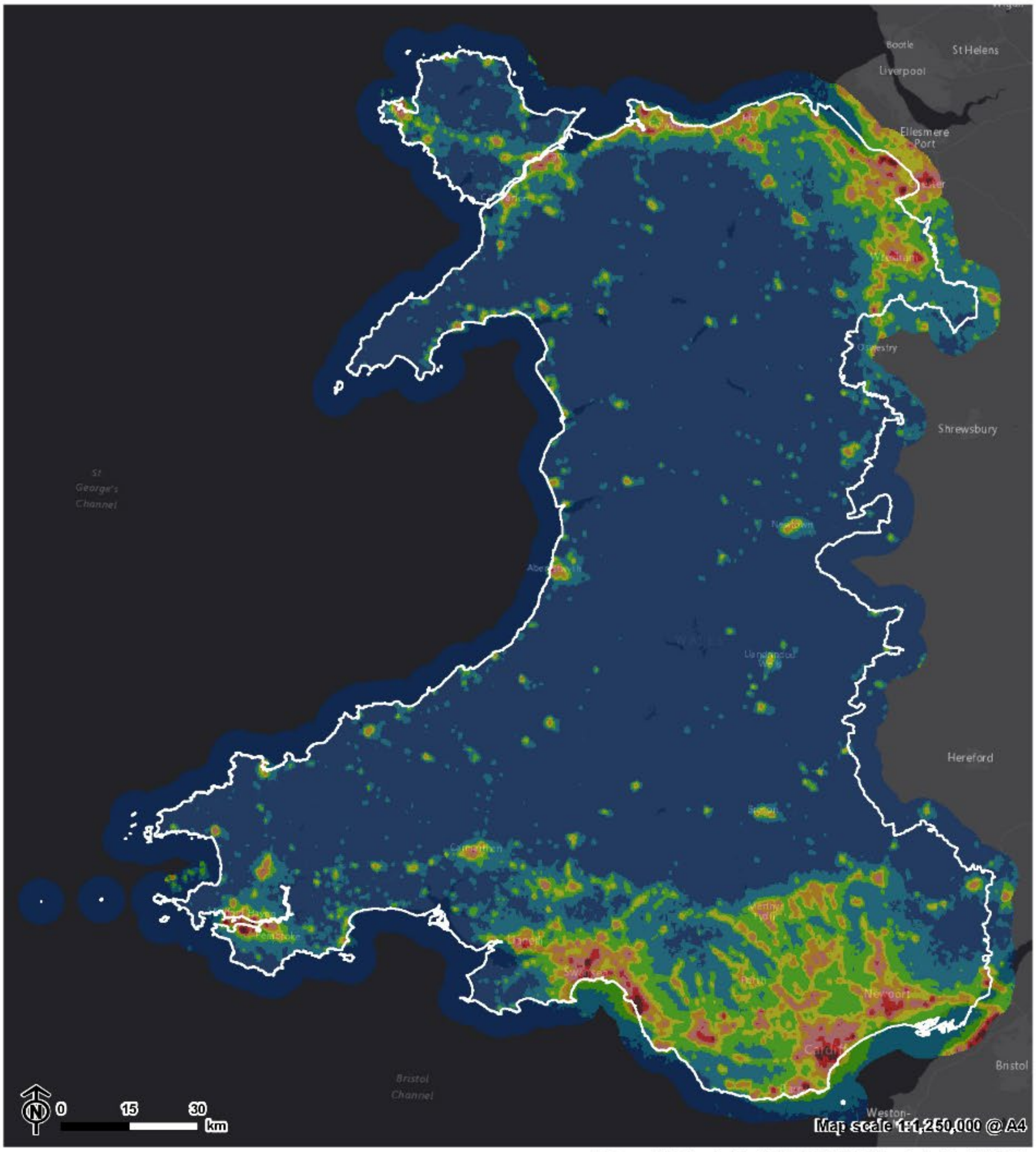

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Figure 1 – Dark skies and light pollution in Wales

Night lights (NanoWatts /cm^2 / sr)

- < 0.5 (Darkest)
- 0.5 - 1
- 1 - 2
- 2 - 4
- 4 - 8
- 8 - 16
- 16 - 32
- > 32 (Brightest)

Source: Visible Infrared Imaging Radiometer Suite, (VIIRS) Day/Night Band (DNB), Earth Observation Group, NOAA National Geophysical Data Center, Colorado School of Mines
Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS user community

Figure 15 Dark Skies and light pollution in Wales

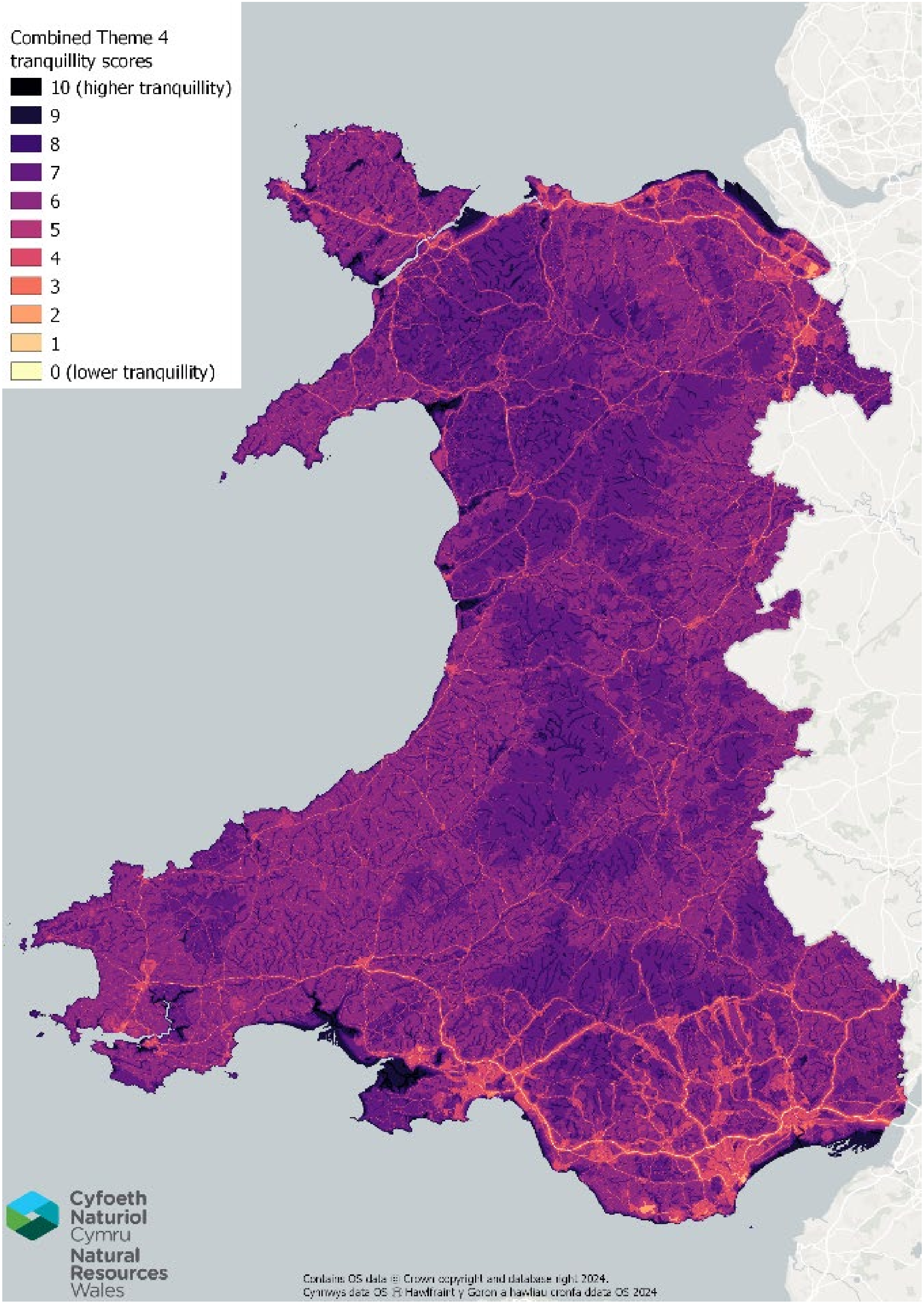


Figure 16 Tranquillity & Place Theme 4 Sound Environment Combined

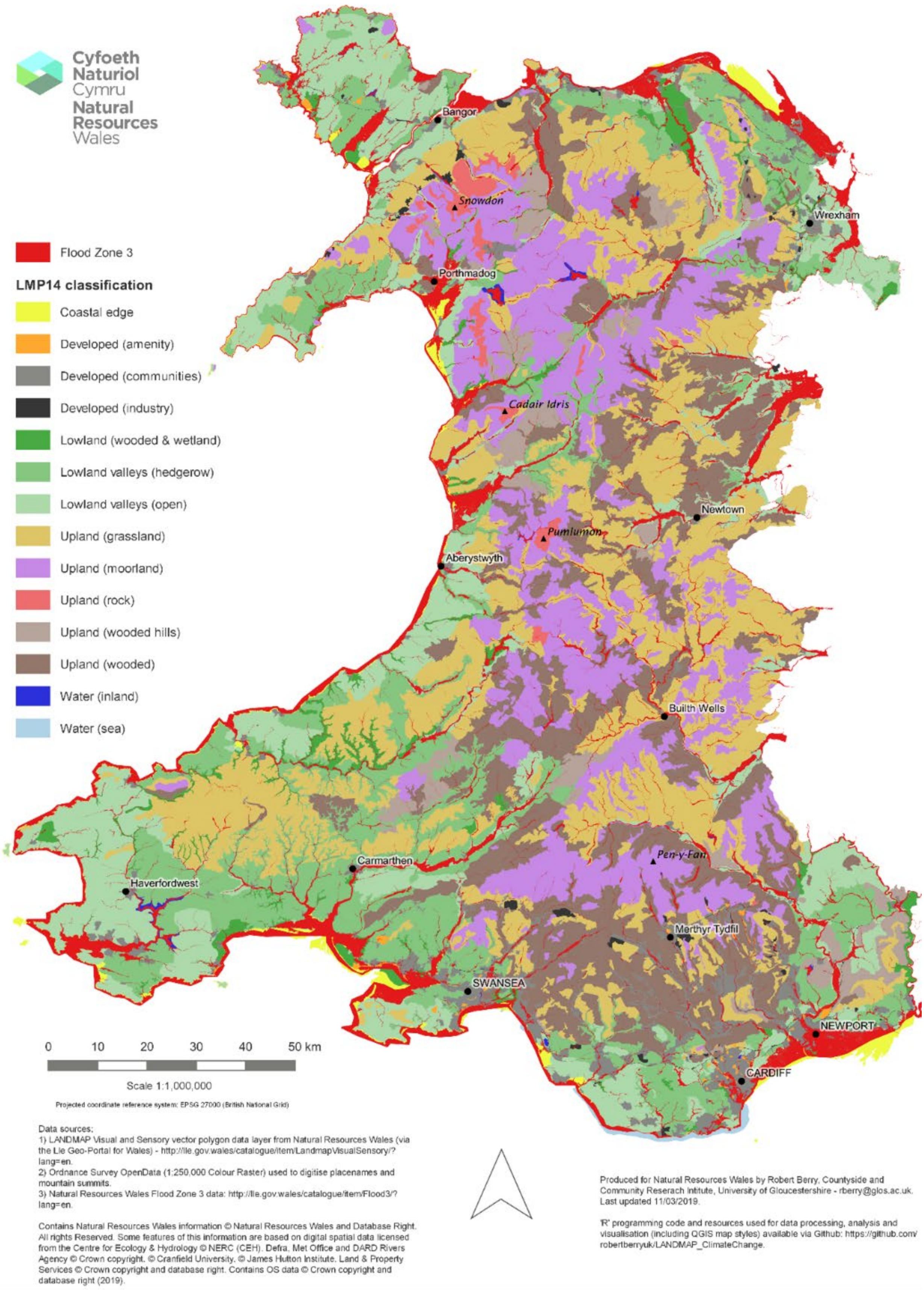


Figure 17 LANDMAP (LMP14) landscape types with Flood Zone 3

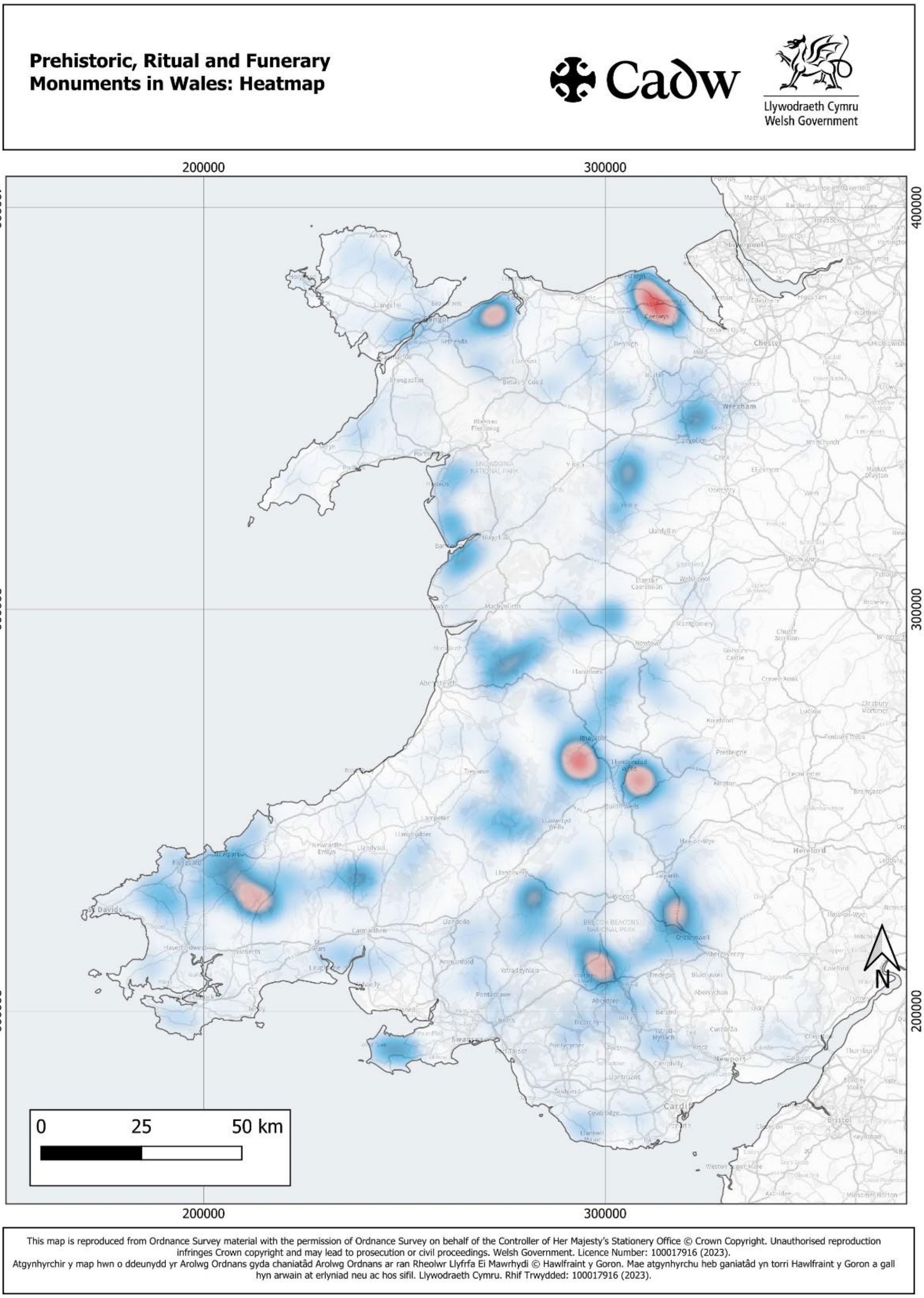


Figure 18 Prehistoric Funerary and Ritual density of designated sites

Upland Open

Upland valleys, hillsides, lower plateau and scarps, 50% open grazing. Key objectives are to restore a mixed farming system, increase the amount and diversity of ffridd and restore and reconnect limestone grassland.

Summary Mitigation and Adaptation Actions:

1. Plant scattered trees for livestock shelter and improved biodiversity 2. Reduced livestock 3. Connect limestone grassland with habitat network 4. Gap up hedgerows and plant small woodlands to sequester carbon 5. Revert more fields to ffridd grassland 6. Restore mixed grazing 7. Restore boundary walls 8. Retain and increase ffridd 9. Expand habitat mosaics and nature network links

Lowland Open

Lowland farms and fields, fewer hedgerow trees, <20% woodland. Key objectives are to maintain agricultural production, conserve and enhance highly evaluated landscapes, increase the extent and quality of nature networks.

Summary Mitigation and Adaptation Actions:

1. Gap up hedgerows and plant small woodlands to sequester carbon 2. Manage existing woodlands and hedgerows to lock in carbon and increase biodiversity 3. Rebalance energy and fuel usage to favour appropriate renewable energy 4. Manage slurry spreading and storage to reduce farm emissions, visual intrusion and environmental harm 5. More trees in hedgerows 6. Protect new tree and hedgerow growth, which provides livestock shelter 7. Balance livestock numbers to available pasture 8. Increase ponds to hold water 9. Convert some fields to less intensive wet pasture or species rich meadows

Upland Wooded

Upland hillsides, scarp slopes and plateau, agricultural fields, 50% woodland. Key objectives are to conserve and enhance the landscape, broadleaved woodlands and priority woodland habitats.

Summary Mitigation and Adaptation Actions:

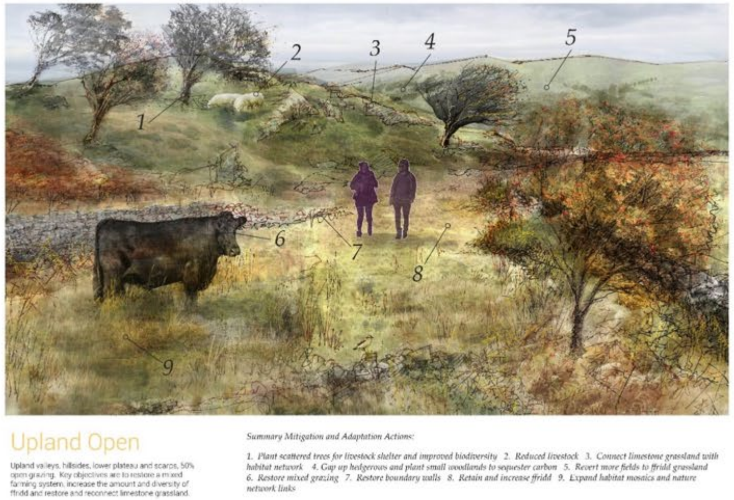
1. Increase native broadleaves in coniferous and mixed woodlands 2. Include firebreaks in existing and new woodland planting 3. Increase trees and semi-natural vegetation along watercourses and upper slopes to slow run-off 4. Drought and disease resistant woodland planting to sequester carbon 5. Fence woodlands and allow natural regeneration 6. Strengthen hedgerows and connectivity 7. Micro-hydro systems where appropriate 8. Conserve existing woodlands and hedgerows to lock in carbon

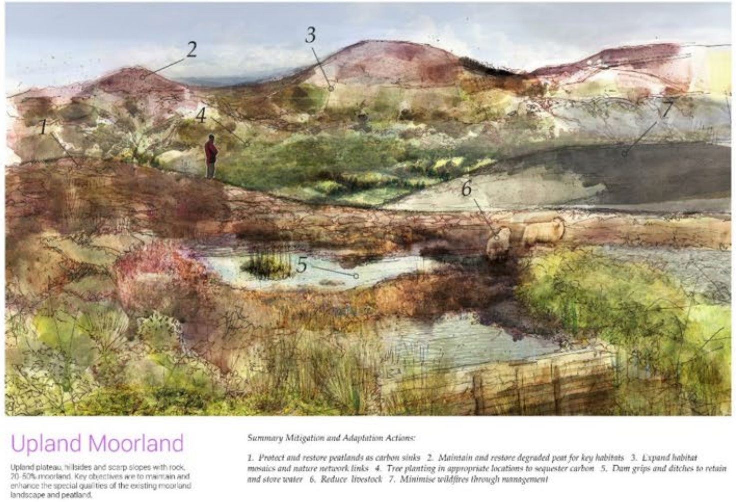
Lowland Wooded

Valleys, river valleys and farmland mosaic, hedgerows and small woods. Key objectives are to enhance the woodland and farmland mosaic, support nature networks, increase carbon sequestration through planting and to improve natural flood management.

Summary Mitigation and Adaptation Actions:

1. Manage existing woodlands and hedgerows to lock in carbon 2. New resilient small woodlands connecting with hedgerows 3. Reduce farm diesel and electricity use, consider renewable energy 4. Allow land to hold excess water and smooth flows 5. Decrease use of synthetic fertilisers to reduce pollution and increase biodiversity 6. Fence off sections of watercourses to livestock improving bankside vegetation 7. Increase calf and lamb rearing to reduce livestock carbon footprint 8. Convert some fields to less intensive wet pasture or species rich meadows 9. Strengthen and plant new hedgerows increasing connectivity





Coal spoil landscape

Dark skies landscape

Figure 19 Desirable future landscape visualisations

Landscape References

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Annex 5: Aim 4 Waste evidence

Evidence Lead: John Fry and Lara Moggridge

External reviewer: Rhodri Asby (Welsh government)

Key Messages

In line with the ambitions of the Beyond Recycling strategy, reducing pressure on natural resources across all sectors (e.g. industry, commerce, construction, agriculture etc) is essential to achieving a circular, low-carbon economy in Wales. This annex presents an in depth assessment of the pressures that impact the Sustainable Management of Natural Resources. It builds on SoNaRR (2020) and the cross-cutting waste and energy assessments, which provide additional details (Natural Resources Wales / SoNaRR2020: Waste) (Natural Resources Wales / SoNaRR2020: Resource efficiency - energy).
Key messages from this assessment with respect to waste and the transition to the circular economy in Wales are:

1. Preventing waste at its source is essential if Wales is to achieve zero waste and one planet living. This starts with designing products that are durable, reliable, repairable, and reusable.
2. Wales is becoming a high recycling nation, but this pace of change must be matched with the provision of suitable waste infrastructure and end markets for all materials, including designing products so that their components can easily be separated and recycled at the end of a product's life cycle.
3. More materials could be recycled with better separation of waste at the source. Encouraging responsible behaviour from households and businesses is key to producing high-quality materials for recycling. Innovation within the waste sector will support this shift, helping to treat waste as a resource and accelerating our transition to a circular economy.
4. As we transition to a circular economy, Wales must also have access to appropriate facilities to manage waste incapable of reuse, recycling, or recovery, ensuring this is done with minimal environmental impact.
5. Irresponsible and illegal waste management worsens the negative impacts of waste - contributing to public health risks, greenhouse gas emissions, and environmental pollution. Waste crime harms communities, undermines legitimate businesses, diverts resources from the circular economy, and compromises Wales' goal of becoming a Zero Waste One Planet Nation.

Introduction

Wales uses many resources for activities in business and industry, farming and food production, home and office. The mass production of products has meant more convenience, variety and greater accessibility for consumers. However, mass production requires substantial material and energy inputs. As highlighted in SoNaRR 2020, when waste is generated from mass production and associated consumption, it can be detrimental to ecosystems, nature and the well-being of the population, especially where it is not managed appropriately at authorised waste sites or is managed through illegal activities (NRW, 2021).

One of the ways Wales is addressing the waste challenge is via the Beyond Recycling Strategy. The strategy sets targets to reduce waste by 26%, send zero waste to landfill, reduce avoidable food waste by 50% and increase recycling to 70% by 2025. By 2030 the target is to reduce waste by 33% and avoidable food waste by 60% (Welsh Government, 2021a). Whilst much still needs to be done to overcome waste pressures from all sources, progress is being made. For example, the amount of household waste not recycled is estimated to have reduced from 217kg per person in 2012-13 to 168kg in 2023-24. (National well-being indicator 15 - (Welsh Government, 2025d).

The Beyond Recycling Strategy also establishes a commitment to transition to a low carbon economy. This means reducing the carbon dioxide equivalent emissions that are embedded in products due to the energy used to manufacture and transport them. The need to reduce the carbon intensity of the Welsh economy is also recognised by the Environment (Wales) Act 2016, which requires at least an 80% reduction in 1990 levels of gross greenhouse gas emissions by 2050. More recently, Wales adopted the more ambitious target of a 95% emission reduction by 2050, as recommended by the Climate Change Committee (2020) and to achieve net zero greenhouse gas emissions by 2050 (Welsh Government, 2021b) .

Waste

The generation of waste, due to the linear take-make-use-dispose economic model, is indicative of the inefficient use of resources, creating demands and driving direct exploitation related pressures and the overuse of natural resources. Whilst waste treatment and disposal contributes a small percentage of the calculated greenhouse gas emissions for Wales, the indirect emissions from the lifecycle of material flows is of significant importance. Globally, 45% of emissions are now attributable to our current 'take-make-use-dispose-repeat' model (WRAP, 2025a). Where waste is mismanaged, this can result in immediate and significant local environmental pollution and also drive pollution of air, water and soils on a larger scale. This section explores waste related drivers and pressures in more depth.

Waste generation

In 2019, the total quantity of waste generated in Wales was estimated to be 7.5 million tonnes, excluding mining and quarrying wastes, agriculture, forestry and fishing. This data has been historically estimated for Wales based on UK modelling or extrapolation rather than Welsh derived data directly obtained from these sectors. This estimated data has been excluded owing to the uncertainty on its reliability and comparability for use in this assessment.

Figure 1 shows that the majority of waste generated in Wales in 2019 was estimated to originate from the construction and demolition sector (46%) followed by the commercial (19%) and industrial sectors (19%). In comparison, waste generated from household sources (16%) contributed the least to total waste generation.

Table 1 provides a comparison of waste generated from key sectors in Wales between 2012 and 2019. There was a statistically significant reduction in waste generated from households, industry, and commerce between these years. There was no statistically significant difference in waste generated by the construction & demolition sector between these years. However, it must be noted that it is difficult to analyse waste generation trends from this sector since it is influenced by the economy, timing and locations of major infrastructure projects.

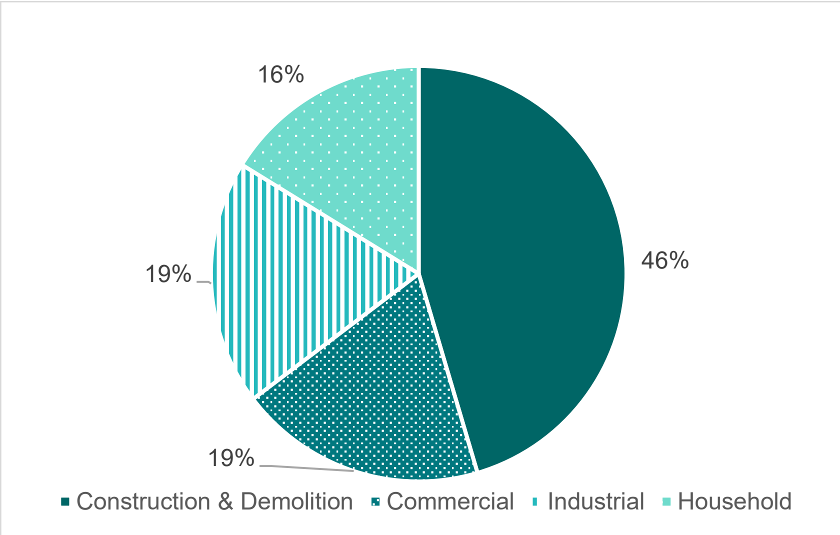

Figure 20: Wastes generated by economic activity and households, 2019 (excluding mining and quarrying, agriculture, forestry and fishing wastes).[4]

Table 64: Comparison of waste generated from key sectors in Wales between 2012 and 2019 Source: (NRW, 2020, 2022; DEFRA, 2025b)

Sector	2012 (millions of tonnes)	2019 (millions of tonnes)	Statistically significant change	Data Source

[4] Note: Welsh estimates for waste from households has been calculated in accordance with the EC Waste Framework Directive. The waste from households has been chosen as the UK interpretation of the EC term ‘household waste’, which is defined as ‘waste generated by households’. Waste from households includes waste from regular household collection, civic amenity sites, bulky waste and other household waste. Waste from households excludes waste from street cleaning/sweeping, gully emptying, separately collected healthcare waste, soil, rubble, plasterboard and asbestos waste. These tonnages are estimated within the construction, demolition and commercial data sets

Construction and demolition	3.36	3.43	No	2012 & 2019 – Wales waste surveys (stratified sampling both years)
Industrial	2.00	1.44	Yes	2012 & 2018 Wales waste surveys (stratified sampling both years)
Commercial	1.67	1.45	Yes – marginal	2012 & 2018 Wales waste surveys (stratified sampling both years)
Household	1.36	1.22	Yes	Welsh local authority reported statistics reported frequently and consistently (WasteDataFlow – both years)
Total	8.39	7.55	Not applicable	Not applicable

Population make-up, size and consumption patterns will influence how resources are used and waste is produced. The population of Wales is expected to continue to grow this century (Office for National Statistics, 2025), which will increase the pressures on resources and potentially hinder efforts to reduce waste.

Climate change

Wales has made substantial progress in reducing emissions from the waste sector, with a 63% reduction in CO_2teq emissions between 1990 and 2016. Between 2016 and 2020 a 15% reduction was achieved (pp.15 [Progress Report: Reducing emissions in Wales - Climate Change Committee (theccc.org.uk)](#)). The remaining emissions are largely driven by historic and ongoing landfilling of waste.

Post pandemic waste trends

It is too early to understand the scale and longevity of the impact the (Covid-19) pandemic has had on waste generated by all sectors in Wales. For example, there was a small increase in waste generated from households in 2020 and 2021 compared to pre-pandemic years. Waste generated from households increased by 35K tonnes in 2021 compared to 2019 (2.8%) as shown in Figure 2. This increase coincided with unprecedented public health measures during the pandemic disrupting previous householder working patterns and increasing time spent at home during lockdowns and other confinement measures (Welsh Parliament, 2024). This also impacted householder behaviours changing consumption patterns related to spending on goods and services that will have had an impact on quantities and types of waste generated at home. For example, during the pandemic there was a sharp fall in expenditure on catering services, but an increase in spending on food and beverages consumed at home. More restaurants and pubs also grew their takeaway services (Office for National Statistics, 2022). This is likely to have displaced some waste that would have otherwise been generated in other settings before the pandemic such as in offices and the accommodation and food service sectors. Waste generated from households reduced by 52K tonnes in 2022 compared to 2019 (4.2%) (Figure 2). This was despite numbers of the GB workforce mainly working from home (exclusively and hybrid working) remaining higher in 2022 compared to 2019 (Hobbs and Mutebi, 2025). It is possible that some of this decrease in waste generation by householders could be attributed to the online share of retail spending falling considerably from its pandemic highs, as shops and restaurants re-opened (Office for National Statistics, 2022). However, the total quantity of waste generated by households in 2022 was less than pre-pandemic years indicating that other changes are likely to have impacted the waste from households trend. The trend reduced by a further 20 thousand tonnes in 2023 compared to 2022.

The impact of the pandemic on waste generated by non-household sectors in Wales in recent years is unknown owing to limitations of current data. Therefore, it is not possible to fully understand the overall impact and trend of waste generation in Wales post-pandemic, without updated evidence of waste generated by all other non-household sectors.

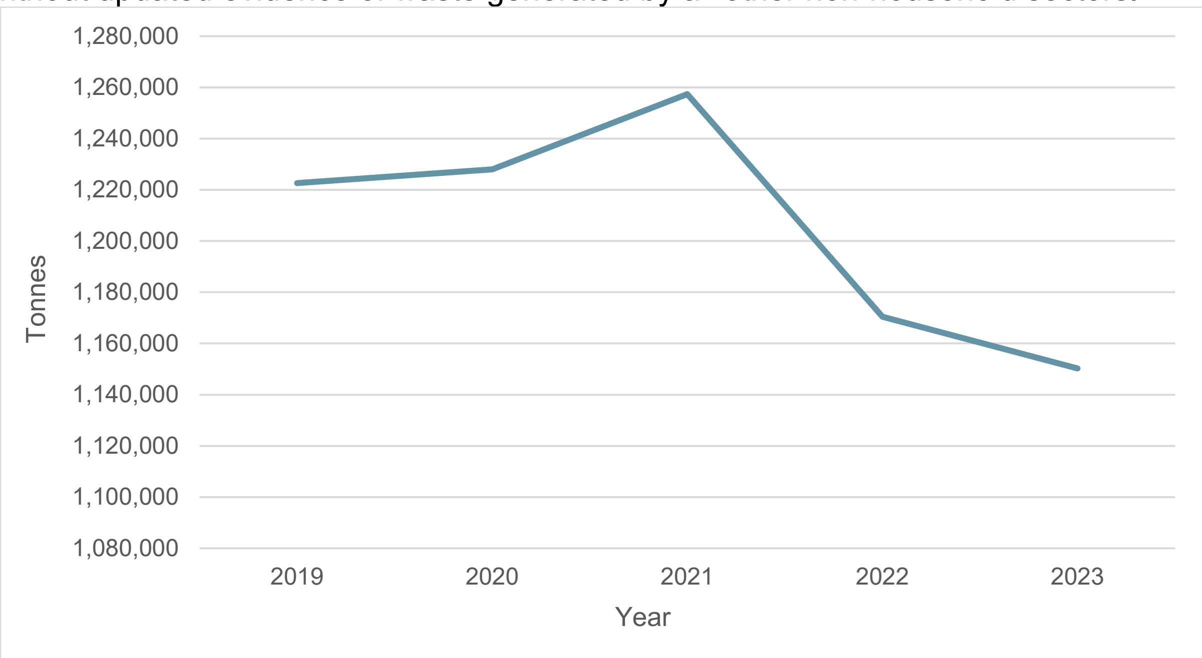

Figure 21: Waste generated from Welsh households 2019-2023 (tonnes)

Emerging Waste Streams

Renewable energy technologies, such as wind turbines, solar photovoltaic panels and batteries, are essential for a transition to climate neutrality. Deployment, maintenance and replacement of this infrastructure requires significant resources, including many substances listed as EU critical raw materials. Waste arising from end-of-life clean energy infrastructure is projected to grow up to 30-fold over the next 10 years, presenting significant challenges. However, this also presents opportunities to recycle metals and other valuable resources back into production systems to reduce consumption of scarce raw virgin materials. Circular economy approaches such as repair, upgrading of equipment and recycling of end-of-life infrastructure are essential in order for a sustainable transition to renewable energy (European Environment Agency, 2021).

Technological advances have led to positive changes in certain areas, such as the development of multi-functional devices replacing the need to own a separate camera, phone, music, media playing devices, and the introduction of e-cigarettes supporting many people to quit smoking. However, these advancements result in changes to waste streams that need to be managed. This creates an expectation for the waste industry to respond with adequate collection and treatment solutions, but this may not be economically or technically feasible. This highlights the importance of producers being accountable for ensuring that sustainable end of life solutions exist for the products and packaging that they place on the market.

There remains the issue of unintended consequences from positive intention. An example is the increase in the number of lithium-ion batteries and the associated significant increase of fire risk at waste sites. Lithium-ion batteries are used extensively in many products and have a number of benefits, including being an important part of our transition to net zero. However, the past 5 years have shown the detrimental impacts these can have where inappropriately disposed. Battery fires in bin lorries and at waste sites across the UK were found to be at an all-time high in 2023 with **over 1,200 fire incidents,** an increase of 71% from 700 in 2022 (Material Focus, 2024).

An added complication to changing waste streams is the timescales at which materials reach their end of life. Horizon scanning to future proof the waste industries ability to respond to demands is a necessary step to avoid issues such as mismanagement and stockpiling of difficult to handle wastes.

The environmental and health risks posed by some older waste types such as carpets and domestic seating has only recently come to light as new evidence emerges. For example, some of these waste types have now been confirmed to contain Persistent Organic Pollutants (POPs) within the flame retardants used on furniture (UK Government, 2024). These must be treated so that harmful substances are removed from the material stream. This limits the recycling options available, but the priority must be to remove the risk these substances can cause to the environment and human health. Whilst POPs are not an entirely new issue, they are becoming more prevalent. As new chemicals are categorised as POPs and more wastes containing POPs are identified, there will be an increase of certain waste streams that will be required to be treated in a specific way, which may hinder the circularity of material types.

Circularity of materials can also be restricted due to the high variations in the composition of different materials and products, where separating out and recycling composite parts can be costly and energy intensive to achieve, if at all possible (Davies-Dennis, 2024). Subsequently, new and expensive approaches to handling what were previously simple waste types are required, which also compromises the transition to a Circular Economy. This further highlights the importance of embedding the circular economy principle of designing out difficult to manage waste at the front end of processes. The Plastics Pact Network convened by the Ellen MacArthur foundation and WRAP (https://www.ellenmacarthurfoundation.org/the-plastics-pact-network) is an example of an initiative set up to address some of these difficulties and change design of products to aid recycling. Investment in infrastructure and management of exports (to broadly equivalent sites overseas to ensure appropriate reprocessing) are other key requirements to deliver a circular economy.

Summary of trends in waste generation

Table 2 presents a summary of the recent trends and likely future trends in waste generation in Wales based on the evidence presented above. These are assessed to be:

- Improving trends or developments (Green)
- Trends or developments show a mixed picture (Orange)

Table 2 reveals improving recent past trends in waste generation (i.e. Wales is producing less waste), although there are limitations with evidence availability. As Table 2 highlights, there is a mixed picture on future trends given progress to date and continued rise in population potentially hindering waste prevention measures.
It is highlighted that the creation of a UK single regular source of data on waste has the potential to help improve the accuracy, reliability and frequency of future waste generation assessments across all sectors located in Wales.

Table 65: Assessment of trends in waste generation in Wales

Time Period	Indicative Assessment SoNaRR2020	Additional Evidence for SoNaRR2025	Indicative Assessment SoNaRR2025	Description	Confidence assessment for SoNaRR2025 -	Confidence assessment reasoning
Short-term past trend 2012 – 2018)	IMPROVING	Waste Data Flow (LA/waste from households) NRW I&C waste survey 2018. NRW C&D waste survey 2019	IMPROVING	There was a statistically significant reduction in waste generated by households, industry, and commerce in 2018 compared to 2012. There was no statistically significance difference in waste generated by the construction & demolition sector between these years. However, it must be noted that it is difficult to analyse waste generation trends from this sector since it is influenced by the economy, timing and locations of major infrastructure projects.	Agreement: HIGH Evidence: MEDIUM	Quantifying waste generated in Wales in a given year is difficult as there is no single regular source of data. Waste generated from households, industry and commerce has decreased (statistically significant). Waste generated from household statistics are updated annually from a consistent data source. However, C&D waste is highly variable in a given year and all non-household data is over five years old. This presents uncertainties on quantities of waste generated by non-household sources since the Covid-19 pandemic. A more comprehensive and regular dataset is required to evidence and assess trends of waste generated by non-household sources in future assessments.

Time Period	Indicative Assessment SoNaRR2020	Additional Evidence for SoNaRR2025	Indicative Assessment SoNaRR2025	Description	Confidence assessment for SoNaRR2025 -	Confidence assessment reasoning
Future trends (To 2030)	MIXED PICTURE	StatsWales	MIXED PICTURE	Pressures on resources are likely to increase owing to demographic, social, technological and economic drivers. Waste prevention measures can be expected to counter growth in waste generation, but the extent of their effectiveness remains uncertain and challenging to monitor	Agreement: HIGH Evidence: MEDIUM	Robust - population is project to increase (Population projections by year and age). Although waste prevention measures are evident, there are significant challenges to overcome in minimising waste and transitioning from a linear to a circular economy.
Future trends (To 2050)	MIXED PICTURE	as above	MIXED PICTURE	The Welsh Government strategy 'Beyond Recycling' outlines proposals to reduce the amount of waste generated. However, more evidence is required to evaluate its effectiveness in future assessments.	Agreement: HIGH Evidence: MEDIUM	Although waste prevention measures are evident, there are significant challenges to overcome in minimising waste and transitioning from a linear to a circular economy.

Waste management

Wales has made major improvements in managing waste over the last two decades by increasing the amount sent for recycling, and reducing the amount sent for disposal. For instance, Figure 3 illustrates the substantial improvements in the management of Welsh Local Authority Municipal Waste (LAMW) since the start of the 21st century. In 2023/24, the quantity of LAMW sent to landfill was close to zero. Of the 1.4 million tonnes of LAMW generated in 2023.24, 47% was recycled and 21% composted. The remaining LAMW was mostly incinerated for energy recovery.

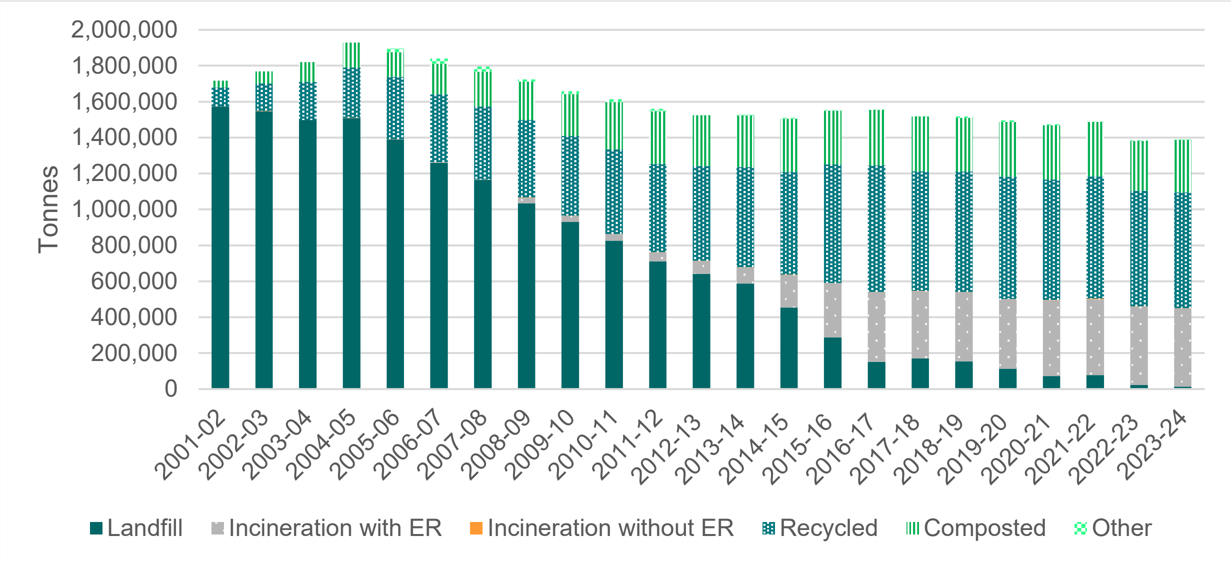

Figure 22: LAMW 2001 to 2024 (Source: NRW - LA municipal annual waste survey (2001-2004) WasteDataFlow (2004 onwards))

Figure 4 illustrates the management of other waste sources, alongside that of Local Authority Municipal Waste. This reveals high levels of reuse, recycling and composting of construction and demolition wastes (93% in 2019). However, it should be noted that recycling rates are weight-based calculations, and the recycling rates of construction and demolition become substantially influenced by the management of aggregate, a heavy material compared to other material types. Industrial and commercial wastes demonstrated comparable levels of reuse, recycling and composting (64% and 69% in 2018, respectively) as observed for local authority municipal waste (67% in 2023/24). It is estimated that there was a considerable decrease in the amount of waste generated, that is not recycled, per person from 794 kg in 2012 to 523 kg in 2019 (Welsh Government, 2025d). However, it must be noted that the methodology for calculating the underlying waste data sets varies by source and precision.

Table 3 presents the recent 2019 statistics on reuse, recycling and composting from these four different waste sources alongside those for 2012. This shows that there were statistically significant improvements in the preparation for re-use, recycling and composting rates of waste generated by households in 2019.
The percentage of local authority municipal waste (which includes waste generated from households) that was prepared for re-use, recycled, or composted has increased substantially over the last two decades from 5% in 1998/99 to 66.6% in

2023-24 (StatsWales 2025). The Welsh local authority collective recycling rate has marginally increased between the years 2019-20 and 2023-24 from 65.1% to 66.6%. However, individual Welsh local authority recycling rates have remained variable amongst these years ranging from 60.1% to 72.8% in 2023-24.

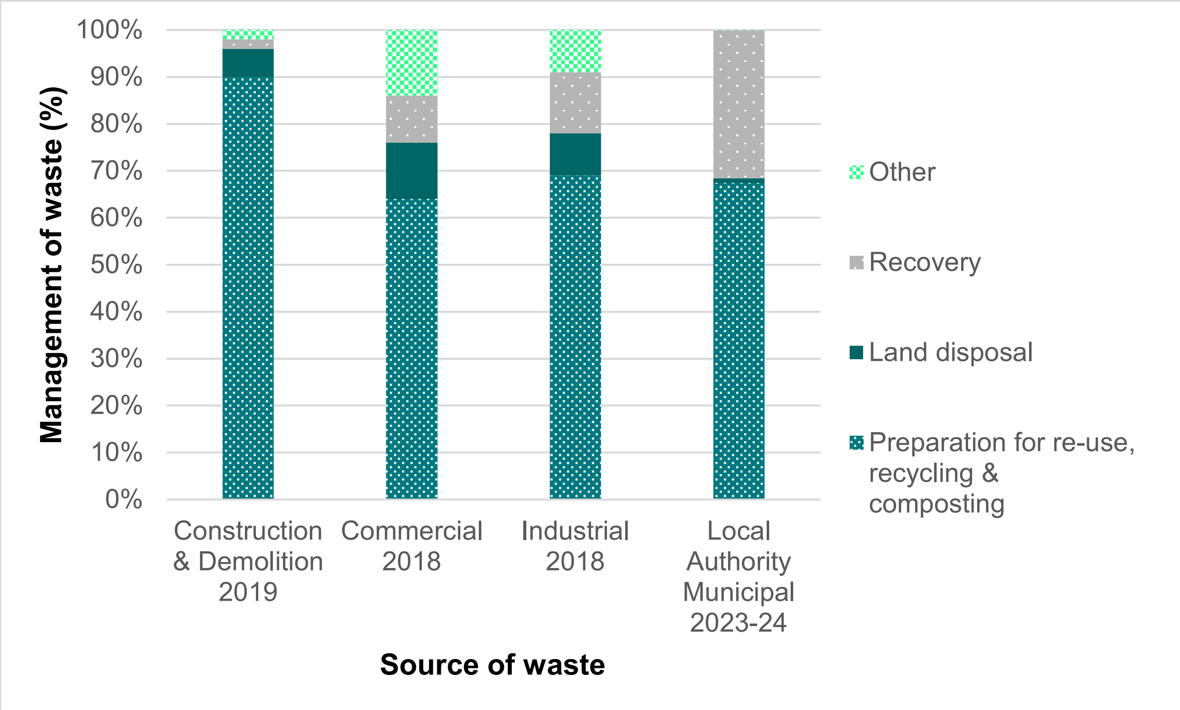

Figure 23: Management of waste generated in Wales by origin (NRW, 2020, 2022; StatsWales, 2025).[5]

Table 66: Comparison of recycling rates of waste generated in Wales by origin 2019 (NRW, 2020, 2022; DEFRA, 2025b)

Waste Source	Preparation for Re-use, Recycling and Composting rate (%) 2012	Preparation for Re-use, Recycling and Composting rate (%) 2019	Statistically significant change	Data Source
Construction and demolition	87%	93%	No	Wales survey (stratified sampling)
Industrial	50%	69%	Yes	Waste surveys (stratified sampling)
Commercial	68%	64%	No	Waste surveys (stratified sampling)
Household	52%	56%	Yes	Welsh local authority reported statistics from household sources (WasteDataFlow)

[5] Management of Waste generated in Wales. 'Recovery' includes Land Recovery and Incineration with Energy Recovery. 'Other' includes land recovery, incineration, treatment, transfer station and unknown. Construction and Demolition figures include hazardous and naturally occurring soils and stones waste. Time series differs owing to availability of data – Construction and Demolition 2019, Industrial and Commercial 2018, Local Authority 2023-24.

Waste transfer and management

During 2023, authorised waste facilities located in Wales (permitted under the Environmental Permitting Regulations 2016) managed a total of 12.6 million tonnes of waste. These figures are not comparable with statistics in the waste generation section because they include double counting (the same waste may be transferred between multiple permitted waste facilities) and wastes originating from outside of Wales. This is also not the total amount of waste managed in Wales because non-permitted waste sites located in Wales are exempt from being required to report waste management data to NRW. However, comparing the quantities of waste managed at permitted transfer and treatment waste facilities located in Wales shows that more waste continues to be managed at these types of facilities than ever before – an increase of over 1.5 million tonnes between 2018 and 2023 (23%). This indicates that waste management practices in Wales have shifted towards prioritising the recovery of materials over disposal. It also illustrates that waste management movements in Wales continue to become more complex leading to increased potential for some unintended consequences such as an increased risk of waste crime.

Figure 5 shows that the quantity of waste sent to permitted landfills located in Wales halved between 2016 and 2020 – a decrease of over 1 million tonnes. However, landfill inputs increased between 2020 and 2022 by approximately 225 thousand tonnes, prior to decreasing 162 thousand tonnes between 2022 and 2023. Summarising reasons to explain the recent trend in landfill inputs in Wales is difficult to do because operational changes at an individual Welsh landfill level can have significant impacts to the overall Wales landfill input figures. Any issues or changes in practices at other waste management sites inside or outside of Wales can also impact landfill inputs. The Covid-19 pandemic is also likely to be a general factor in disrupting the previous trend since 2020 that is difficult to quantify. However, the total reported inputs to Welsh landfills in 2023 were the second lowest recorded this century.

In terms of waste landfilled in Wales, the majority of inputs to permitted landfills in Wales in 2023 were mixtures of materials from mechanical treatment (36%) and soils (28%). In addition, soil was the largest contributing material type disposed directly to landfill by the Construction & Demolition Sectors in 2019, accounting for approximately 72% of waste reported as landfilled by the sector (NRW, 2022).

The quantity of waste sent to incineration at permitted facilities in Wales has more than doubled since 2015 predominantly owing to municipal energy recovery facilities becoming operational during this period. However, the quantity of waste incinerated at permitted facilities located in Wales has plateaued since 2020 in recent years at similar levels to inputs to landfill. In 2023, approximately 1.1 million tonnes of waste was incinerated in Wales. Approximately 55% of this waste was incinerated at municipal waste incinerators and 37% at waste wood incinerators.

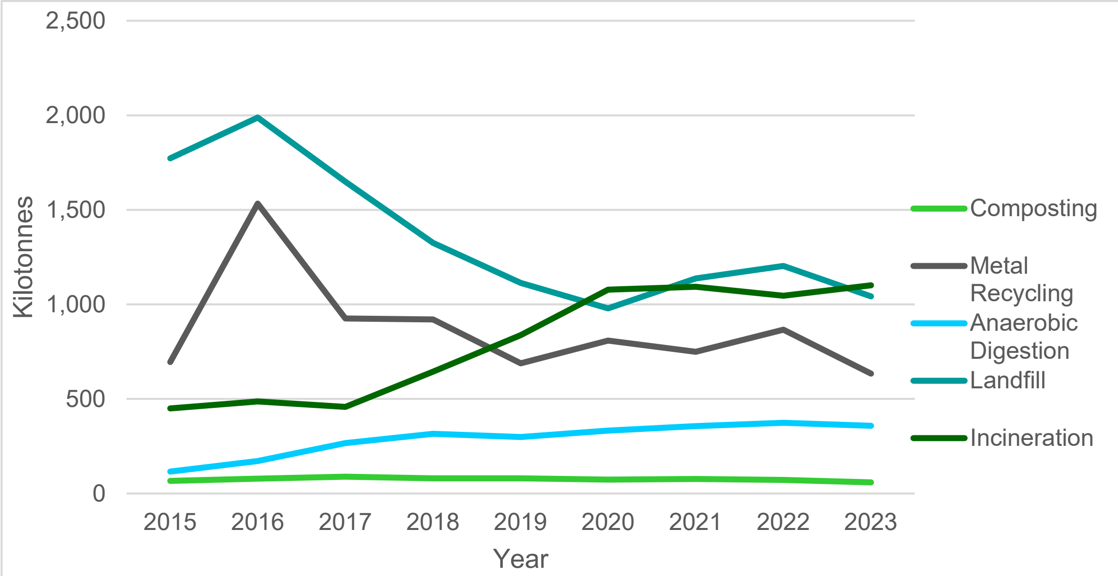

Figure 24: Waste inputs to Welsh permitted waste facilities by main end fate activity type 2015 – 2023 (Kilotonnes) (NRW, 2025).

The quantity of waste sent to permitted anaerobic digestion facilities located in Wales more than tripled in 2023 compared to 2015, an increase of approximately 242 thousand tonnes. This increase coincided with an increase in the number of facilities and food waste being separately collected in Wales for recycling from domestic premises. Although the trend in composting has remained similar in recent years, it must be noted that this dataset only includes those facilities where composting is the sole waste activity of the site. This means that the dataset excludes any composting undertaken at permitted facilities that also undertake other waste treatment activities.

Land disposal & recovery

Ongoing and historic landfilling of waste leads to substantial pressures on natural resources. For instance, landfill emissions are currently estimated to contribute 2% of the total carbon releases across all sectors in Wales, and 80% of all emissions from the waste sector.

There are around 1,500 historic landfills identified in Wales which may impact on local ecosystems and may continue to have an impact for decades to come (NRW, 2024a). For example, coastal landfills may impact Marine Protected Area features across Wales. Some pressures that waste from landfills could have on the marine environment include abrasion, smothering, chemical contamination as well as nutrient enrichment. A recent assessment identified that approximately 265 historic landfills had the potential to release waste into the marine environment based on current flooding and coastal erosion (Robbins *et al.*, 2023). This number is likely to increase further over time.

Landfill is still required whilst some waste continues to be generated in Wales that is unsuitable to be sent for recycling or recovery, in order to protect the environment and human health. For example, asbestos and other hazardous wastes. There may also be occasions when landfill might be required as a contingency or to address a temporary shortfall in capacity of more sustainable alternatives.

It is recognised that waste materials can be used beneficially in recovery activities. For example, the permanent deposit of waste on land may constitute a recovery operation where the waste is suitable for use and there is a genuine need for it, replacing the use of virgin materials. This highlights the important role waste has in the circular economy to protect natural resources by acting as a genuine replacement. These recovery activities can be especially useful in large scale developments where, for example, large volumes of materials are required to level land or create flood defences. As we move towards zero waste to landfill in Wales, the co-ordination and planning of such waste flows will become vital to ensure there is effective oversight and an alternative use for these wastes. This will be needed to prevent large scale developments having no viable outlet for inert wastes generated, leading to potentially uncontrolled and illegal stockpiling of large quantities of waste.

It is estimated that approximately 10 million tonnes of organic manures are applied to agricultural land in Wales each year. This includes livestock manures and slurries, waste, sewage sludge, and end-of-waste materials (Rollett and Williams, 2022). When managed and utilised appropriately, organic manures play a valuable role in enhancing soil health, supplying nutrients, supporting a circular economy, and contributing to food sustainability and security. However, poor management, such as over-application to soil, can negatively impact soil health and cause environmental harm.

Ensuring the quality of organic manures used on land must be a high priority, alongside careful consideration of the quantities applied relative to demand. For instance, ongoing research is highlighting concerns about contaminants in sewage sludge. The UK Water Industry Research (UKWIR) Chemicals Investigations Programme has already provided evidence on this issue, and Phase 4 is expected to further identify contaminants of concern (UK Water Industry Research, 2025).

The introduction of The Waste Separation Requirements (Wales) Regulations 2023 will lead to increased separate collection of food waste in Wales. Similarly, the rollout of “Simpler Recycling” in England is expected to boost food waste collection across the border. Where food waste cannot be prevented, it must be managed appropriately at waste facilities. In 2022, there were 50 anaerobic digestion (AD) plants operating in Wales (Welsh Government, 2023a). The digestate produced by these facilities competes with other organic manures (such as manures and slurries) for beneficial use on land.

The most recent assessment of Wales’ available landbank indicated that there was sufficient capacity to absorb organic manures (Rollett and Williams, 2022). However, further evidence is needed to determine whether Wales has the right types of land in the right locations to accommodate additional organic waste. Factors such as changes to agricultural regulation, competing land use demands, and climate change impacts may further constrain landbank availability.

Additional considerations in organic waste treatment include plastic contamination in composts and digestates, and methane emissions from AD plants. A recent report commissioned by DESNZ indicated that AD facilities and digestate storage may be a net source of methane emissions (Howes et al., 2023).

Illegal Waste Management

There have been significant changes in the way waste is managed in Wales over the last two decades. The industry has transformed from a 'collection and disposal at landfill' model towards a recycling industry that separates, sorts, and treats waste through many different collectors, handlers, processors, and exporters. This supports the transition to a circular economy and managing resources in a more sustainable way.

However, this changing landscape of the waste industry, where greater quantities of waste are managed above ground, has had some unintended consequences. It has become increasingly attractive to those seeking to profit from mismanaging waste. Criminals have taken advantage of the increasing cost of legitimate waste disposal, by collecting, storing, disposing and exporting waste at low prices without any intention of handling it correctly and safely. It includes abandonment and burning of waste, large-scale fly-tipping, illegal waste transfer stations, misdescription of waste, unsafe disposal, and waste carriers offences. Organised gangs have also infiltrated the industry and are operating with a veil of legitimacy.

This undermines legitimate industry, pollutes the environment, harms communities, creates costs for landowners and local authorities, and diverts waste away from a circular economy. A key driver for this criminality is to avoid the correct costs of handling waste, including Landfill Disposals Tax. Organised criminals are attracted to the industry because of the potential for high profits, often using it to launder money and fund other criminal activities. For example, the charity Hope for Justice reported that two-thirds of modern slavery victims that it engaged with in 2017 had spent some time being employed in the UK waste industry (Roden, 2024).

As with any criminal activity, its prevalence and impact can be difficult to quantify. However, the latest evidence indicates that the scale of the issue is still significant. The Environment Agency undertook waste crime surveys in 2021 and 2023. The aim of these surveys was to understand and evaluate the waste industry's (including land owners and service providers) perceptions of waste crime in England.

The 2023 survey highlighted the pervasive nature of waste crime, with an estimated 18% of all waste being illegally managed (Environment Agency, 2023). It is reasonable to assume that the results would be similar in Wales on a pro rata basis against the population and economic activity in England. This assumption can be made on the basis that England and Wales have broadly similar waste infrastructure and regulatory controls. Applying this same apportionment to waste generated in Wales in 2019 would equate to around 1.4 million tonnes of waste being potentially managed illegally in Wales.

Criminality in the waste sector is on the rise and is increasingly complex and serious in nature. It costs the economy in the UK an estimated £1 billion per year, (double the cost estimated for the UK in 2013), which would equate to an estimated impact of over £50 million when scaled by population in Wales (Environmental Services Association, 2021).

The prevalence of waste crime in Wales is further supported through evidence of incidents reported to Natural Resources Wales. In 2023, 3,051 waste incidents were reported to Natural Resources Wales (NRW, 2023). These incidents included large-scale fly-tipping incidents, burning of waste, illegal waste sites, misdescription of waste, and waste carriers offences. It is estimated that just a quarter of waste crimes are reported indicating that the true number of waste crime incidents in Wales is likely to be much higher (Environment Agency, 2023).

Since the introduction of the Landfill Disposals Tax in Wales in 2017 there is an unauthorised disposals rate for illegal deposits of waste that currently stands at £189.25 per tonne (Welsh Government, 2024a). Given most waste crime involves unauthorised disposal of waste at the scale of thousands of tonnes, this creates a significant financial deterrent for people seeking to dispose of waste illegally and helps to prevent waste crime in the future. The Welsh Revenue Authority is responsible for the collection and management of this tax and have delegated powers to Natural Resources Wales to assist with this work. To date, a significant amount of work has been undertaken and tax collected (Welsh Revenue Authority, 2024) .

Welsh local authorities have a duty to clear fly-tipping from public land in their areas and consequently deal with the vast majority of fly-tipping on public land. There were 42,171 local authority reported fly-tipping incidents in Wales in 2023-24. This was 6% more than the previous year and 20% more than 2018-19 (Welsh Government, 2024b). Interpretating trends across years is difficult owing to changes and improvements in data reporting mechanisms and guidance. However, it is clear that fly-tipping remains a significant issue, detrimentally impacting Welsh ecosystems, health, and public spending. Fly-tipping clear-ups cost the Welsh taxpayer an estimated £1.83 million between 2022 and 2023 with household type waste accounting for 70% of the total (Fly-tipping Action Wales, 2024).

Diversion of waste by criminals away from legitimate uses threatens our efforts towards creating a circular economy. This undermines progress in reducing our carbon emissions as well as an estimated 20,000 new jobs which a circular economy could create in Wales in activities such as increased repairing, remanufacturing, rental and leasing (based on downscaling 450,000 jobs that could be created in the UK, as estimated by (Green Alliance, 2021).

Where waste is handled illegally it is likely to be disposed of with no controls, to the detriment of human health and the environment. Appropriate resources and tools must be in place for regulators to identify, stop and take enforcement against waste criminals. Ensuring that waste streams have viable outlets to be handled appropriately is a key consideration when framing policies for waste, for example when implementing financial disincentives, or banning the disposal of certain waste types. This also includes emerging waste streams, which require appropriate disposal methods or need to develop a viable end recycling market.

Summary of trends in waste management

Table 4 presents a summary of the recent trends and likely future trends in waste management in Wales based on the evidence presented above. Table 4 reveals improving recent past trends in waste management in Wales (i.e. Wales is sending less waste to landfill and more for preparation for re-use, recycling & composting).

As Table 4 highlights, these improving trends are anticipated to continue through to 2030 as regulatory reforms to improve waste segregation and increase recycling come into force. A mixed picture on future trends to 2050 is identified, generally associated with legacy wastes that remain a long-term waste management issue in Wales (e.g., hazardous waste, Persistent Organic Pollutant wastes, electronic wastes, batteries, solar panels, wind turbines etc).

It is highlighted that improvements in digital tracking of waste from start to end point via a singular regular source of data would improve the accuracy and reliability of future assessments.

Table 67: Assessment of trends in waste management in Wales

Time Period	Indicative Assessment SoNaRR2020	Additional Evidence for SoNaRR2025	Indicative Assessment SoNaRR2025	Description	Confidence assessment for SoNaRR2025 -	Confidence assessment reasoning
Past Trends (2012-2019 for all managed waste; 2000-2023 for Welsh local authority managed waste; 2015-2022 for waste managed at permitted facilities)	IMPROVING	Waste Data Flow (LA/waste from households); NRW I&C waste survey 2018; NRW C&D waste survey 2019; NRW waste data interrogator (permit returns)	IMPROVING	Management of total waste (excluding mining and quarrying) generated by all sectors has generally moved towards recycling and away from landfill. **(Same as SoNaRR 2020).** Waste recycled by Welsh LA's continuing to increase (albeit marginally). High C&D sector recycling rates (based on new 2019 evidence). No new evidence of I&C since 2018 but there had been a statistically significant improvement in industrial waste recycling in that survey.	Agreement: HIGH Evidence: MEDIUM	Identifying accurate final waste management destinations is very difficult using current datasets. Reasons for this include complexities of waste management routes, frequency of data provision, and data limitations linking end fates back to the origin of the waste. Information on illegal waste activities is also extremely limited. There is uncertainty on impacts post Covid-19 on Welsh non household sector recycling improvements. This reduces the confidence that recycling rates are improving for all non household sectors generating waste in Wales. A more comprehensive & regular dataset is needed to evidence and assess waste management trends in future assessments.

Time Period	Indicative Assessment SoNaRR2020	Additional Evidence for SoNaRR2025	Indicative Assessment SoNaRR2025	Description	Confidence assessment for SoNaRR2025 -	Confidence assessment reasoning
Future trends (To 2030)	IMPROVING	Waste Data Flow (LA/waste from households); NRW I&C waste survey 2018; NRW C&D waste survey 2019; NRW waste data interrogator (permit returns) INSERT links to reform?	IMPROVING	Regulatory reform that is expected to increase recycling includes mandating separate collection of waste from non-domestic premises in Wales and extended producer responsibility requirements for increasing recycling of packaging waste in the UK.	Agreement: HIGH Evidence: MEDIUM	The effectiveness of reform will be determined by how successful it is implemented in terms of maximising participation and material capture rates in recycling infrastructure where opportunities are currently being lost. Substandard and illegal practices compromise this and are an ongoing concern requiring more attention. **(Same as SoNaRR 2020).**

Time Period	Indicative Assessment SoNaRR2020	Additional Evidence for SoNaRR2025	Indicative Assessment SoNaRR2025	Description	Confidence assessment for SoNaRR2025 -	Confidence assessment reasoning
Future trends (To 2050)	MIXED PICTURE	Waste Data Flow (LA/waste from households); NRW I&C waste survey 2018; NRW C&D waste survey 2019; NRW waste data interrogator (permit returns)	MIXED PICTURE	Welsh Government ambition (set in Beyond Recycling) is to be a zero waste nation by 2050 - this means Wales re-uses, repairs & recycles everything.	Agreement: HIGH Evidence: HIGH	Some legacy & emerging waste streams generated today require disposal (via landfill or incineration) in order to protect the environment & human health (e.g. hazardous waste, POP's, wood). Other waste streams are problematic to recycle owing to a lack of consideration of suitability for recycling at their end of life (i.e. at the manufacturing stage) and limited viable recycling markets existing for them (e.g. carpets, mattresses, solar panels, wind turbines, etc). Substandard and illegal practices also compromise the recycling of waste. All of the above compromise and must be overcome in order to realise the long term ambition for Wales to be a zero waste nation by 2050.

Progress with respect to waste and achieving a circular economy

If everyone in the world were to consume the same as the average Welsh citizen, over 2 planet Earths would be required to provide raw materials, energy and food as well as absorb the pollution and waste created (Welsh Government, 2023b). This is clearly unsustainable, so Welsh citizens must start living within global environmental limits. The Welsh Government Circular Economy strategy ‘Beyond Recycling’ sets a one planet resource use and zero waste aspiration for 2050 (zero waste means that 100% of waste that is still generated in 2050 will be re-used or recycled as a resource). A circular economy aims to keep materials and products in use for as long as possible, extracting the maximum value from them while in use and eliminating waste.

An estimated 7.5 million tonnes of waste was generated in Wales in 2019 (excluding waste from mining and quarrying, agriculture, forestry and fishing), with almost half of the waste originating from the construction and demolition sector. There was a statistically significant reduction in waste generated from households, industry, and commerce compared to 2012. There are indications that waste generated by households has also reduced since the Covid-19 pandemic. However, assessing the trend of total waste generation is difficult in the absence of a regular comprehensive dataset for all sectors. Further evidence is needed to fully understand the overall impact and trend of waste generation in Wales in the years since the pandemic.

Improvements in the way waste is managed have been so significant that Wales is now considered to be amongst the highest performing countries in the world for recycling municipal waste (Eunomia, 2024). Focus to date has been aimed mainly at fast moving goods and household waste (CIWM, 2024). However, recent Welsh legislation to mandate separate recycling collections from non-domestic properties and ban separately collected waste being sent for disposal is expected to further improve overall recycling rates in the next few years.

There are considerable amounts of recyclable materials still present within the mixed residual waste streams generated by industry, commerce and households in Wales that are sent for disposal. This presents significant opportunities for increasing recycling rates further by improving participation and capture rates of existing recycling schemes. There are also opportunities to significantly reduce inputs to Welsh landfill by focusing on understanding the reasons for the two most prevalent landfilled material types – waste derived from mechanical treatment and waste soils. This is also important in order to ensure that these materials have viable alternative recovery options in the future.

Food is a key waste stream contributing to residual waste collected from households and businesses in Wales to focus recycling efforts on. However, efforts to prevent food waste should take precedence since edible food waste accounts for the largest percentage of total local authority municipal waste (WRAP Cymru, 2023b). Where food waste cannot be prevented, it must be managed at waste facilities and the resultant organic outputs used appropriately. Aside from having a detrimental impact to our environment and economy, discarding edible food waste highlights social injustice. In recent years some social initiatives have been very successful in diverting surplus food from the food industry, avoiding it becoming a waste (FareShare Cymru, 2025). However, it is estimated that more food is wasted from UK households than any single sector in the supply chain. This highlights the need for systemic change to create the right conditions for helping Welsh citizens only buy what they need and eat what they have bought (WRAP, 2022).

Preventing waste generation and using waste as a resource are important strategies to reduce overall resource use to sustainable levels. They have considerable potential to reduce the environmental pressures associated with Wales' economic activities, both within Wales and outside. They also bring considerable benefits to the economy (European Environment Agency, 2020).

There are examples of positive steps being taken in recent years to prevent waste and develop re-use and repair infrastructure in Wales. This includes some examples of Welsh businesses becoming more innovative and attempting to disrupt mainstream take-make-use-disposal models. However, a universal culture of waste prevention, reuse and repair is needed in Wales that builds on the progress made to date. It is estimated that 67% of Welsh citizens have yet to engage in buying second-hand items, providing an insight into the scale of behaviour change needed but also the opportunity that exists to grow re-use, repair and rental models in Wales. Recent studies indicate that Welsh citizens are increasingly interested in alternative business models for acquiring goods with further potential to encourage those already purchasing second-hand items to consider them for more of their purchases (WRAP Cymru, 2023a).

Effective education and disincentives for over-consumption are absent and subsidies to support circular activities not sufficient for the systemic change required (CIWM, 2024). More collaboration is required between the public and private sector to enable minor and complex repair to become more mainstream. The Third sector (e.g. charities, voluntary & community groups) have a wealth of experience and knowledge to learn from. In addition, repair skills need to be integrated into education and training. Businesses also need to transition to service and rental economic models. This will help to accelerate the much needed mainstream transition from our ingrained, unsustainable throw-away culture to one that is truly circular and sustainable.

Technological advances have led to positive changes in certain areas. These advancements have resulted in changes to waste streams that need to be managed. This creates an expectation for the waste industry to react quickly with adequate collection and treatment methods as opposed to producers being accountable for ensuring that sustainable end of life solutions already exist for the products that they place on the market. Changes in product design are required to enable more reuse and repair such as through creating modular systems, having replaceable components, making products that can be upgraded, removing sealed units and built-in obsolescence. With the drive to a circular economy, it is clear that the waste industry will need to continuously evolve to respond to future needs. It is vital that these changes are matched with strong regulation against the legislative framework to maintain high standards of environmental and human health protection, ensure a level playing field and, importantly, tackle increasing opportunities for waste criminals to take advantage of the changing landscape.

Waste crime continues to be attractive to those seeking to profit from mis-managing waste, which undermines legitimate industry, pollutes the environment, harms communities and diverts waste away from a Circular Economy. Appropriate resources and tools must be in place to identify, stop and take enforcement against waste criminals. Furthermore, emerging waste streams and those that require disposal, place increasing pressure on land use and waste treatment capacity for Wales in the short term. In the longer term, waste crime and emerging waste streams compromise the ability for Wales to become a One Planet Zero Waste Nation.

Actions and Opportunities

The possible actions and opportunities with respect to waste and achieving a transition to a circular economy in Wales are summarised in Table 5

Table 68: Waste related actions for achieving a circular economy in Wales

Action	Waste prevention (reduce, re-use, recycle and recover)	Increase resource use efficiency	Awareness raising	Pollution management
Implementing circular principles in product design stages and extended producer responsibility models create modular systems to reduce waste generation and ensure maintaining use of resources over time	✓	✓	✓	✓
Promotion of using and buying used goods (e.g., via swap shops or re-use shops)	✓	✓	✓	X
Scaling up repair services (e.g., via repair café's)	✓	✓	✓	X
Raising awareness of how people can prevent or recycle (e.g., communication campaigns).	✓	✓	✓	X
Reducing resource consumption, including initiatives to support circular activities	✓	✓	✓	✓
Investment in technologies and high quality recycling	X	✓	X	✓
Investment in adequate monitoring to monitor waste flows and handling (i.e. lifecycle assessments and digital waste tracking)	✓	✓	✓	✓
Waste crime: investment in regulators to identify, stop and take enforcement against waste criminals.	X	X	✓	✓

Sources: (CIWM, 2024; WRAP, 2025b)

The key opportunities taken up since SoNaRR 2020 comprise:

- The Beyond Recycling strategy on making a circular economy a reality in Wales was published by Welsh Government in 2021 (Welsh Government, 2021a).

- The sale of some single-use plastic items was banned in Wales in October 2023, and more are proposed by 2026. The purpose of the new law is to phase out the need for unnecessary single-use plastic being used and sold in Wales and reduce the flow of plastic polluting the environment (Welsh Government, 2023a).

- The sale of single use vapes was banned in Wales on 1st June 2025. The purpose of the ban was to reduce the environmental harm caused by the production and incorrect disposal of single-use vapes (Welsh Government, 2025b).

- The Courtauld Commitment 2030 is a voluntary agreement that enables collaborative action across the entire UK food chain with the aim to deliver farm-to-fork reductions in food waste, greenhouse gas (GHG) emissions and water stress that will help the UK food and drink sector achieve global environmental goals. There has been some notable success measured such as an estimated 14% reduction in total greenhouse gas emissions between 2015-2021 (WRAP, 2023).

- Welsh local authorities creating “Re-use Shops” in an effort to encourage more diversion of re-useable items away from becoming waste and help tackle perceived barriers such as the condition of an item and inconvenience associated with donating (WRAP, 2025b). For example, it is estimated that over 80% of Welsh local authorities (18 out of 22) have at least one re-use shop at a Household Waste Recycling Centre to help intercept re-useable items that would otherwise become waste (Welsh Parliament, 2025).

- Repair Café Wales organised events to help local communities to have household items fixed for free or receive advice from volunteers (Repair Cafe Wales, 2025). In addition, there are examples of Welsh initiatives that help businesses to sustainably procure services to facilitate more re-use and remanufacture such as educational and workplace furniture services (Ministry of Furniture, 2025).

- Workplace Recycling Regulations (2024) requires all businesses, charities and public sector organisations to separate their waste in six separate recyclable waste streams (as a minimum) and for it to be kept separate after collection. A ban was also introduced for sending food waste to sewer, separately collected waste being sent to disposal (incineration and landfill) and all wood waste being sent to landfill (Welsh Government, 2024c);

- Extended Producer Responsibility for packaging (pEPR) came into force in Wales in 2025, making producers responsible for the full cost of recycling and waste management for packaging materials when they have come to the end of their intended life (Welsh Government, 2025a).

- Amendments to UK Waste Electrical and Electronic Equipment Regulations to incorporate online market places and producers of vapes were made on 22nd July 2025. These amendments are to ensure that producers pay towards the end of life management of the electrical goods that they place on the market (Welsh Government, 2025e).

- In April 2022, a Plastic Packaging Tax was introduced to provide a clear economic incentive to use recycled plastic in the manufacture of plastic packaging, in the hope of creating greater demand for this material. In turn stimulating increased levels of recycling and collection of plastic waste, diverting it away from landfill or incineration, and encouraging companies to consider the design of their packaging (Business Wales, 2022).

- An incineration moratorium on large scale energy from waste was put into immediate effect in Wales in 2021. This moratorium means the Welsh Government does not consider there to be a need for any new large-scale energy from waste plants of 10MW or greater to be built in Wales to manage residual waste. This response attempts to ensure Wales has sufficient capacity to deal with its own residual waste arisings in a way which does not impede the achievement of the Beyond recycling goals of zero waste and net zero carbon for 2050 (Welsh Government, 2021c) .

- The increasing rates of Landfill Disposals Tax on materials disposed at landfills in Wales helps to economically disincentivise this activity. Rates have continued to increase annually since 2020 to discourage its use. In addition, there is a higher unauthorised disposals rate for taxable disposals made at places other than authorised landfill sites to disincentivise waste crime (Welsh Government, 2024a).

- Landfill Emissions Reduction Project has been funded by Welsh Government since 2022. This project is being managed by Natural Resources Wales with the aims of improving the accuracy of Landfill Gas emissions and reporting and working with landfill operators to improve landfill gas capture and destruction (utilisation or flaring) to reduce landfill gas emissions (NRW, 2024b).

A commitment is also in place to deliver the following:

- A Deposit Return Scheme where consumers pay a small deposit of a drinks container at the point of purchase, which is refunded when the empty container is returned at a collection point (Welsh Government, 2025f). A consultation was launched on 18th August 2025 to inform an approach that included glass drink containers and prioritised reuse over traditional recycling methods (Welsh Government, 2025c).

- A UK Digital waste tracking service to address existing evidence gaps by transforming outdated systems for recording waste movements. A key aim of digitising waste records is to increase transparency of reporting, making it more difficult for rogue waste companies to compete in the waste industry and commit waste crime (DEFRA, 2025a).

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Annex 6: Aim 4 Energy evidence

Evidence Lead: Samantha Jones and Kalpana Balakrishnam

Key Messages

Key messages from the assessment with respect to energy and the transition to the circular economy in Wales comprise:

1. The greenest energy is the energy we don't use
2. Welsh electricity consumption is projected to approximately double by 2035 as we transition away from fossil fuels ((Welsh Government, 2025)
3. Renewable energy is a prerequisite to achieving our net zero targets. Wales has immense resources and potential for production of clean, renewable energy over the years to come.
4. The development of these energy resources, and the transportation of energy to markets throughout the UK and further afield, will require investment in infrastructure and transportation corridors, with resulting impacts on land use and other natural resources.
5. Welsh energy technology development will need to strike a balance between exploiting renewable energy resources for the benefit of the people of Wales, and to mitigate climate change, and the needs of our natural and urban environments.
6. It is vital that future energy developments avoid the mistakes of past Welsh energy industries, by planning for and protecting the health of our ecosystems.

Energy

Universal, affordable and clean energy is a prerequisite for economic and social development. In a modern economy, almost all goods and services have energy implications, from the foods consumed, buildings lived and worked in, vehicles used and day-to-day consumables at home and work (NRW, 2021). However, the generation of energy has long been associated with fossil fuels and associated greenhouse gas emissions. Consequently, the global energy system is one of the main drivers of the climate emergency (SoNaRR 2020, [Natural Resources Wales / SoNaRR2020: Transforming the energy system]()). The three main components in the category of "energy" are:

1 primary energy production (power stations),

2 production of heat (mainly domestic),

3 transport, mainly using fossil fuels.

In 2021, Wales set out its targets for the pathway to achieving net zero by 2050, including achieving a 63% reduction in emissions by 2030 and an 89% reduction by 2040 (Welsh Government, 2021a). Welsh Government's priority is to reduce emissions from fossil fuel power generation. It has set targets to generate enough electricity from renewable sources to meet 70% of Wales' electricity needs by 2030. This has since been updated to meet 100% of its electricity from renewable sources by 2035 (Welsh Government, 2025)In 2023 renewable electricity generation was equivalent to 58% of its electricity consumption (excluding losses). This is a slight decrease from 2022 when it was 59%. This is largely due to an estimated increase in electricity consumption. (Welsh Government, 2025).

Whilst Wales is making promising progress towards these targets, predicted increases in population and demand for electricity will create substantial future challenges. As such, it is also important that energy is used more efficiently to mitigate against additional energy generation demands.

Whilst the proliferation of renewable energy-related infrastructure on land and in marine and coastal settings is essential for meeting emission targets, they also contribute to environmental pressures on land, ecosystems and human health, and depletion of resources. Therefore, these infrastructure developments must be well-planned to mitigate pressures on ecosystems and human well-being.

Energy generation

There have been the significant changes in the fuel mix contributing to primary energy production in the UK since 1990. This is characterised by the elimination of coal for energy generation, with a concomitant rise in renewable wind and solar generation (National Atmospheric Emissions Inventory, 2023a). In Wales generation of electricity from renewable sources, mainly wind and solar, has been steadily increasing over the past 15 years (Welsh Government, 2023a). Figure 6 shows the trends in the different technologies for electricity generation specifically, showing that there is no longer any significant energy generation using coal or nuclear power within Wales (Welsh Government, 2023a).

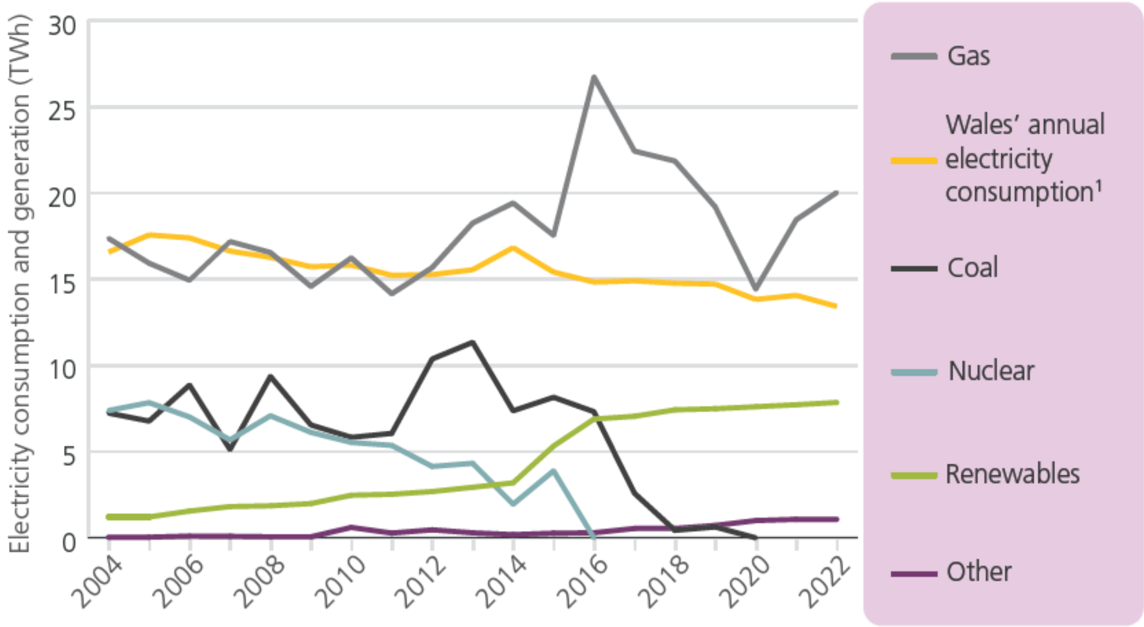

Figure 25 Electricity generation breakdown for Wales, 2004–2022. Source: (Welsh Government, 2023a).

The National Grid Electricity System Operator reported in January 2023 an all-time peak in zero-carbon electricity generation, at 87.6% clean energy on the electrical grid (National Grid ESO, 2024a).

Renewable energy generation

Table 69 outlines the capacity in megawatts (MW) and annual generation of renewable electricity and heat in gigawatt-hours (GWh) in Wales by the various renewable technologies. As Table 69 shows, the capacity of renewable energy was 3,663 MW in 2023, which is more than twice the installed capacity in 2012. The renewable heat capacity was 869 MW National Well-being Indicator 12 (Welsh Government, 2025)

Table 69: Renewable energy generation by technology in Wales in 2023 (Welsh Government, 2025)

Renewable energy technologies	Number of projects	Electricity capacity (MW)	Estimated electricity generation (GWh)	Heat capacity (MW)	Estimated heat generation (GWh)
Anaerobic digestion	50	18	94	9	54
Biomass	3691	-	-	482	1479
Biomass electricity and CHP	51	132	691	120	663
Energy from Waste	2	26	134	-	-

Renewable energy technologies	Number of projects	Electricity capacity (MW)	Estimated electricity generation (GWh)	Heat capacity (MW)	Estimated heat generation (GWh)
Heat pumps	22,067	-	-	231	396
Hydropower	380	170	332	-	-
Landfill gas	21	22	53	-	-
Offshore wind	3	726	2163	-	-
Onshore wind	754	1267	3106	-	-
Sewage gas	4	11	41	13	78
Solar PV	86,398	1291	1184	-	-
Solar thermal	4828	-	-	14	8
Grand total	**118,249**	**3663**	**7798**	**869**	**2678**

The trends in installation capacity for these technologies in Wales over time can be seen in Figure 6. Significant challenges remain in meeting the 70% green electricity target by 2030, largely due to a lack of price support for renewable generation (Welsh Government, 2023a), and network unavailability or constraints in some areas (Energy Systems Catapult, 2023; National Infrastructure Commission for Wales, 2023). In addition to the 2030 target, in 2023 the Minister for Climate Change proposed an additional target of achieving 100% renewable electricity generation in Wales by 2035 (Welsh Government, 2023b).

The “boom” in renewable energy capacity installations has apparently levelled over during the last few years. However, the latest data from the Microgeneration Certification Scheme (MCS) database shows significant growth in registrations of new domestic and small-scale solar and heat pump capacity during 2023 (The MCS Foundation, 2024). The total number of MCS registrations in Wales by 2024 was around 114,000, including 15,000 air-source heat pumps, 92,000 solar PV installations, 3000 solar thermal and 2000 biomass/micro-CHP installations.

The installation trend shows strong correlations with previous changes to Feed-In Tariff (FIT) and Smart Export Guarantee (SEG) schemes administered by the UK Government (2012, 2016), but the most recent peak in 2023 is not attributable to this. Data indicate that increasing numbers of households are investing in solar PV as a response to very high gas and electricity prices on the national energy grids (The MCS Foundation, 2024). Analysis of Welsh Local Authorities by MCS registrations, as shown in Table 70, shows those authorities with the highest registration rates correlate with the likelihood that a home will be off the gas grid (e.g. Ceredigion, Powys, Pembrokeshire). Cardiff City Council area has the lowest scheme take-up rate (3.6%). [These data will only provide an estimate of the take-up of renewable energy technologies, since some installations will not be registered with the MCS.]

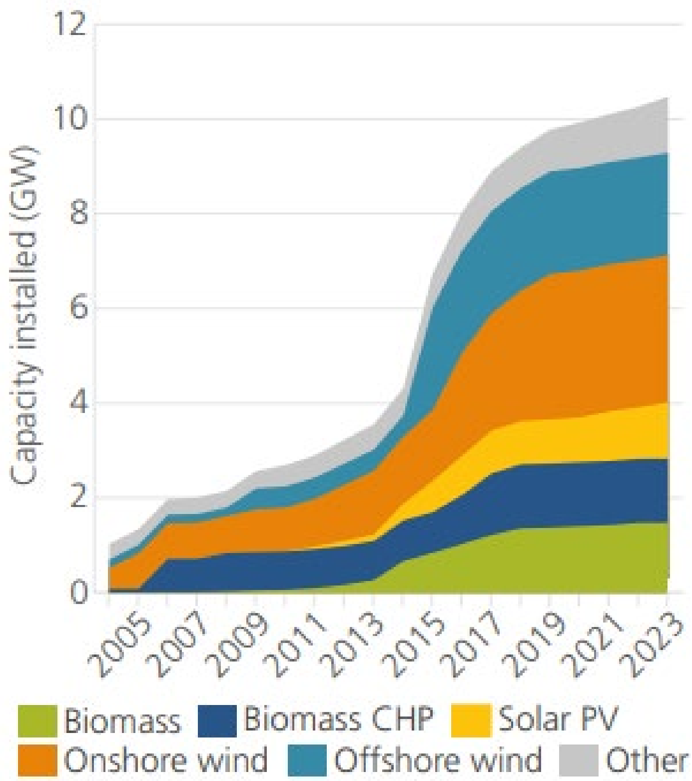

Figure 26 Renewable energy generation capacity for Wales 2005 - 2023. Source: (Welsh Government, 2025).

Table 70 Percentages of households with a current MCS scheme registration by Welsh Local Authority, as of January 2024. Source: (MCS Data Dashboard, no date)

Local Authority area	**% of households with a current MCS registration**	**% of households off the gas grid**
Blaenau Gwent	4.8	3.2
Bridgend	5.6	3.9
Caerphilly	5.1	3.4
Cardiff	3.6	12.2
Carmarthenshire	11.8	24.8
Ceredigion	22.2	32.3
Conwy	7.9	13.6
Denbighshire	11.1	21.0
Flintshire	10.5	15.3
Gwynedd	12.1	33.9
Isle of Anglesey	19.8	27.5
Merthyr Tydfil	4.4	3.6

Local Authority area	% of households with a current MCS registration	% of households off the gas grid
Monmouthshire	13.9	15.5
Neath Port Talbot	4.8	7.4
Newport	4.7	7.4
Pembrokeshire	15.7	22.2
Powys	17.8	41.6
Rhondda Cynon Taf	5.4	3.2
Swansea	5.0	7.7
Torfaen	7.0	3.5
Vale of Glamorgan	5.8	9.7
Wrexham	10.3	11.2
Total for Wales	**8.46**	**12.75%**

Greenhouse Gas Emissions from the Energy Sector

Figure 8 unpicks the contributions of the different parts of the energy system to GHG emissions in the UK (National Atmospheric Emissions Inventory, 2023a). Primary energy supply industries (in orange) accounted for 29% of UK GHG emissions in 2021, with a steadily falling trend except for a rebound from 2020 to 2021 related to post-Covid lockdown economic recovery.

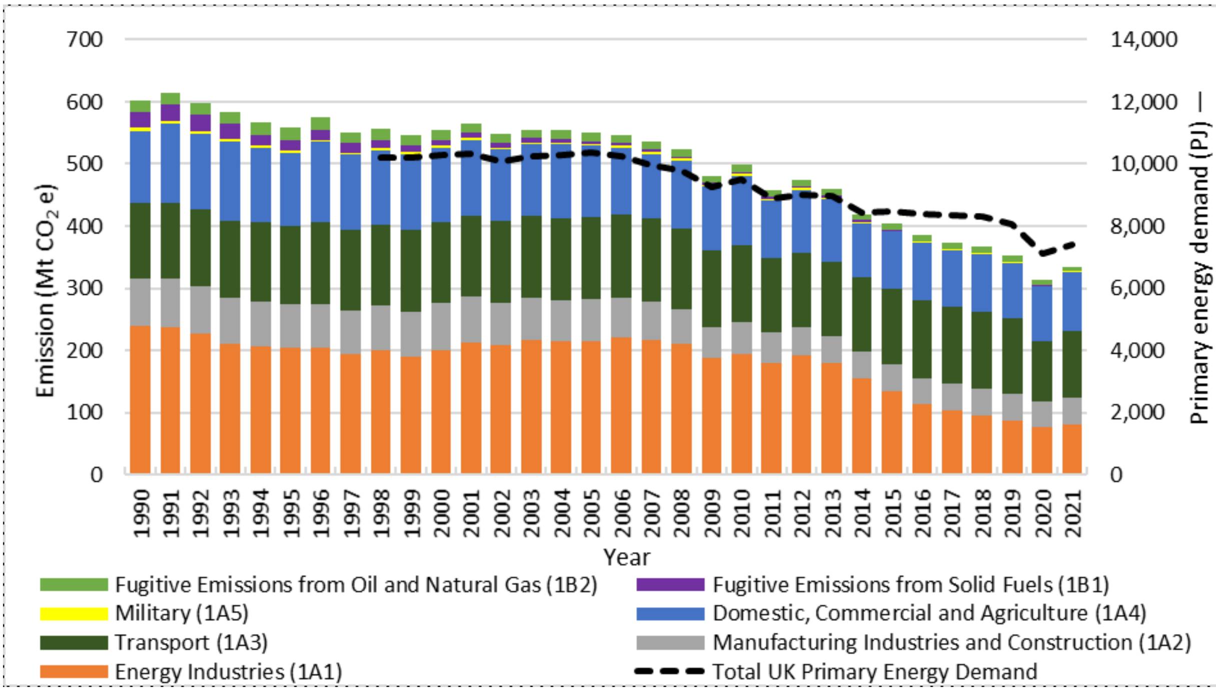

Figure 27 Sectoral shares of energy-related GHG emissions in the UK, 1990–2021. Source: National Atmospheric Emissions Inventory, 2023a.

Table 71 and Table 72 show the GHG emissions for Wales versus the UK in the standard baseline year of 1990, the last SoNaRR reporting year (2018), and the most recent data (2022), indicating an estimated reduction in Welsh GHG emissions of 37% at that point. 1990 17.8 Mt CO_2e GHG, 2018 (SoNaRR 2018) 10.9 and 2022 10.3

Table 71 Total Greenhouse gas emissions data in Wales and the UK, in Mt CO2e, across the 7 GHGs defined in the Kyoto Protocol. Source: National Atmospheric Emissions Inventory, 2024a (Greenhouse Gas Inventories for England, Scotland, Wales & Northern Ireland: 19

Region	**1990 (baseline)**	**2018 (last SoNaRR)**	**2022**
UK	838.6	506.8	440.9
Wales	56.2	38.4	35.7

Table 72 Energy sector Greenhouse gas emissions data in Wales and the UK, in Mt CO2e, across the 7 GHGs defined in the Kyoto Protocol. Source: National Atmospheric Emissions Inventory, 2024a (Greenhouse Gas Inventories for England, Scotland, Wales & Northern Ire

Region	**1990 (baseline)**	**2018 (last SoNaRR)**	**2022**
UK	838.6	506.8	440.9
Wales	17.8	10.9	10.3

The emissions data for Wales in intervening years have been highly variable (National Atmospheric Emissions Inventory, 2023a). Wales hosts a disproportionately high capacity of the UK's gas-fired power stations, resulting in a large proportion of emissions from a few point sources. Therefore, total Welsh emissions in any given year are highly dependent on the extent to which these point sources are utilised by the UK power grid. Additionally, while Wales contains only 4.7% of the UK population, Wales contributes 18.8% of the UK carbon emissions from major industries (Welsh Government, 2022).

Nonetheless, there has been substantial progress in reducing emissions from industry in Wales. Between 1990 and 2020, CO_2teq have reduced by 35% followed by a further 10% reduction between 2016 and 2020 (Climate Change Committee, 2023, p. 15). It is unclear how much is due to reducing the carbon intensity of industries or diversifying/reducing activities.

Emissions from the power generation sector in Wales are characterised by an increase in 43% CO_2teq between 1990 and 2016, followed by a dramatic decarbonisation of the sector between 2016 and 2020 leading to a 68% fall in CO_2teq emissions (Climate Change Committee, 2023, p. 15)). Experimental statistics indicate Wales' low carbon and renewable energy economy is becoming an important part of the overall economy, contributing £3.3 billion to GDP and supported 15,600 full time jobs in Wales in 2023 (Office for National Statistics, 2025).

Greenhouse gas emissions from just electricity supply have dropped from 11.2 Mt CO_2e in 1990 to 6.8 Mt CO_2e in 2022 (Welsh Government, 2025) (National well-being indicator 41). This has contributed to the overall decline in emissions of green house gasses in Wales from 56.2 Mt CO_2e in 1990 to 36.0 Mt CO_2e in 2022 (Welsh Government, 2025) (National well-being indicator 41).

Summary

The following tables give a brief description of the future prospects for energy generation and energy-related emissions. These are assessed to be:

- Improving trends or developments dominate (green).
- Trends or developments show a mixed picture (amber), or
- Deteriorating trends or developments dominate (red).

Table 73 Future prospects for energy generation in Wales

Time Period	Indicative Assessment	Description
Outlook to 2030	Mixed Picture	The goal is for 70% of all electricity consumption to come from renewable sources by 2030, up from 59% currently. Progress will be made towards this target, although it may not be fully met by 2030, especially as total electricity demand rises. Increasing renewables are likely to come onstream, mostly onshore wind and solar PV as the technological/engineering barriers are fewer than for offshore wind (floating or fixed). Other emerging technologies such as battery storage and hydrogen electrolysis could be developed. However, there is no clear UK-level policy as to how this will happen. Expansion of renewable electricity faces lack of infrastructure and investment support. Political pressure is likely to grow to take action on grid infrastructure constraints, especially in Mid Wales, in order to expand the exploitation of wind energy. Natural gas will continue to play a key role in the generation of electricity through power stations, and in the domestic heating sector. Higher domestic fuel prices could drive a steady growth in “home as power station” developments, either self-funded by those households with sufficient disposable income, or in social housing through local authority and Housing Association schemes.
Prospect to meet policy objective/ targets by 2050	Mixed Picture	The overarching goal is for Wales to achieve net zero GHG emissions by 2050. There is also a proposed intermediate target to produce 100% of Welsh electricity demand from renewable sources by 2035. Renewables complemented by both large-scale and distributed energy storage (possibly including hydrogen) will be required. Considerable progress will be made with onshore and offshore wind, including floating wind in the Celtic Sea, and also with large-scale solar parks. Major projects such as tidal lagoons or hydropower systems could make a significant contribution, but in order to achieve the targets, those projects would need to start now. The prospect of nuclear energy development in North Wales is looking increasingly likely, although this would be subject to political support and possibly international investment. Any progress in these areas must be complemented by demand reduction and energy efficiency measures.

Robustness of data: There are adequate data on electricity generation and production of fuel at the UK and Welsh levels, although there can be a time lag before publication.

Table 74 Future prospects for energy-related greenhouse gas emissions in Wales

Time period	Indicative Assessment	Description
Outlook to 2030	Mixed Picture	Wales is still in the process of meeting its targets in reducing GHG emissions by 63% by 2030 but has made significant progress (37% by 2022). Welsh figures up to 2030 will be increasingly influenced by the extent of natural gas use in power stations to support the National Grid, and whether these are subject to carbon-capture adaptations (CCUS). Slow progress will be made in reducing direct emissions from transport and domestic heating, despite the existence of adequate replacement technologies. New dwellings should be switched to heat pump technologies from 2025, but this will leave a huge legacy issue for the 80% of Welsh homes with a gas boiler.
Prospect to meet policy objectives/ targets by 2050	Mixed picture	The Welsh and UK target is to achieve Net Zero emissions by 2050. Transport is likely to remain the largest emitting sector of greenhouse gases, having overtaken the energy sector in 2016. The number of road vehicles is still rising, despite the interruption of the Covid pandemic, and the total mileage is expected to surpass pre-Covid mileage soon. Van traffic has doubled since the 1990s (Department for Transport, 2023). The UK Government has committed to ban the sale of new diesel, petrol, and hybrid vehicles by 2035 to help the transition to zero emission vehicles. A ban on installation of gas boilers in new homes should be in place but work on the legacy gas systems will continue. Some industries that still produce large amounts of CO_2 could have switched to carbon capture technologies. Other greenhouse gases and fugitive emissions could still present problems.

Robustness of data: Data is probably adequate in helping to assess the sectoral emission and contribution.

Energy consumption

As part of meeting the goal of 70% renewable energy in Wales by 2030, there will need to be a combination of both decreasing energy consumption and increasing renewable energy generation. Figure 9 shows the Welsh Government projections for electricity only, with a steep upward trend for electricity consumption as heat and transport systems decarbonise. This also demonstrates the gap between where we are now (solid green line) and where we need to be to meet the 70% target (dashed line).

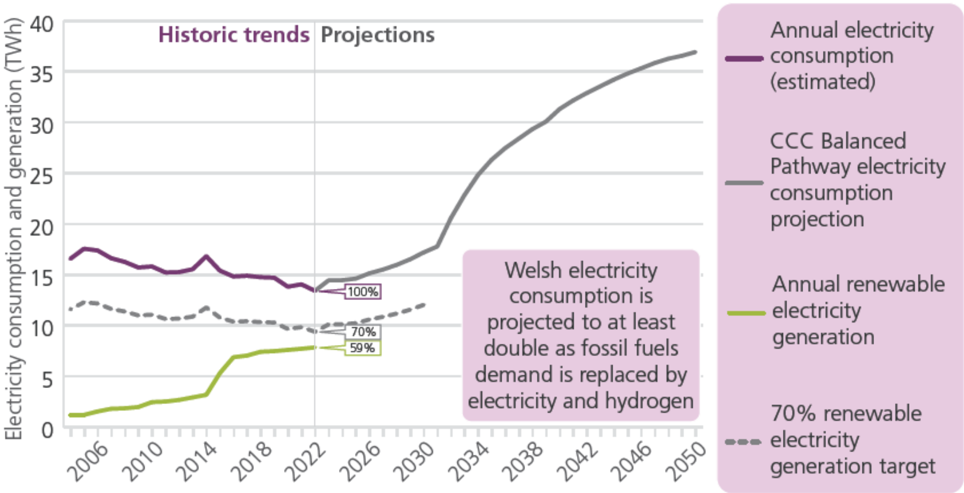

Figure 28 Comparison of annual Welsh electricity consumption and generation trends against the 70% target. Source: Welsh Government, 2023a.

Several Local Authority areas (Denbighshire, Ceredigion and Powys) are already able to generate enough renewable electricity locally, mainly through wind farms, to meet their entire equivalent electricity consumption. However, the anticipated growth in electricity demand means that renewable generation capacity will still need to rise strongly throughout Wales just to meet our national needs.

Production of renewable heat was approximately 2.6 TWh in 2023 (Welsh Government, 2025), a slight increase from 2.5 TWh in 2022, which is equivalent to only about 11% of estimated Welsh domestic heat demand (a reduction from 13% in 2019: (Welsh Government, 2020). The bulk of heat demand in Wales is still met through fossil fuels, largely imported natural gas, and it seems that despite the uptick in domestic renewable heat installations, demand for heat is increasing more quickly than renewable heat capacity.

Consistent with the UK trend, total energy consumption in Wales reduced by 22% between 2005 and 2021, with most sectors showing a reduction in use (Regen, 2024, fig. 11)

Recent projections published by Welsh Government, based on the 2021 Census data, shows increasing estimates of population growth in Wales up to 2031 and beyond (Welsh Government, 2024a). The most recent projection shows anticipated population growth of 5.8%, from 3.11 million to 3.29 million, between the 2021 and 2031 Censuses. With increasing population, we can reasonably anticipate an effect on future energy demand in the domestic and transport sectors. Looking back at previous population growth in Wales shows that urban growth is likely to be highest (Senedd Cymru, 2019), with Cardiff, Bridgend, Newport and Swansea likely to see relatively higher growth, and therefore energy consumption.

Additionally, previous projections made in 2020 up to 2045 show modest growth but significant ageing of the Welsh population (StatsWales, not dated). This ageing demographic profile may also have an impact on energy consumption profiles and household income.

Energy efficiency

The importance of continued improvements in energy efficiency have been highlighted in all four of the Welsh Government-sponsored Regional Energy Strategies published since the last SoNaRR report (Welsh Government, 2021c). The energy price inflation experienced in the UK since the Ukraine crisis has brought increasing focus onto this area, especially for domestic consumers.

In Wales, the regulation of "energy conservation" is a reserved matter and the responsibility of the UK Government, whilst the promotion of energy efficiency is shared with Welsh Government. This means that Welsh Government can develop incentivisation schemes and offer advice and support, for example through the Welsh Government Energy Service which supports public bodies and community groups. Wales has an energy efficiency strategy covering 2016–2026 that includes a wide variety of topics including innovation and skills (Welsh Government, 2016). Targets from that document referenced EU policy at the time, including measures to deliver "20 by 20" – 20% reduction in energy use by 2020, and then an extension to 27% reduction by 2030. These have not yet been followed up by new energy efficiency targets, because as cleaner energy sources are being developed and installed, the focus is fully upon emissions targets, rather than energy targets.

The Welsh housing stock is relatively old, with approximately 33% of dwellings being pre-1930 in age, compared with an equivalent figure of 22% in England, for example (Office for National Statistics, 2023). Older properties are generally more expensive and difficult to insulate or modify to improve energy efficiency. According to National Well-being Indicator 33, less than half (47%) of homes in Wales have adequate and cost-effective energy performance in 2017-18 (Welsh Government, 2025).

Building Regulations are devolved to Wales and cover the "conservation of fuel and power" for new and existing dwellings. Adequate maintenance of social housing is covered by the Welsh Housing Quality Standard 2023 (Welsh Government, 2023b). These standards require adequate heating and ventilation, minimisation of emissions, smart meter installation, and water-saving measures. At the time of the last SoNaRR report, Welsh Government were consulting on new Building Regulations covering Part L – Conservation of Fuel and Power, to replace the 2014 standards. Interim regulations for new dwellings (Part L 2021) came into force in 2022, while even more stringent standards are expected to come into force later in 2025 (Welsh Government, 2020b), and are likely to include such measures as:

- Higher fabric standards, such as triple glazing
- Solar PV panels, waste heat recovery systems, or other suitable energy saving technologies

- A low-carbon heating system, such as a heat pump, electrical heating, or connection to a district heat network
- A combined carbon emissions reduction of 75–80% compared with the 2014 Part L Standards for new builds.

Summary

The following tables give a brief description of the future prospects for energy related emissions, generation, consumption and efficiency. These are assessed to be:

- Improving trends or developments dominate (green).
- Trends or developments show a mixed picture (amber), or
- Deteriorating trends or developments dominate (red).

Table 75 Future prospects for energy consumption in Wales

Time Period	Indicative Assessment	Description
Outlook to 2030	Mixed Picture	There is no specific target for total energy consumption, since the focus is upon GHG emissions and energy generation. Clearly, total consumption of high carbon energy needs to be reduced drastically. Fossil fuels must be substituted by low carbon and renewably generated alternative fuels. A high priority should be to minimise use of any energy source through demand reduction and energy efficiency measures. Energy consumption in buildings will need to be reduced through energy efficiency measures, fuel substitutions, and use of domestic and commercial renewable energy installation and storage. Transport in 2030 will remain largely powered by fossil fuels, especially as the UK government has announced the pushback of the deadline for the sale of new diesel and petrol cars to 2035, instead of 2030. It is likely we will see progress with public fleets, buses and HGVs. Major hydrogen infrastructure is not possible before 2030, but possibly a few exemplar fleets of larger vehicles may be operating. Much enhanced EV charging coverage is likely. The industrial sector may see the biggest changes, especially the energy-intensive industries such as steelmaking. Recent developments at Port Talbot steelworks will be important in this regard, as a major point source of energy consumption in Wales.

Time Period	Indicative Assessment	Description
Prospect to meet policy objectives/ targets by 2050	Mixed picture	There is no specific target for total energy consumption, since the focus is upon GHG emissions and energy generation. Total energy consumption over such a long time period is likely to be strongly affected by population trends, which can only be roughly estimated. Current projections up to 2045 show modest growth but significant ageing of the Welsh population. Around 80% of UK (and Welsh) dwellings are heated by natural gas. Elimination of fossil fuel burning through the gas grid will be very difficult to achieve by 2050, although it is possible that offsetting schemes might be able to mitigate the remaining emissions if they reach a much lower level. It is possible that increasing global temperatures may somewhat ameliorate the need for heating in buildings, but this is likely to be substituted by a greater need for cooling systems, especially during the increasingly hot summer months. All indications are that a much greater proportion of our energy consumption will be met through electricity by 2050, rather than other means.

Robustness of data: There is adequate data on energy consumption by sector and fuel type at the UK level, but data is either not robust or available or both at the Welsh level to make a thorough Welsh Assessment.

Table 76 Future prospects for energy efficiency in Wales

Time Period	Indicative Assessment	Description
Outlook to 2030	Deteriorating	Welsh Government has an Energy Efficiency strategy for the period 2016 to 2026 and a programme to deliver energy efficiency improvements to fuel-poor households. But there are no recent energy efficiency targets set since our exit from the EU, as the focus remains on GHG emissions targets. There are plans to change substantially the Building Regulation standards for new dwellings by 2025 (see above), but the current norm is still for the major developers to install gas heating systems into new homes, thus cementing our national reliance on the gas grid. There has been a general downward trend in domestic consumption since around 2000, due to improvements in energy efficiency of appliances. This trend has not kept pace with rises in energy prices, hence the increasing rates of fuel poverty in Wales despite some investment into schemes like NEST for the most vulnerable (Welsh Government, 2023e). The Local Area Energy Planning process has also highlighted the scale of work remaining to be done to minimise the energy needs of our domestic, commercial, industrial and transport sectors, with progress being very slow.
Prospect to meet policy objectives/ targets by 2050	Mixed picture	Looking further ahead, there are signs that the industrial sector will make significant progress by 2050, driven by partnerships like the South Wales Industrial Cluster, which has identified energy efficiency as a cornerstone of its work for the future. A major upgrade of the energy performance of the entire building stock will be required, with the support of the public. Exemplar communities to demonstrate upgrading projects and heat networks are likely to support this. Strategies to engage homeowners will need to focus on reducing energy costs, improving local communities, and support with capital costs. The UK and Welsh efforts to decarbonise will require increased investment across the energy system with more focus on behaviour change and innovation to help ensure minimisation of costs in investment, and further improvements in energy efficiency. Welsh Government will need a strategy driven by specific efficiency targets.

Robustness of data: There is adequate data in relation to energy efficiency at the UK and Wales level with regards to housing and fuel poverty. However, there is a lack of data in relation to energy efficiency for transport, industry and commercial sectors.

Pressures on Natural Resources from the energy sector

The generation of energy (both from fossil fuel and renewable sources) drives a number of pressures that affect the state of natural resources and ecosystems, such as:

- **Climate change:** Greenhouse gas emissions from energy generation.
- **Pollution:** Other atmospheric emissions (e.g., NO_x, SO_2) and land pollution, conventional and nuclear wastes (e.g. batteries).
- **Land and sea use and management changes**: Increase in built development and infrastructure to support energy generation.
- **Direct exploitation:** Overuse of renewable natural resources such as biomass for electricity generation.

Climate Change

The energy sector is an indirect driver of climate change pressures on natural resources and ecosystems. The means the sector is a significant contributor to climate change, which then drives pressures on ecosystems, such as sea-level rise on coastal margins.

Energy supply industries in the UK contributed 29% of total greenhouse gas emissions in 2021. Wales is also responsible for a disproportionate share (18.8%) of all UK carbon emissions because of the hosting of major emitting industries (e.g. steel) and fossil fuel power stations (e.g. Pembroke). Nonetheless, Wales has demonstrated sustained emissions reductions from industry since 1990 and substantial recent reductions in emissions associated with power generation. However, the global trend remains one of increasing emissions (United Nations, 2025) and therefore increasing climate change pressures on natural resources, ecosystems and people, both in Wales and around the world.

Pollution

Despite progress with reducing greenhouse gas (GHG) emissions from the energy sector, Welsh emissions figures for some gases and particulates remain relatively high, partly because of the siting of some key UK energy infrastructure in Wales. These are direct drivers of pressures on air quality, which in turn creates pressures on ecosystems through atmospheric deposition, and may cause human health impacts. In addition to atmospheric pollution, the energy sector can be a driver of pollution to other media. This includes land pollution caused by inappropriate disposal of wastes associated with the sector (e.g. heavy metals in batteries).

NOx gases (NO, NO2, NO3)

These are considered as indirect GHGs because they can increase ozone levels in the troposphere, which also drives global warming, but importantly they are toxic in their own right in the local environment. NO_x gases have documented health impacts for humans (Brunt *et al.*, 2016) and animals, can raise local levels of ozone (with further health impacts) and can react in the atmosphere to form acid rain (HNO_3). Subsequent nitrification of water bodies can cause algal blooms/eutrophication and loss of biodiversity (Ryalls *et al.*, 2022).

Most NO_x emissions in the UK derive from our need for energy, either through combustion in power stations (10%) or from various forms of transport (47%) (National Atmospheric Emissions Inventory, 2024a). The Welsh energy sector has slashed its emissions of NO_x, now 91% reduced since a peak in 2013 (L Garland *et al.*, 2023). This was largely achieved by the cessation of coal burning at Aberthaw power station in the Vale of Glamorgan.

Sulphur dioxide (SO2)

SO_2 emissions also mainly arise from combustion (91% of emissions in the UK in 2021), and can affect respiratory health as well as producing acid rain (National Atmospheric Emissions Inventory, 2024b). Since 1990, total UK SO_2 emissions have reduced by 96%, mainly achieved by the almost total removal of the use of coal and coke in our energy system.

In Wales, reductions since 2006 are largely due to retrofitting of flue gas desulphurisation at power stations, with fluctuations related to electricity demand (L Garland *et al.*, 2023). Power stations alone have achieved a 99% drop in SO_2 emissions from 2005 to 2021, Still, the Welsh emissions represented 11% of total UK SO_2 emissions in 2021, proportionately much higher than expected for our population, due to the combination of energy and heavy industries sited in Wales.

PM2.5

$PM_{2.5}$ can cause respiratory diseases in humans and other animals (Vallero, 2015). A large proportion of the anthropogenic particles emitted can be characterised as soot produced by combustion processes, including from vehicles. Over time some of the uncontrolled sources of combustion, such as the burning of coal and other solid fuels, have been reduced. A steady reduction in transport-related emissions is observed between 2005 and 2021, leaving most $PM_{2.5}$ emissions coming from other sources of combustion in Wales. Vehicle emission regulations to try to meet World Health Organization guidelines of $<10\mu g/m^3$ have supported this improvement. It should also be stated that other significant sources of PM are natural, such as airborne sea salt, dust, pollen, etc.

Battery wastes

The efficiency of renewable energy technologies that rely on intermittent sources, such as solar and wind energy, can be hugely improved by using energy storage. Battery energy storage systems (BESS) are now commonly being installed across the UK, in homes, at a variety of commercial scales, and in some cases to offer a rapid-response grid stability service to National Grid. One large BESS development is currently underway at Uskmouth Power Station, Newport. This 460 MWh (230 MW) facility is being constructed by a partnership between E.ON and Quinbrook Infrastructure Partners, and is expected to be operational in 2025.

BESS is anticipated to make a significant contribution to greening of the grid by maximising the efficient use of renewable but intermittent energy sources. However, battery technology and mass production create substantial demands for natural resources and create potentially significant end-of life disposal issues due to heavy metal contents that can drive land pollution pressures on ecosystems via inappropriate disposal.

Furthermore, toxic emissions can occur in the event of runaway battery overheating. Such battery fires have so far been rare in the UK, but a previous lithium battery fire at a BESS facility near Liverpool in 2020 saw the emission of HF and HCl, plus highly alkaline material within the structure (Merseyside Fire and Rescue Service, 2022). The potential for fires and local pollution impacts on people and nature will need to be carefully managed and monitored as BESS facilities become more common.

Land and sea use and management changes

The shift to low-carbon energy systems through extensive technologies could have an impact on our landscapes. Virtually every prominent energy decarbonisation scenario involves increasing the land footprint of energy (e.g. (van de Ven *et al.*, 2021; Lovering *et al.*, 2022). This directly drives pressures on ecosystems associated with the proliferation of built development and infrastructure.

Hydropower

In 2022 the estimated hydropower generation in Wales was 350 GWh across 379 projects (Welsh Government, 2023a). 95% of hydropower in Wales is located in the North and Mid Wales regions, where there are high levels of hydropower resource ad suitable topography. Over half of this capacity is in Gwynedd and Ceredigion, which host the Eryri National Park and Cambrian Mountains respectively (Welsh Government, 2023a).

The land footprint of hydroelectric facilities depends on the area of flooded land, which varies significantly according to the size of the facility and the terrain. Large-scale hydropower, which involves storing water in reservoirs behind dams, necessarily inundates land. In contrast, the land footprints and biodiversity impacts of mini (<10MW) or micro (<1MW) hydropower systems integrated into water flows (run-of-river), are much smaller, as these do not require large reservoirs.

No hydropower projects bigger than 2 MW have been developed in Wales since the start of the 21st century, and only two projects larger than 1 MW: the 1.8 MW Ystradffin site in Carmarthenshire commissioned in 2020, and a 1.4 MW site commissioned in Gwynedd in 2013. From 2012 to 2018, 16 MW of small-scale hydropower projects (less than 1 MW) were deployed in Wales as a result of Feed-in Tariff (FiT) support. Three new hydro projects were commissioned across Wales in 2022, with a total capacity of 0.1 MW. These sites, located in Gwynedd and Monmouthshire, each have an electrical capacity of 50 kW or less (Welsh Government, 2023a).

Onshore wind turbines

Onshore wind power can deliver a substantial contribution to achieving net zero targets, and many turbines are already in operation in Wales. The last reported UK Government figures from 2022 indicate there are 738, with the most turbines installed in Pembrokeshire (152); Powys (126); and, Carmarthenshire (113) (UK Government, no date).

Pre-assessed Areas for Wind Energy are identified in the Future Wales Plan (Welsh Government, 2021b), and while they do not impact directly upon National Parks or National Landscapes, they will have significant impacts upon ecosystems and amenity (see Figure 10). Wind farm developments proposed for these areas are to be viewed with a "presumption in favour" in the planning process, with "significant weight" to be given to renewable energy targets. Final decisions on applications would be made by the Welsh Minister. Planning applications for new wind turbine installations require an environmental statement, EIA or similar, to assess likelihood of bird impacts or other negative environmental impacts during the operation of the turbines.

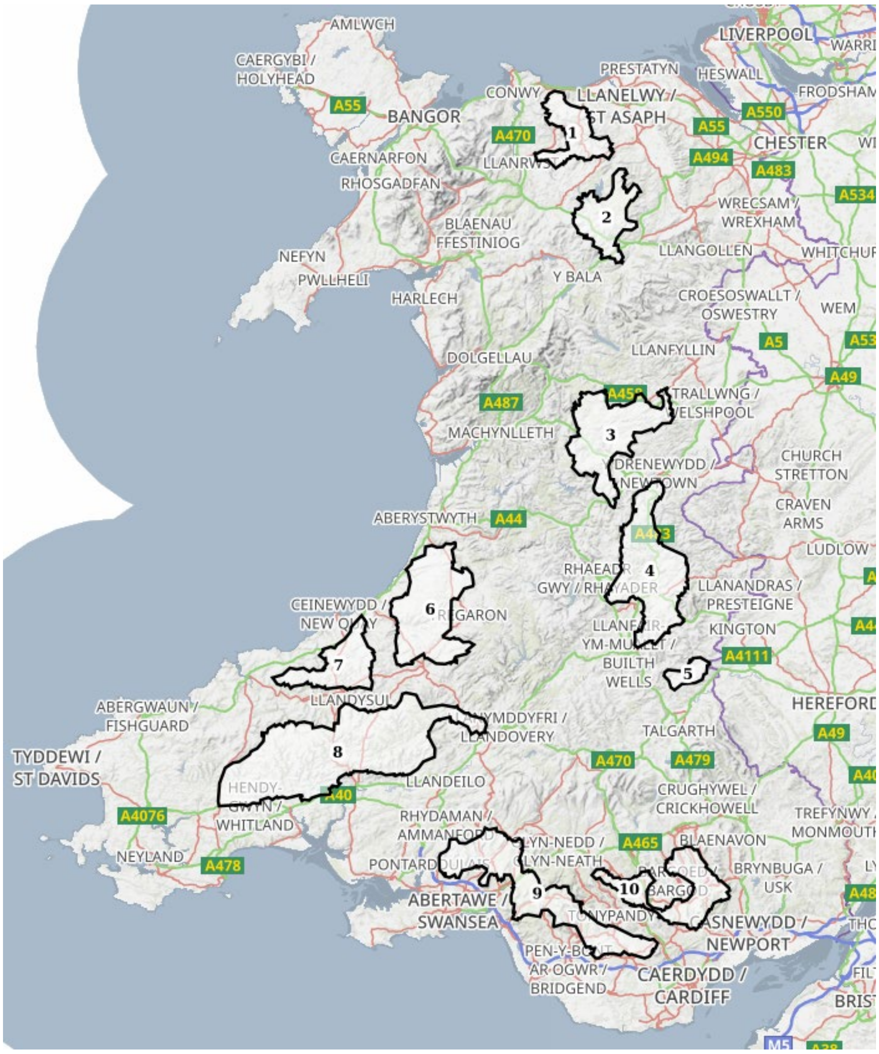

Figure 29 Pre-assessed Areas for Wind Energy in Wales, as identified in the Future Wales plan of Welsh Government in 2021. Source: DataMapWales, 2024.

Electrical grid infrastructure

In terms of grid infrastructure, there is an overlapping, but different set of potential environmental pressures compared with wind turbines. Planning Policy Wales expresses a preference for undergrounding of cables, but exceptions are possible because PPW allows for “a balanced view to be taken on costs which could render otherwise acceptable projects unviable”. The electricity industry’s current view is that undergrounding can cost from 3 to 20 times more than overhead lines, although the introduction of a cable ploughing technique is strongly challenging this assumption, and may bring costs down significantly. Use of cable ploughing would remain problematic in sensitive locations such as wetlands or archaeological sites or have physical limitations in exposed terrains (e.g. areas of very shallow soils).

Solar farms

Use of ground-mounted solar PV to generate electricity will increase in scale in Wales in the coming years. Local Area Energy Plans (LAEPs) (many published in 2024) support large-scale installations in nearly every Local Authority in Wales, but especially in South Wales due to greater sunshine hours per year plus existing grid connectivity. As a rule of thumb, we can use guidance that solar PV is likely to see a 5-fold increase by 2035 (Rankl and Sutherland, 2023), with a typical operation period of up to 40 years, and the potential either for remediation or repowering after that. A review of published LAEPs for Wales, and using a conversion factor of 4 acres of land per MW of installation (Department for Energy Security & Net Zero, 2024), indicates that counties in South Wales might see around 1.5% of their land area given over to ground-mounted solar PV, which would represent a 15-fold increase in solar farm area from the current position.

Visual impacts of solar PV farms will therefore grow in importance. The cumulative impact of multiple sites, potentially to a high density, could affect communities, landscapes and ecosystems. They could also present significant opportunities, if well-designed and managed, to improve local habitats and ecosystem services, particularly in terms of pollinators and the diversity of plants and hedgerow species.

Offshore and coastal renewables

Based on both UK Government and Welsh policies, it is likely that Wales will see a significant increase in offshore and coastal developments related to renewable energies over the next 10–20 years and beyond. These may include:

- Deployment of Round 4 / Extensions fixed offshore wind turbines in the Irish Sea
- Deployment of floating offshore wind (FLOW) turbines in the Celtic Sea
- Offshore cabling between the turbines and the coast
- Onshore cabling linking to national grid infrastructure
- Related coastal developments such as substations
- Related upgrading of pre-existing grid connections
- Port development to accommodate FLOW turbine construction and deployment
- Construction and operation of tidal lagoons as part of tidal range projects
- Deployment and operation of tidal turbines as part of tidal stream projects.

Celtic Sea FLOW projects

Floating offshore wind turbines and substructures are vast engineering projects – substructures alone can measure up to 80 metres across and weigh thousands of tonnes. By the early 2030s, with turbine capacities expected to reach 15MW, turbines could reach as high as 300 metres. Floating turbines are tethered to the seabed through a variety of different mooring and anchoring technologies. Typical water depths in the Celtic Sea will be 60-100m.

The areas designated for FLOW in the Celtic Sea lie more than 30 km offshore, falling under the ownership of the Crown Estate. Three designated areas are being leased for development up to the year 2035 (see Figure 11), with three further areas intended for future development. The first three areas are intended to accommodate 4.5 GW of generation capacity, which would require around 267 turbines reaching a blade height of up to 265m (Marine Energy Wales, no date).

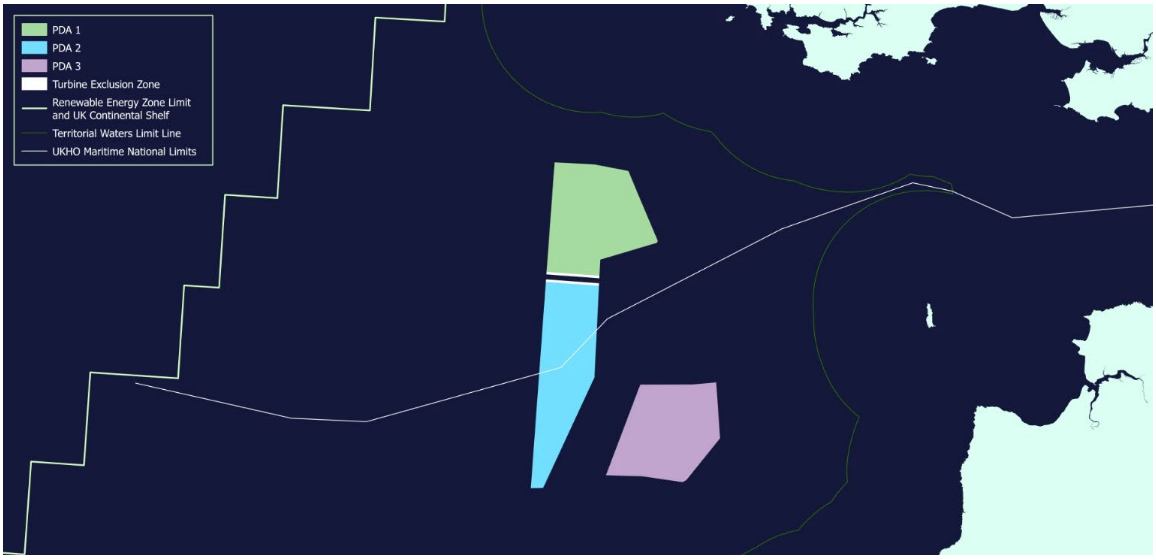

Figure 30. Current Project Development Areas for FLOW in the Celtic Sea. Source: Crown Estate, 2024a.

The Blue Gem Wind Erebus demonstration project will use the Windfloat system (Principle Power), likely with chain and drag-anchor mooring systems, with a plan to deploy up to 10 turbines in 2026-27. Floventis has named its demonstration projects Llŷr 1 and Llŷr 2, and each will include up to 10 turbines. A third demonstration project (Flotation Energy) is named White Cross, and it plans to take the infrastructure and power into North Devon rather than Wales.

Port development

Welsh Government is a strong supporter of the Freeport programme on economic grounds and to support new green industries (Welsh Government, 2023f). Currently the two designated freeports are the Celtic freeport at Milford Haven/Port Talbot, and the Anglesey freeport at Holyhead. The Celtic Freeport will focus on FLOW technologies. A report written on behalf of the Crown Estate gives a flavour of the scale and magnitude of the onshore infrastructure that might be required to provide assembly and deployment operations for FLOW in the Celtic Sea (Smith *et al.*, 2020).

Recent developments in March 2024 saw Port Talbot being named as a Primary List location for investment through the UK Government's FLOWMIS project (FLOW Manufacturing Investment Scheme). One of only two UK ports to be named, this could lead to investment of £1 billion to prepare the port for wind turbine assembly and deployment into the Celtic Sea (Marine Energy Wales, 2024).

Tidal lagoons

Tidal lagoons are part of Welsh Government's wider commitment to make Wales a world centre for emerging marine technologies. Welsh Government has recently run a Tidal Lagoon Challenge funding round, and the winners were announced in March 2024 (Welsh Government, 2024b). The intention is to help to remove barriers to tidal lagoon development around Wales. Additionally, in March 2024 the Western Gateway launched the independent Severn Estuary Commission, which is tasked with re-examining the potential of the Severn Estuary to provide renewable tidal energy. So far they have completed a Call for Information in an attempt to collect together all extant data relating to previous project proposals and environmental investigations (Severn Estuary Commission, 2024).

In North Wales, there is a proposed tidal lagoon being taken forwards in Conwy/Denbighshire, with a 30 km barrier running from Prestatyn to Llandudno to enclose a sea area of 150 km^2. This massive North Wales Tidal Energy project has support of local authorities but would require UK Government support and approval. Similarly, another smaller project at Mostyn has been proposed and is working on all required approvals and marine licensing (Mostyn SeaPower).

Tidal stream projects

The Morlais Tidal Demonstration Zone project, just off Holy Island (Ynys Môn), is currently in progress, and NRW have granted appropriate licences. The 35 km^2 Crown Estate site comprises a demonstrator zone for the concept of large-scale tidal-stream energy (up to 240 MW) with the installation of tidal turbines anchored or fixed to the seabed at around 50 m depth. The first devices are due to be deployed during 2026, and a range of designs will be tested from different bidding companies. Another smaller development zone has been identified at Holyhead Deep, slightly further offshore, for initially another 10 MW using tidal kite technology (Minesto), possibly increasing to up to 80 MW.

A full analysis, once up and running, will indicate whether widespread expansion of this technology is feasible. The seawater current velocities (ideally at least 2 m/s) required for high efficiency are not available everywhere, so candidate locations would probably be limited to the 4 areas initially indicated by the Welsh Government (Welsh Government, 2021d) – these are off Ynys Môn, Llŷn, Pembrokeshire, and through the Severn Estuary.

Direct exploitation

Direct exploitation of natural resources associated with the energy sector drives direct pressures on ecosystems. In some circumstances, using ecosystems to supply fuels, such as biomass, may be unsustainable.

Bioenergy

The UK Government's Biomass Strategy (2023) highlights the key role of bioenergy for Net Zero, particularly bioenergy with carbon capture and storage (BECCS). The use of such bioenergy technologies requires land to grow feedstocks, which may conflict with other potential land uses and space for nature, and in some cases would be entirely unrealistic. For example, the Royal Society has published estimates of the amount of land and renewable energy that might be needed simply to replace the UK's current supply of aviation fuel (The Royal Society, 2023)

Anaerobic digestion for biomethane production

Waste streams in Wales are pulled into the energy production system largely through either incineration of non-recyclable wastes (Energy from Waste), or processing of wet wastes through anaerobic digestion (AD) plants. The main feedstocks for AD plants are:

- Sewage sludge
- Farm slurry and other agricultural waste
- Domestic food waste collected by local authorities.

Outputs from AD plants consist mainly of biogas, and digestate material which can be applied to land as a soil improver/fertiliser. The biogas can either be combusted on-site to provide electricity and heat generation or can be refined for injection into the gas grid infrastructure for onward use in gas plant as biomethane.

Future outlook for this technology is uncertain in government policy. Welsh Government takes the general view that with policies in place to reduce all waste streams, it would be contradictory to also support the development of infrastructure that would rely on these same wastes (for example, see the incinerator moratorium: Welsh Government, 2021d). The Heat Strategy for Wales is clear that heat pumps are the preferred technology, whilst recognising there may be a small role for biogas (Welsh Government, 2024). The Renewable Energy Deep Dive from 2021, and updated in 2023, did not mention biogas or biomethane. These technologies also play only a minor role in the Local Area Energy Planning currently taking place in local authorities in Wales.

Summary of progress with respect to energy and achieving a circular economy

Wales has immense resources and potential for production of clean, renewable energy over the years to come. Generation of electricity from renewable sources, mainly wind and solar, has been steadily increasing over the past 15 years (Welsh Government, 2023a) and currently stands at 27%. The Microgeneration Certification Scheme (MCS) database shows significant growth in registrations of new domestic and small-scale solar and heat pump capacity during 2023 (The MCS Foundation, 2024). The total number of MCS registrations in Wales by 2024 was around 114,000 installations (15,000 air-source heat pumps, 92,000 solar PV installations, 3000 solar thermal and 2000 biomass/micro-CHP).

The increase in renewable energy generation has helped contribute reducing GHG emissions from Wales' energy sector. SoNaRR (2020) reported estimated reduction in Welsh GHG emissions of 37% between the 1990 baseline (17.8 Mt CO_2e) and 2018 (10.9 Mt CO_2e). Further gains have been achieved since then, with annual emissions estimated at 10.3 Mt CO_2e in 2022.

Furthermore, the Welsh housing stock is relatively old, with approximately 33% of dwellings being pre-1930 in age, compared with an equivalent figure of 22% in England, for example (Office for National Statistics, 2023). Older properties are generally more expensive and difficult to insulate or modify to improve energy efficiency.

Consistent with the UK trend, total energy consumption in Wales reduced by 22% between 2005 and 2021, with most sectors showing a reduction in use (Regen, 2024, fig. 11). Production of renewable heat was approximately 2.5 TWh in 2022, which is equivalent to only about 11% of estimated Welsh domestic heat demand (a reduction from 13% in 2019: (Welsh Government, 2020). The bulk of heat demand in Wales is still met through fossil fuels, largely imported natural gas, and it seems that despite the uptick in domestic renewable heat installations, demand for heat is increasing more quickly than renewable heat capacity.

Experimental statistics indicate Wales' low carbon and renewable energy economy is becoming an important part of the overall economy, contributing £3.3 billion to GDP and supporting 15,600 full time jobs in Wales in 2023 (Office for National Statistics, 2025). It is hoped that many job losses in traditional industries could be mitigated through retraining and job creation at the Celtic Freeport, for example, and through the wider development of the low carbon energy sector in Wales.

Development of these energy resources, and the transportation of energy to markets throughout the UK and further afield, will require investment in infrastructure and transportation corridors, with resulting impacts on land use and other natural resources. It is vital that future energy developments avoid the mistakes of past Welsh energy industries, by planning for and protecting the health of our ecosystems. The proliferation of renewable energy infrastructure can address direct drivers of climate change and pollution pressures on natural resources; it will also directly drive land and sea use change and direct exploitation drivers of pressures natural resources. As such, it is imperative that renewable energy development happens in the right places.

Renewable energy is a prerequisite to achieving our net zero targets. However, Welsh electricity consumption is projected to at least double by 2050 as we transition away from fossil fuels (Welsh Government, 2023a). As such, the focus needs to be on the greenest energy being the energy we don't use.

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Annex 7: SoNaRR 2025 Ammonia Case Study

Author: Neil Davies

Introduction

The Environment (Wales) Act 2016 and the Well-being of Future Generations (Wales) Act 2015 are legislative frameworks aimed at promoting sustainability, environmental protection, and the well-being of both current and future generations in Wales. Both acts collectively contribute to safeguarding ecosystems and human health by promoting sustainable practices, conservation efforts, and a holistic approach to decision-making that considers the long-term well-being of the environment and future generations in Wales.

As required under the Environment (Wales) Act 2016, the State of Natural Resources Report (SoNaRR) assesses Wales's sustainable management of natural resources (SMNR) and identifies opportunities for action. NRW recognises that to fulfil the goals identified in the Environment (Wales) Act 2016 and the Well-being of Future Generations (Wales) Act 2015, we need to bridge the gap between where we are now and where we need to be to achieve a sustainable future. To help inform this, SoNaRR assesses SMNR against four long-term aims. These are: safeguarded and enhanced natural resources, resilient ecosystems, healthy places for people, and a regenerative economy.

One of the biggest challenges to Wales' SMNR aims for the protection of human health and ecosystems is the emission of pollutants to the atmosphere from anthropogenic sources. While often overlooked, the atmosphere and the earth's ecosystems are two parts of a coupled system and air pollution from anthropogenic sources can have a significant detrimental impact on both ecosystems and human health (as illustrated in Figure 31).

In this context, ammonia (NH_3) is a major atmospheric pollutant in Wales, both harmful to human health and the environment. When combined with other pollutants it forms particulate matter that can cause respiratory and cardiovascular disease. When deposited from the atmosphere, it causes acidification and eutrophication of soils, habitats and fresh waters. Agriculture currently contributes over 85% of the total ammonia emissions in Wales (Welsh Government, 2019) and The Clean Air Plan (Welsh Government, 2020) for Wales, which was passed into law via the Environment (Air Quality and Soundscapes) (Wales) Bill (2024) (Welsh Government, 2023) promotes multiple strategies for improving air quality in Wales and directly links to SMNR by actively working to reduce anthropogenic pollution. Strategies specifically targeted at reducing ammonia emissions from farming include supporting the delivery of the Sustainable Farming Scheme, promoting the uptake of best practice to reduce agricultural ammonia emissions and the development of future regulation "…to tackle agricultural pollution, which will contribute to achieving air quality targets including Wales' contribution to a 16% reduction of UK ammonia emissions by 2030." (Welsh Government, 2023).

This case study explores how we might better understand the relationships between the agricultural drivers of NH_3 emission pressures and their impacts in Wales using a Driver-Pressure-State-Impact-Response (DPSIR) model. It shows how this evidence can help better target responses to reduce NH3 emission from agriculture and highlights potential barriers to widespread adoption of these response measures.

Driver-Pressure-State-Impact-Response (DPSIR) model

The Driver-Pressure-State-Impact-Response (DPSIR) model is a causal framework adopted by SoNaRR to support the analysis of SMNR for different ecosystem and natural resource types. The DPSIR model is a conceptual framework commonly used in environmental management and sustainability studies, which facilitates the organisation and analysis of complex environmental issues by breaking them down into the following key components:

1. **Driver**

   This represents the underlying human activities or processes that lead to environmental changes. Drivers can be social, economic, technological, or political factors influencing the environment.

2. **Pressure**

   The pressures are the specific stressors or forces resulting from human activities that directly affect the state of environment. These could include air pollution emissions, agricultural intensification, or overuse of renewable natural resources.

3. **State**

   This refers to the current condition of the environment, including its physical, chemical, and biological characteristics. It reflects the effect a pressure has on the environment.

4. **Impact**

   Impacts are the changes to human health, ecosystem resilience, or other elements of well-being caused by changes in the state of the environment. These changes can be positive or negative and may have direct or indirect effects.

5. **Response**

   Responses are the measures or actions taken to address or mitigate the impacts on the environment and human-well-being associated with the above drivers, pressures and states. This involves policy decisions, regulations, conservation efforts, or any other interventions aimed at managing environmental and associated impacts on well-being.

The DPSIR framework provides a systematic way to understand and address environmental problems and their impacts on people, facilitating the development of effective strategies for sustainable resource management and environmental protection. It is therefore an appropriate tool to better understand factors currently influencing the rise of NH_3 emissions from agriculture in Wales. Using this framework, we can identify methods or strategies to reduce impacts of agricultural NH_3 emissions in Wales on human well-being and ecosystem resilience.

DPSIR Case Study: Atmospheric ammonia deep dive

Case studies are a useful way in which to explore subjects and concepts that relate to SoNaRR's assessment of natural resources, ecosystems and SMNR. Reflecting that the atmosphere and ecosystems exist as coupled systems, this case study demonstrates the relationship between the DPSIR assessments for air (as a natural resource) and the ecosystems where atmospheric NH_3 deposition is a concern (or pressure). This relationship is shown in Figure 1, which illustrates how changes in atmospheric NH_3 concentrations impact on both human health (Arrow A) and ecosystem resilience (Arrow B). It shows how responses to manage ammonia emissions from agriculture can simultaneously deliver better outcomes for both people (Arrow C) and nature (Arrow D).

Evidence: Drivers and Pressures

The National Atmospheric Emissions Inventory(NAEI) compiles and estimates emissions from sources and activities across the whole of the UK, including agriculture (The UK National Atmospheric Emissions Inventory, 2023). Despite an encouraging downward trend in atmospheric pollutants from anthropogenic sources over the last twenty years, the NAEI reveals atmospheric emissions of ammonia (NH_3) from agricultural sources remain stubbornly high in Wales.

The NAEI estimates emissions of ammonia from the agricultural sector in Wales using data collected by Emissions Inventory Reporting from Intensive Farming Installations (NRW, 2023) along with the annual Survey of Agriculture and Horticulture in Wales which provides data on agricultural activity such as livestock numbers, fertiliser use and crop areas etc.

Detailed national data and tailored methodologies show that key sources of NH_3 include livestock manure, particularly from cattle and pigs, and nitrogen-based fertilizer application. Emissions are then estimated using a methodology which incorporates animal populations, manure management, fertilizer usage, and crop production methods.

Since 2005, several updates have been made to emission factors, reflecting changes in scientific understanding and agricultural practices. These include revisions to nitrogen excretion rates, poultry management practices, manure handling, fertilizer use, and the inclusion of new sources such as foliar urea, directly to a plant's leaves rather than application to the soil, and anaerobic digestion. Despite using this detailed approach, uncertainties remain due to a variety of factors which influence emissions from diffuse sources. Nevertheless, the combined uncertainty for agricultural NH_3 emissions has decreased since 2005, indicating improved accuracy in estimation methods (See Annex I).

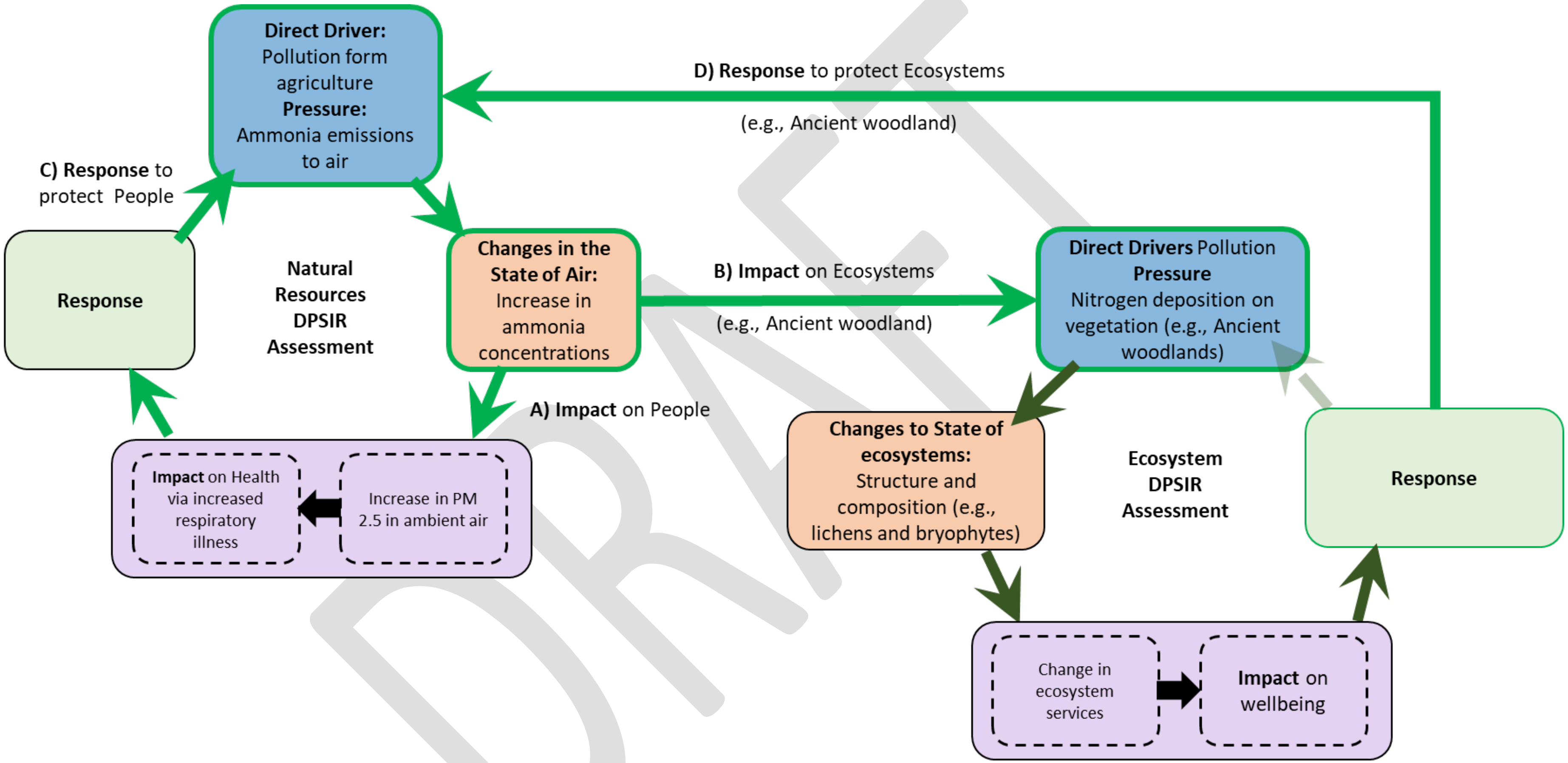


Figure 31: Relationship between DPSIR Assessment for Air and DPSIR Assessments for Ecosystems

According to the NAEI report (Mitchell *et al.*, 2024), emissions of NH_3 in Wales were estimated to be 23 Kilotonnes (kt) in 2022, with more than 92% of NH_3 emissions originating from agriculture (see Figure 32 and Figure 33:). It should be noted that drivers of recent increases in NH_3 emissions from agricultural practices are primarily driven by increases of livestock numbers (Welsh Government, 2024) and a move towards more intensive farming practices (particularly poultry), both of which result in increased manure production and application of fertilizers to soil which include the application of fertilizers in the form of digestate from waste-fed anaerobic digesters. While the digestate provides a fertilizer with high nutrient content, both its production and use can result in additional NH_3 emissions which incorporate non-agricultural sources of NH_3 from the digester feedstock which often includes domestic household food and drink waste, and sewage sludge.

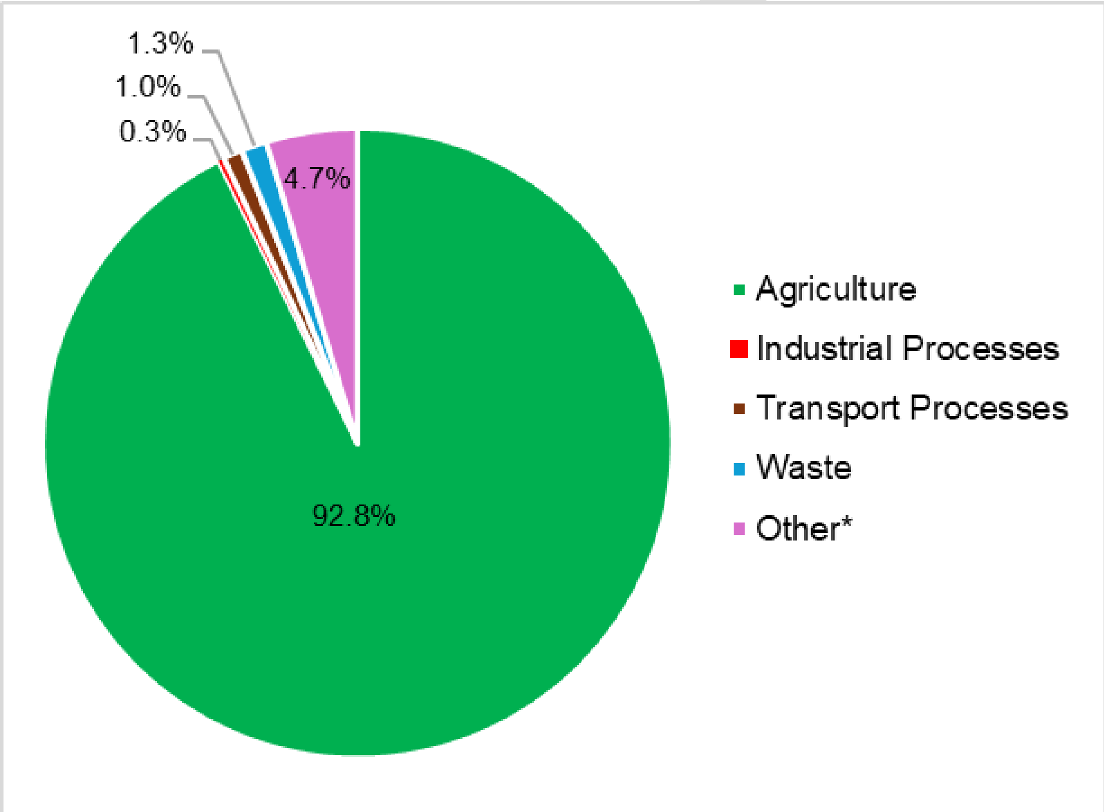


Figure 32: NH3 Emission Contributions in Wales Ranked by Sector, 2022

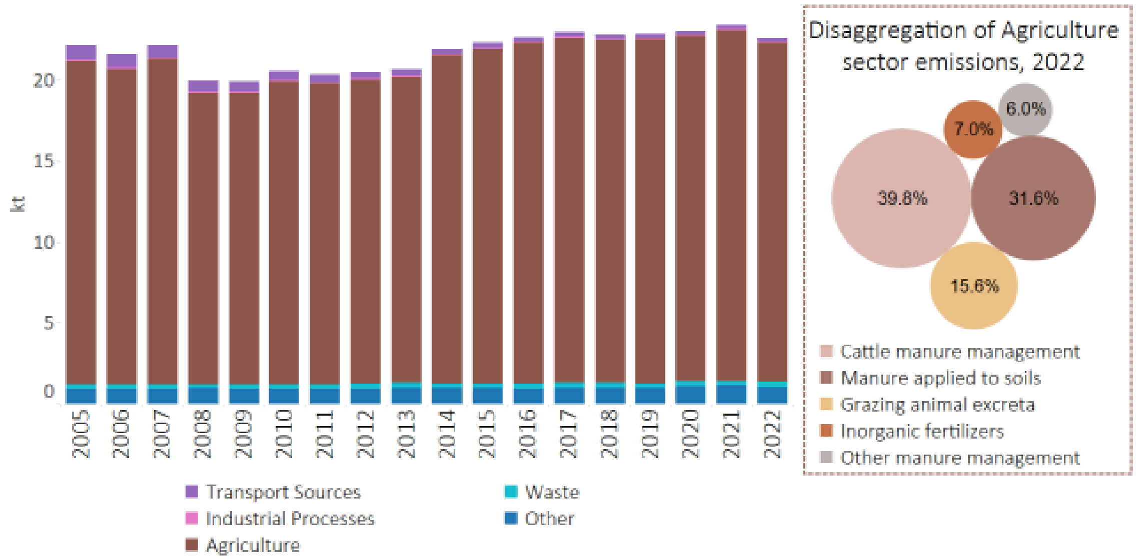


Figure 33: Agricultural NH3 Emission Sources in Wales NAEI ((Mitchell et al., 2024)

Analysis of emissions of NH_3 from agricultural sources clearly shows a significant proportion of land area in Wales where the long term trend is one of increasing NH_3 emissions (see Figure 34a). As Figure 34 shows, approximately 35.4% of land area in Wales was subject to a persistent increasing trend in local agricultural NH_3 emissions between 2005 and 2021, whilst only 17.8% of the land area was subject to reductions in local NH_3 emissions. Of the terrestrial Sites of Special Scientific Interest (SSSIs) whose designation includes biological features, 33% intersect with areas showing an increasing trend in agricultural NH_3 emissions (see :Figure 35).

In fact, the proportion of areas where trends show decreasing NH_3 emissions is significantly lower in the decade leading up to the most recent data year available (2013 to 2022) relative to the ten-year period spanning 2005 to 2014 (see Figure 36). In short, NH_3 emission pressures from agriculture have generally increased across much of Wales in recent years. This is particularly noticeable across larger contiguous areas in the southwest and north east of Wales, with patches also observed in the south, east and north west (see Figure 36).

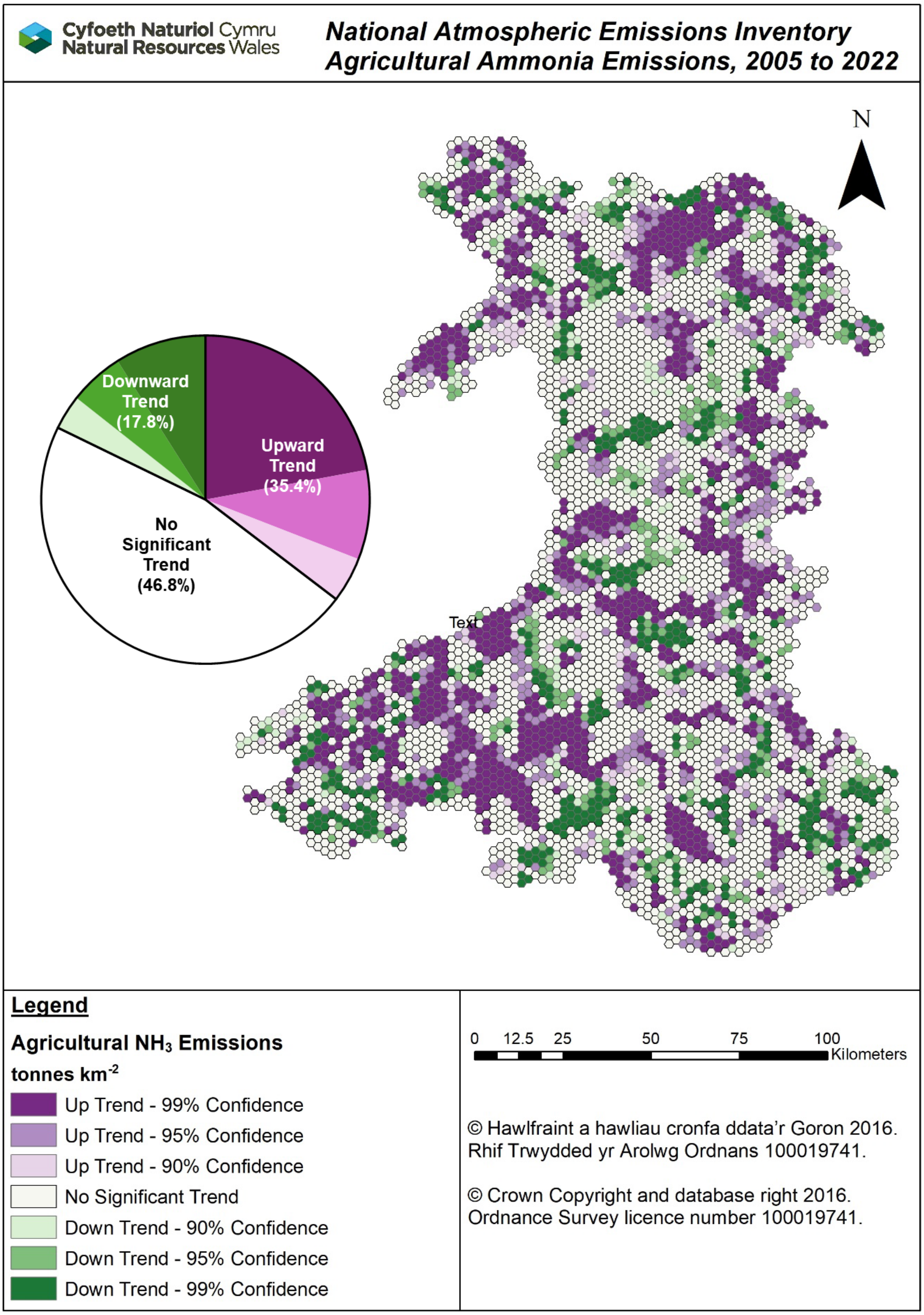
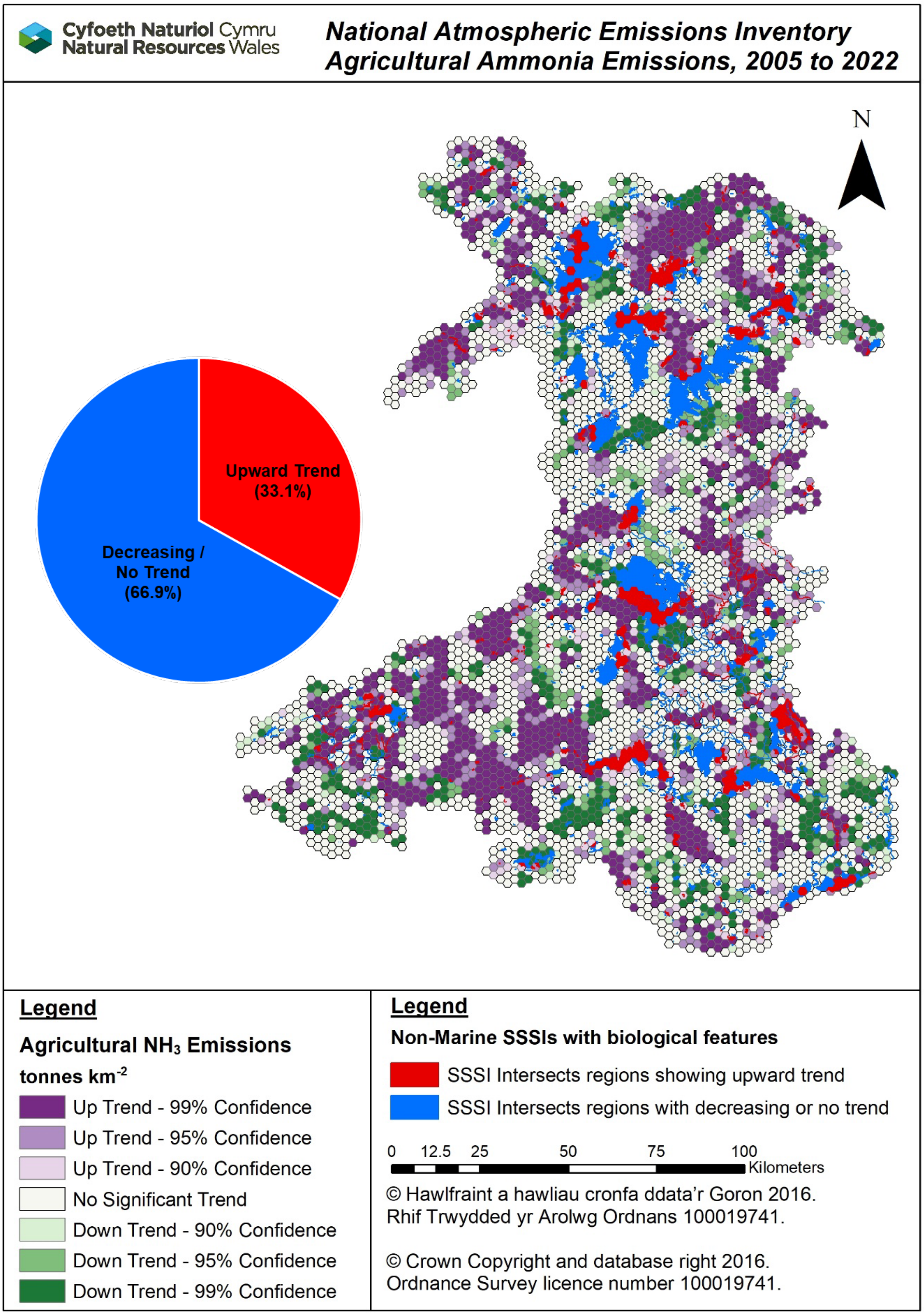


Figure 34: Agricultural NH_3 Emissions Trends in Wales between 2005 and 2022



:Figure 35 *SSSIs intersecting areas showing upward trends of NH_3 emissions*

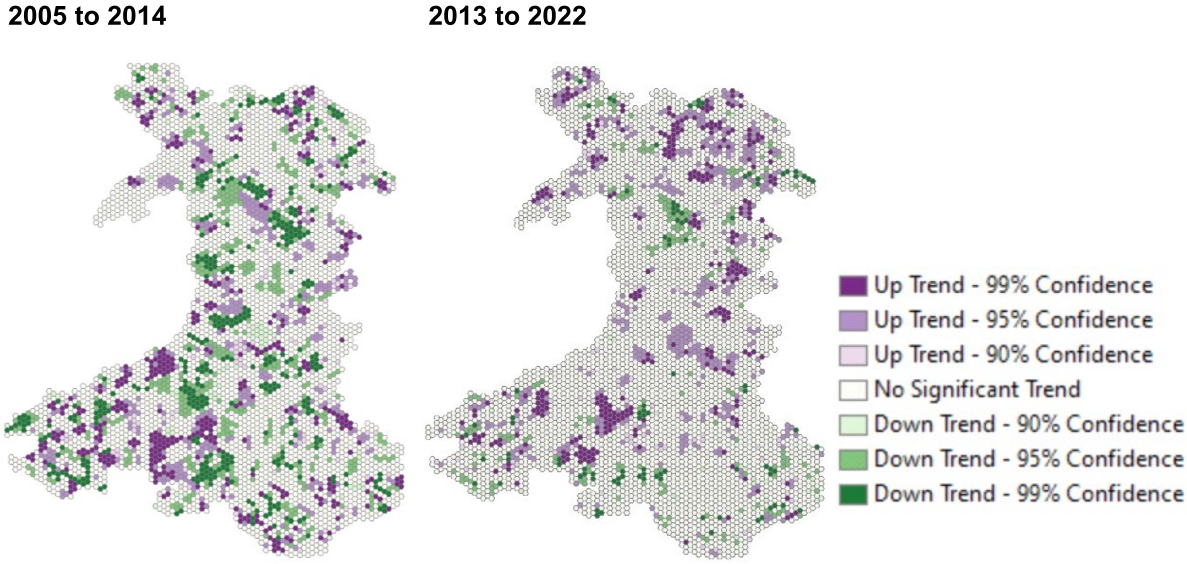


Figure 36: Reduction in areas showing downward trends of NH3 emissions in Wales

Evidence: State

Whilst there are several sites for monitoring local ambient ammonia concentrations in Wales, there are no overall national monitoring programmes for ammonia concentrations at the national scales. In order to understand where ambient ammonia concentrations may be a potential concern, modelling approaches are employed based on the atmospheric emissions described in the Drivers and Pressures section above. Figure 38 provides an example with respect to potential impacts on ecosystem health associated with exceedance of critical thresholds for ammonia deposition.

Evidence: Impacts on Human Health

NH_3 released from agricultural sources also contributes significantly to the generation of fine particulate matter ($PM_{2.5}$) (Wyer *et al.*, 2022). As Figure 37 shows, the formation of $PM_{2.5}$ from NH_3 is influenced by the availability of other gases like NOx and SO_2. Meteorological conditions, particularly temperature and relative humidity, also affect rates of formation.

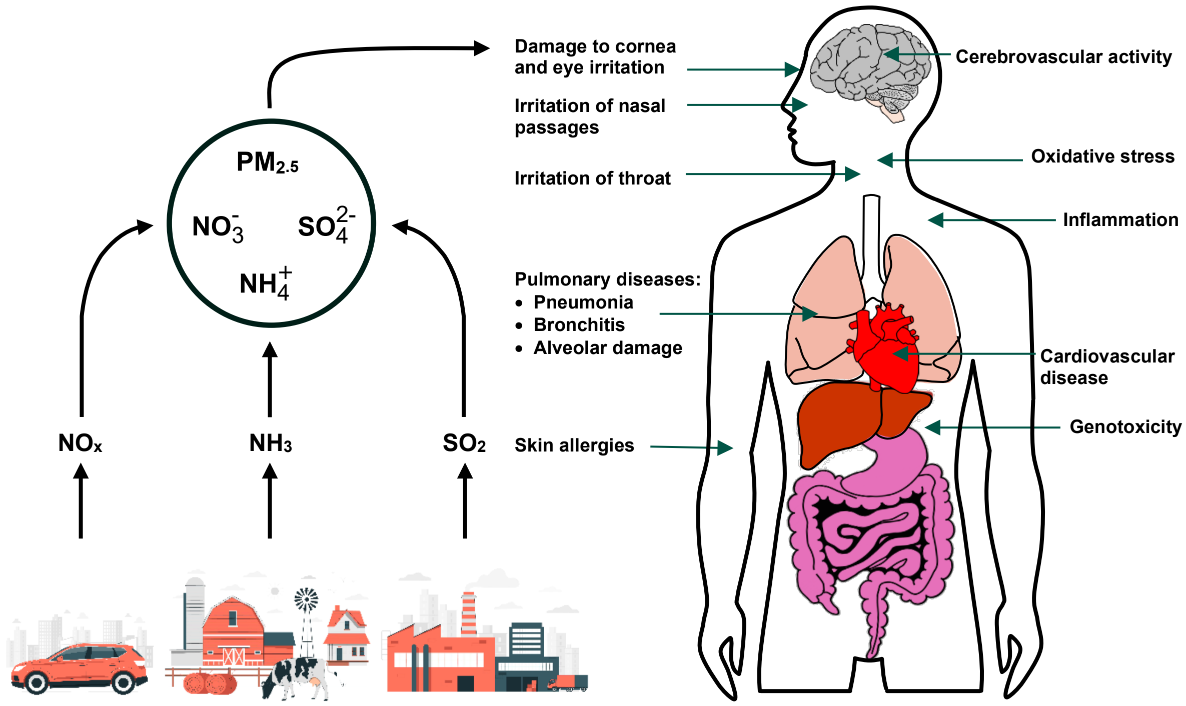


Figure 37: NH_3 reacts with other gases in the atmosphere, primarily nitrogen oxides (NOx) and sulphur dioxide (SO_2), to form secondary particulate matter ($PM_{2.5}$).

It's important to note that while NH_3 itself has a short atmospheric lifetime, the particulate matter formed through these reactions can persist for several days and be transported over long distances. This makes NH_3 emissions a significant contributor to $PM_{2.5}$ pollution. As Figure 6 shows, exposure to $PM_{2.5}$ pollution has significant implications for human health, including aggravating asthma symptoms and increased risk of death due to cardiopulmonary disease. While it is not possible to separate out effects of multiple air pollutants, based on analysis by the UK expert Committee on the Medical Effects of Air Pollution (COMEAP), Public Health Wales estimated the burden of long-term air pollution exposure (including $PM_{2.5}$) in 2017 to be the equivalent of 1,000 to 1,400 deaths each year (Public Health Wales, 2020). Data[6] available from the Stats Wales website indicates that air quality indicators for $PM_{2.5}$ in 2022 remain at the same levels identified for 2017 (Welsh Government, no date).

The Clean Air Plan for Wales (Welsh Government, 2023) outlines several strategies to mitigate the health impacts of PM2.5 with the Key measures identified as

- **Enhancing Air Quality Monitoring**: Developing a new Air Pollution Monitoring Network to better assess and manage PM2.5 levels, particularly in areas with vulnerable populations.
- **Develop Evidence Based Targets**: Welsh Government is working closely with the Clean Air Advisory Panel to receive independent and expert advice on the

development of evidence-based and effective air quality targets to reduce impacts on both current and future generations in Wales.

- **Promoting Active Travel and Public Transport**: Investing in infrastructure to encourage walking, cycling, and the use of public transport, thereby reducing emissions from private vehicles.
- **Regulating Domestic Combustion**: Reviewing local authority powers to address emissions from domestic burning of solid fuels, such as wood and coal, which are significant sources of PM2.5.
- **Implementing Clean Air Zones**: Investigating measures like Clean Air Zones or Low Emission Zones to reduce personal vehicle use and lower PM2.5 emissions in urban areas

Evidence: Impacts on Ecosystems

In terrestrial habitats, NH3 deposition from the atmosphere is a significant pressure on ecosystems. It can alter soil nutrient levels, with the increased availability of nitrogen favouring certain plant species that are adapted to high-nitrogen conditions. This can lead to a shift in plant communities, with nitrogen-loving species outcompeting those adapted to lower-nitrogen environments. As a result, sensitive habitats, including those hosting protected species, may experience a decline in biodiversity due to this species succession. Most Welsh habitats have evolved in naturally low-nitrogen environments, so NH3 enrichment causes widespread deterioration of semi-natural habitats. In addition, NH3 has direct toxic effects on many mosses, liverworts, lichens and fungi, causing species death and significant loss of biomass in bryophyte- and lichen-rich ecosystems including woodland, bog and heathland. A Critical Level of 1µg/m3 NH3 has been set to protect these lichen- and bryophyte-rich ecosystems from direct damage. NH3 has also been shown to reduce the survival of common grassland lepidoptera* (* Kurze, S, T Heinken, T Fartmann. 2018. Nitrogen enrichment in host plants increases the mortality of common Lepidoptera species. *Oecologia* 188: 1227–1237), providing direct impacts on animal species as well as indirect impacts through habitat change.

As Figure 4 shows, approximately 35.6% of land area in Wales was subject to a persistent increasing trend in agricultural NH_3 emissions between 2005 and 2021, with 25.5% of Sites of Special Scientific Interest (SSSI) and 20.3% of Special Areas of Conservation (SAC) land area exposed to increasing trends in NH_3 emissions from agricultural sources. In 2021, 45.2% of land area in Wales exceeded the 1mug/m^3 critical level of NH3 concentration which has been set to protect bryophytes and lichens (see Figure 7) (Rowe *et al.*, 2024).. This also applied for the area of SSSIs designated for biological features (Excluding offshore areas), with 45% of SSSI land area exposed to NH_3 concentrations greater than 1 mg/m^3. The geographical areas of impact concern mainly in the southwest and the east of Wales, plus Anglesey.

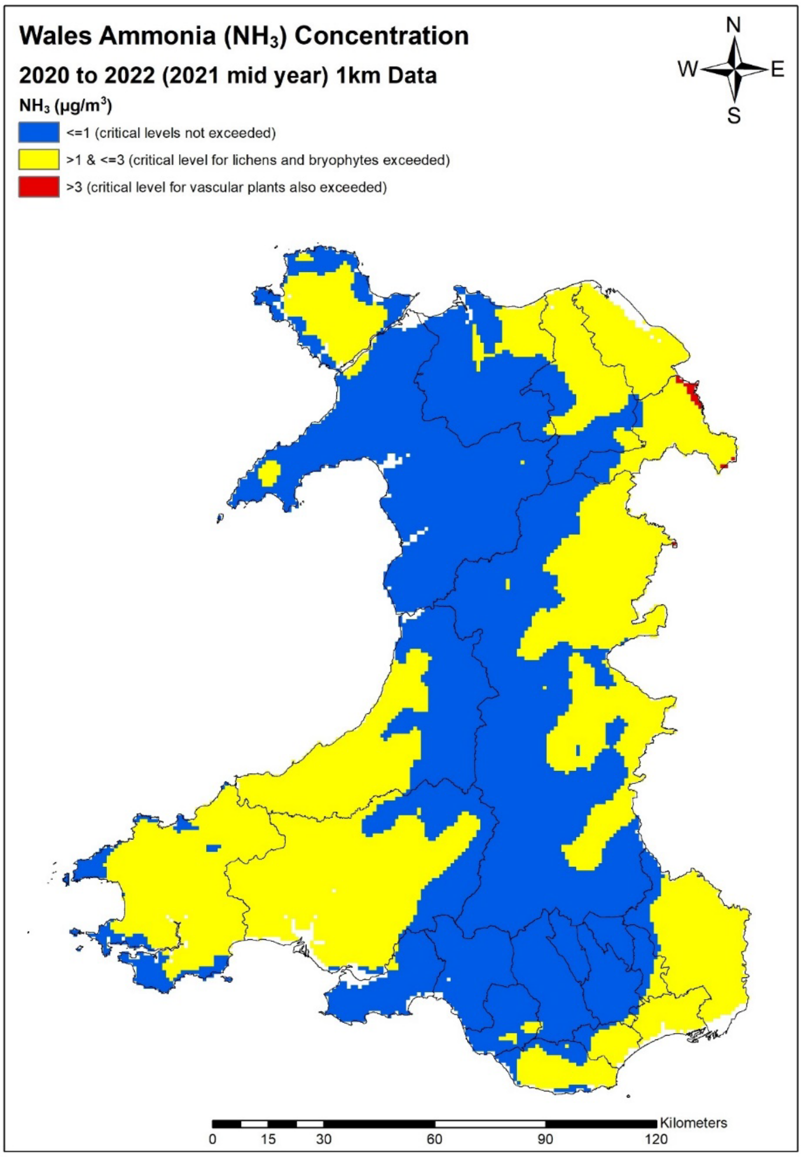


Figure 38: Distribution of areas exceeding critical levels of NH_3 concentration for the protection of lichens/bryophytes (1 mg/m^3) and higher plants (3 mg/m^3).

Comparison between Figure 34 and Figure 38 reveals that the areas of concern for increasing emissions between 2013 and 2022 are largely coincidental with areas of concern for exceedance of critical levels in Wales. This confirms local NH_3 emissions from agriculture as an increasing pressure on ecosystem resilience over the last decade. Indeed, The Clean Air Plan for Wales identifies a number of actions (Welsh Government, 2020, ch. Agriculture and Land Use) to specifically tackle pollution from agriculture and land use, specifically aimed at reducing NH_3 emissions.

The changes in species composition that result from NH_3 deposition can have a cascade effect on entire ecosystems, affecting food webs, nutrient cycling, ecosystem functioning and the delivery of ecosystem services (Guthrie *et al.*, 2018). Protected species that rely on specific plant communities or environmental conditions will also face increasingly challenging conditions as their suitable habitat declines, driving species change (Sheppard *et al.*, 2011). Consequently, any exceedance of critical levels is an indication that the ecosystem or habitat is at risk from potentially harmful effects, with knock on impacts for biodiversity and people (via reductions in ecosystem services supply). This effect of ammonia deposition on ancient woodland ecosystems is a particular concern. Table 77 presents the percentage of each woodland type in Wales that experiences ammonia concentrations above the critical levels for bryophyte- and lichen-rich woodlands. As reveals, approximately the extent of ancient woodland exposed to levels of ammonia above the critical threshold of 1 to 3 µg/m3 NH3 has increased by over 10,000ha between 2015/17 and 2020/2022.

Table 77: Area (hectares, ha) of each category of Ancient Woodland (from Ancient Woodland Inventory (NRW, 2011)) in Wales exposed to three bands of ammonia concentrations (the proportion, %, within each band across each category is shown in brackets) within the time periods 2015-2017 and 2020-2022

Category of Ancient Woodland	**Period**	**Below Critical Level for Lichens and Bryophytes (<1 µg/m^3 NH$_3$)**	**Above Critical Level for Lichens and Bryophytes and Below Critical level for Vascular Plants (1 to 3 µg/m^3 NH$_3$)**	**Above Critical Level for Vascular Plants (>3 µg/m^3 NH$_3$)**	**Total (hectares)**
Ancient Semi Natural Woodland (hectares)	2015-2017	19451.07 (46.80%)	22103.42 (53.18%)	7.48 (0.02%)	41561.97 (100%)
Ancient Woodland Site of Unknown Category (hectares)	2015-2017	1236.87 (44.51%)	1541.86 (55.49%)	0.00 (0.00%)	2778.73 (100%)
Plantation on Ancient Woodland Site (hectares)	2015-2017	12747.73 (47.54%)	14060.95 (52.44%)	3.36 (0.01%)	26812.04 (100%)
Restored Ancient Woodland Site (hectares)	2015-2017	8873.65 (38.30%)	14295.39 (61.70%)	0.00 (0.00%)	23169.03 (100%)

Category of Ancient Woodland	Period	Below Critical Level for Lichens and Bryophytes (<1 µg/m^3 NH_3)	Above Critical Level for Lichens and Bryophytes and Below Critical level for Vascular Plants (1 to 3 µg/m^3 NH_3)	Above Critical Level for Vascular Plants (>3 µg/m^3 NH_3)	Total (hectares)
Grand Total (hectares)	**2015 - 2017**	**42309.31 (44.86%)**	**52001.62 (55.13%)**	**10.84 (0.01%)**	**94321.77 (100%)**
Ancient Semi Natural Woodland (hectares)	2020-2022	14282.19 (34.36%)	27199.21 (65.44%)	80.57 (0.19%)	41561.97 (100%)
Ancient Woodland Site of Unknown Category (hectares)	2020-2022	831.34 (29.92%)	1946.06 (70.03%)	1.33 (0.05%)	2778.73 (100%)
Plantation on Ancient Woodland Site (hectares)	2020-2022	10239.32 (38.19%)	16555.52 (61.75%)	17.19 (0.06%)	26812.04 (100%)
Restored Ancient Woodland Site (hectares)	2020-2022	6369.00 (27.49%)	16742.88 (72.26%)	57.16 (0.25%)	23169.03 (100%)
Grand Total (hectares)	**2020 – 2-22**	**31721.85 (33.63%)**	**62443.67 (66.20%)**	**156.25 (0.17%)**	**94321.77 (100%)**

Note: SoNaRR (2020) included a table of the percentage of each woodland type in Wales that experiences ammonia concentrations above the critical levels for bryophyte- and lichen-rich woodlands. Those data were based on modelling using the FRAME model (Dore *et al.*, 2007), but since then this model has been replaced by the EMEP4UK model (Rowe *et al.*, 2023). To allow comparison between reports, 2020 data were recalculated using EMEP4UK (UKCEH, 2024), and the changes apparent in Table 77 are therefore the result of genuine changes in ammonia concentrations rather than a change of approach.

This means that the data presented in SoNaRR (2020) should no longer be referred to or compared with Table 77.

Exploring Responses

Increasing trends in agricultural NH_3 emissions are a clear indication that significant challenges remain to meet our obligations under the Environment (Air Quality and Soundscapes) (Wales) Bill (2024) and the Well-being of Future Generations (Wales) Act 2015. This increase in NH_3 emissions is impacting on human health via its contribution towards secondary $PM_{2.5}$ production and impacting on ecosystem resilience via deposition. This highlights the ongoing need to carefully manage the conflicting pressures between agricultural production and protecting human health and ecosystems.

Using the DPSIR framework, we can systematically analyse the issues associated with NH_3 emissions from agriculture, understand the various components, and design targeted responses to mitigate impacts on human health and ecosystem resilience in Wales. The most tractable way of limiting the impact of atmospheric NH_3 on people and ecosystems is by reducing emissions at source. Possible responses to achieve a reduction in NH_3 emissions from the agricultural sector include:

- Sustainable agriculture responses to reduce the NH_3 emissions pressures from agriculture
    1. Promote best practices such as soil testing, slurry management improvements, and collaborative farming approaches to reduce high emissions associated with manure management and grazing animals from by the sector.
    2. Align reducing agricultural NH_3 emissions with broader goals linked to climate change mitigation and biodiversity objectives, securing co-benefits via improved air and soil quality.
- Pollution management responses
    1. Promote adoption of technologies like covered slurry storage, anaerobic digestion, and precision fertilizer application equipment to reduce NH_3 volatilization associated with manure storage, the main source of NH_3 emissions from the sector.
    2. Implement innovative housing designs that enhance air circulation and reduce NH_3 build-up in conjunction with the use of scrubbers to reduce NH_3 emissions from intensive agricultural production facilities.
    3. Targeted crude protein diets for livestock to reduce nitrogen intake by livestock and associated concentrations in manure and excreta, the main sources of NH_3 emissions from the agricultural sector in Wales.
    4. Enable shared investments in technologies or infrastructure, like anaerobic digestion systems, that can lower emissions efficiently.

- Nature based Solution responses
    1. Introducing buffer zones or green infrastructure to absorb and mitigate NH_3 emissions. This would also have the co-benefit of reducing agricultural runoff associated with washout.
- Education and awareness responses
    1. Educating farmers through advisory programs can fill knowledge gaps and improve uptake of mitigation strategies.
    2. Co-design and collaborative approaches enable farmer-driven solutions.
    3. Targeted soil testing to support improved nutrient management and better use of fertilizers. This could reduce excess nitrogen application, decrease NH_3 volatilization and optimize costs.

Case Study Summary

The DPSIR Assessment deep dive for ammonia presents the evidence that the agricultural sector is the main source of NH3 emissions in Wales by a substantial margin. The NAEI identifies agricultural emissions of ammonia comprise 92% of all ammonia emissions in Wales, mainly associated manure management and grazing livestock excreta. Increasing trends in emissions between 2012 and 2021 are particularly notable across larger areas in the southwest and north east of Wales, with patches also observed in the south, east and north west. Overall,

The evidence is clear that, as a precursor to PM 2.5, ammonia has documented ill health effects. It also has established effects on ecosystem resilience, with approximately 45% of the land area Wales exposed to concentrations above critical thresholds for sensitive species. These ecosystem impacts are mainly anticipated in the southwest and eastern areas of the country, as well as Anglesey.

Implementing a combination of the identified responses to manage agricultural NH_3 emission pressures based on where they are of particular concern, local conditions and farming systems is needed to achieve more sustainable and environmentally friendly agriculture. Regular assessments can help refine the responses over time, based on the effectiveness of implemented responses and changes in environmental conditions. This would support a comprehensive and structured approach to mitigating the impacts from NH_3 emissions, protecting the resilience of ecosystems and the well-being of current and future generations by reducing health impacts from $PM_{2.5}$ inhalation. This is one of the ambitions of the Welsh Sustainable Farming Scheme (SFS), proposed to launch in 2025, which integrates measures aimed at reducing NH_3 emissions as part of a broader set of environmental and agricultural sustainability goals.

There remain several barriers to successfully implementing responses to reduce NH3 emissions from the agricultural sector. These include high initial costs associated with NH_3-reducing measures; Knowledge gaps; and tenancy-related constraints. For instance, smaller farms and tenants may find it harder to participate in NH_3 reducing measures due to restrictive tenancy agreements that impede changes, as well their relatively limited resources. Clearly, some of the responses suggested also come with trade-offs that need to be considered. For example, limiting fertilizer application could reduce crop yields, creating economic risks for farmers.

Case study Annex

National Atmospheric Emissions Inventory

The National Atmospheric Emissions Inventory (NAEI) compiles and estimates ammonia (NH_3) emissions from agriculture in the UK using a mix of detailed national data and methodologies tailored for specific emission sources. Key sources of agricultural NH_3 emissions include livestock manure, particularly from cattle and pigs, as well as the application of nitrogen-based fertilizers to soils.

Wales livestock numbers at agricultural holding level are obtained from the annual returns to the June Agricultural and Horticultural Survey (Welsh Government, 2024), for the years from 2005 onwards, additional details on all types of cattle is provided by data from the Cattle Tracing Service database (BCMS, no date). Each agricultural holding is categorised according to Robust Farm Type (RFT), and is spatially located within a 10 x 10 km grid square for association with soil type and climate allowing for differences in management practices and/or environmental factors to be reflected in the emission estimates. RFT is a classification used across different UK surveys (e.g. Farm Business Survey), enabling linking of input or output datasets where appropriate

These surveys are considered the most complete and robust data sources for UK livestock numbers and have remained relatively consistent over a long timescale. They are structured to be representative of the UK agricultural sectors and are associated with low uncertainties (actual values depending on year and livestock category).

The emissions are categorized and estimated using a Tier 3 methodology[7], which incorporates farm animal population data, manure management practices, fertilizer usage, and crop production specifics (National Atmospheric Emissions Inventory, 2023; Elliott *et al.*, 2024). . Tier 3 methods typically apply more complex modelling approaches that are developed to generate more accurate estimates than Tier 1 and 2, often through research to better understand high-emitting emission sources (see also Section 1.4.2. of UK Informative Inventory Report (1990 to 2022)

Since 2005, the estimation of NH_3 emissions from agricultural sources in the UK has undergone several updates, with changes to emission factors (EFs) reflecting revised scientific understanding and agricultural practices:

1. **Revisions to Nitrogen Excretion Rates**: Updates have been made for various livestock categories, including cattle, pigs, and poultry. These revisions account for changes in milk yield, slaughter weight, and feed composition. For example, nitrogen excretion rates for cattle were adjusted in response to changing milk production levels and updated manure management practices (Misselbrook *et al.*, 2023; Carswell *et al.*, 2024).

2. **Poultry Management**: Recent changes include a revision of the time outdoor poultry spends outside, reducing the outdoor ratio from 20% to 10%. This reflects updated activity data based on studies commissioned by environmental agencies (Carswell *et al.*, 2024)
3. **Manure Management**: Changes include increased adoption of Low Emission Slurry Spreading Equipment (LESSE) and revisions to the proportions of manure managed in slurry versus solid forms. These adjustments affect NH_3 emissions from storage, land spreading, and housing systems (Misselbrook *et al.*, 2023; Carswell *et al.*, 2024)
4. **Fertiliser Use**: The proportion of urea-based fertilisers, which have a high NH_3 EF, has increased. However, the introduction of urease inhibitors with these fertilisers has been shown to reduce emissions significantly. Updates to fertiliser practices also include improved data on application rates and timings (Misselbrook and Gilhespy, 2022; Carswell *et al.*, 2024).
5. **Inclusion of New Sources**: Foliar urea and manure diverted to anaerobic digestion have been incorporated into the inventory, reflecting new practices and technologies in agricultural management (Carswell *et al.*, 2024).
6. **Regional Adjustments**: Changes were also made for specific devolved administrations, such as adjustments to manure storage systems and slurry applications in Northern Ireland, reflecting local practices (Misselbrook *et al.*, 2023; Carswell *et al.*, 2024)

These methodological refinements, often informed by new surveys and research, aim to provide more accurate emissions estimates and support mitigation strategies.

NH_3 emission estimates are dominated by uncertainties in the estimates of emissions from agricultural sources, which represent the majority of the national total NH_3 emissions. Although the UK uses a detailed (largely Tier 3) approach to estimating emissions from agriculture, which accounts for different animal sub-categories and management systems, it is not possible to fully represent the many factors influencing emissions from what are often diffuse emission sources including, for example, animal stocking densities, daily weather, soil type and conditions, etc. These are therefore reflected in the uncertainties associated with individual emission factors, the parameters of which are continually updated to reflect the latest understanding for the latest submissions.

Combined uncertainty as % of total national emissions has dropped from 24.6% in 2005 to 13.1% in 2022 for NH_3 emissions associated with agriculture (manure management and application of fertilisers to soil, see also Table 1-8 in “Assessment of NH_3 uncertainty, UK Informative Inventory Report” (1990 to 2022)(Elliott *et al.*, 2024)).

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Annex 8: List of Tables

Annex 9: List of figures