

The Second State of Natural Resources Report (SoNaRR2020)

Assessment of the achievement of sustainable management of natural resources: Invasive Non-native Species

Natural Resources Wales

Final Report

About Natural Resources Wales

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

Evidence at Natural Resources Wales

Natural Resources Wales is an evidence-informed organisation. We seek to ensure that our strategy, decisions, operations, and advice to Welsh Government and others, are underpinned by sound and quality-assured evidence. We recognise that it is critically important to have a good understanding of our changing environment.

We will realise this vision by:

- Maintaining and developing the technical specialist skills of our staff;
- Securing our data and information;
- Having a well resourced proactive programme of evidence work;
- Continuing to review and add to our evidence to ensure it is fit for the challenges facing us; and
- Communicating our evidence in an open and transparent way.

Title: **SoNaRR2020** Assessment of the achievement of Sustainable Management of Natural Resources: Invasive Non-native Species

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Restrictions: None

The Second State of Natural Resources Report (SoNaRR2020) contents

This document is one of a group of products that make up the second State of Natural Resources Report (SoNaRR2020). The full suite of products are:

Executive Summary. Foreword, Introduction, Summary and Conclusions. Published as a series of webpages and a PDF document in December 2020

The Natural Resource Registers. Drivers, Pressures, Impacts and Opportunities for Action for eight Broad Ecosystems. Published as a series of PDF documents and as an interactive infographic in December 2020

Assessments against the four Aims of SMNR. Published as a series of PDF documents in December 2020:

SoNaRR2020 Aim 1. Stocks of Natural Resources are Safeguarded and Enhanced

SoNaRR2020 Aim 2. Ecosystems are Resilient to Expected and Unforeseen Change

SoNaRR2020 Aim 3. Wales has Healthy Places for People, Protected from Environmental Risks

SoNaRR2020 Aim 4. Contributing to a Regenerative Economy, Achieving Sustainable Levels of Production and Consumption

The SoNaRR2020 Assessment of Biodiversity. Published in March 2021

Assessments by Broad Ecosystem. Published as a series of PDF documents in March 2021:

Assessment of the Achievement of SMNR: Coastal Margins

Assessment of the Achievement of SMNR: Enclosed Farmland

Assessment of the Achievement of SMNR: Freshwater

Assessment of the Achievement of SMNR: Marine

Assessment of the Achievement of SMNR: Mountains, Moorlands and Heaths

Assessment of the Achievement of SMNR: Woodlands

Assessment of the Achievement of SMNR: Urban

Assessment of the Achievement of SMNR: Semi-Natural Grassland

Assessments by Cross-cutting theme. Published as a series of PDF documents in March 2021:

Assessment of the Achievement of SMNR: Air Quality

Assessment of the Achievement of SMNR: Climate Change

Assessment of the Achievement of SMNR: Energy Efficiency

Assessment of the Achievement of SMNR: Invasive Non-native Species

Assessment of the Achievement of SMNR: Land use and Soils

Assessment of the Achievement of SMNR: Waste

Assessment of the Achievement of SMNR: Water Efficiency

Updated SoNaRR evidence needs. Published as a data table on web in March 2021

Acronyms and Glossary of terms. Published as a PDF in December 2020 and updated in 2021 as a data table on the web

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1. Headline Messages

Invasive non-native species (INNS) affect the environment, economy, and well-being of the people of Wales; they are identified as one of the top 5 drivers affecting biodiversity worldwide in the IPBES Global Assessment Report on Biodiversity and Ecosystem Services (2019) and have been estimated to cost the economy of Wales £125 million annually, in 2010.

The rate at which new INNS are establishing in Great Britain (GB) has increased exponentially in the last 50 years. This trend is set to continue with the main long-term global drivers being the movement of goods and people as well as climate change.

350 different species of INNS have been identified as priority species in Wales. Analysis of occurrence records of these species in Wales found 100% of the INNS recorded could affect the environment, 80% could affect the economy and 62% could affect well-being.

INNS affect all the SoNaRR ecosystem types in Wales. Freshwater and marine ecosystems in Wales are impacted by the widest variety of priority INNS, followed by woodlands and semi-natural grasslands. Whilst semi-natural grasslands, woodlands, freshwater, and urban ecosystems in Wales are impacted by the highest number of priority INNS.

The INNS of priority to Wales were found to have a higher impact on supporting and provisioning ecosystem services in Wales, and a lower impact on cultural and regulating ecosystem services.

A considerable amount of work is being undertaken on the ground to tackle INNS in Wales, but the differing drivers, organisations, and spatial scales involved demonstrate that there is capacity to improve the coordination of these activities. This could be addressed by developing a strategic, coordinated, evidence-based steer for action to inform decision makers and funders to enable INNS issues in Wales to be addressed more effectively.

INNS are estimated to cost the agriculture sector in Wales at least £71 million per annum; they can affect productivity, directly damage crops, act as vectors for pathogens, affect soil health, and exacerbate soil erosion. Existing and future land management policy levers may have the potential to increase coordinated action to tackle INNS within appropriate spatial and time scales.

There is a need to focus more on prevention, such as biosecurity campaigns, advice and training, and early intervention action, such as rapid response, horizon scanning, and addressing priority pathways, to tackle newly arrived species within Wales or areas of Wales where they are not currently found.

INNS distribution, impact, and control data gaps identified in Wales need to be addressed. This could be achieved by increasing the recording of INNS on national biological record databases and by encouraging and undertaking key research.

2. Introduction

INNS are any non-native animal or plant that can spread and subsequently cause damage to the environment, the economy, human health and way of life (GBNNSS, 2019a).

INNS are one of the main threats to biodiversity loss worldwide (Secretariat on the Convention on Biological Diversity, 2014; IPBES, 2019). They can affect **ecosystem resilience** in many ways including through competition, predation, environmental impact, and altering the structure of ecosystems (Pyšek et al., 2012).

INNS can have a significant impact on **well-being** by affecting recreational activities, exacerbating flooding, restricting recreational access and affecting overall **human health** (Pejchar and Mooney, 2009).

INNS also have significant impacts on the **prosperity of Wales**; they primarily affect agricultural, forestry, and horticultural activities, and can also impact aquaculture, transport, utilities, and construction (Williams et al., 2010; Booy et al., 2017). The cost of INNS to Wales is estimated to be at least £125 million a year (Williams et al., 2010).

The key global pressures affecting the introduction and spread of INNS are the increased movement of people and goods (Hulme, 2009; GBNNSS, 2019b; CBD, 2014a; CBD, 2014b; Levine and D'Antonio, 2003; Meyerson and Mooney, 2007; Westphal et al., 2008), unmanaged pathways of introduction and climate change (Firn et al., 2015; Seebens et al., 2015).

Tackling INNS issues is an important element in creating **sustainable resilient ecosystems** that protect biodiversity. In doing so, such ecosystems are better able to adapt to threats such as climate change and provide ecosystem services to the communities of Wales, including flood and pollution mitigation, pollination, provision of resources, and ensuring that species and green spaces can continue to be enjoyed by all communities of Wales in the future. Facilitating the provision of these ecosystem services by tackling INNS will contribute towards the **well-being** goals laid out in the Well-being of Future Generations (Wales) Act 2015.

3. State and Trends

Summary Assessment of State and Trends

This section gives an assessment of progress towards INNS policy and legislative targets and objectives, as well as a forward look at how they might be progressed in the future. The information is presented as summary tables for each policy driver (Table 1 to Table 6). Trends and progress to reaching the policy/legislative targets are coded as:

- Improving trends or developments dominate;
- Trends or developments show a mixed picture, or
- Deteriorating trends or developments dominate.

Further information is provided to put this in context.

Table 1 Key message - Past trends and progress, future outlooks and prospects for the GB INNS Strategy Implementation plan

Time Period	Indicative Assessment	Description
<p>Past trends and progress (5 years)</p>	<p>Mixed picture</p>	<p>The strategy is owned by the Great Britain Non-native Species Secretariat (GBNNSS); Wales contributes to and undertakes actions listed in the strategy implementation plan. Since the strategy was published (2015), good progress has been made in fulfilling actions:</p> <ul style="list-style-type: none"> • GB level analysis and prioritisation of pathways • 3 GB pathway action plans drafted • GB Horizon scanning exercise (Roy et al., 2019) • GB Contingency plans drafted for priority species (except for terrestrial invertebrates) have been amended and drafted for adoption at a Wales-wide level • Promotion of recording GB and Wales, for example through iRecord and the Local Environmental Records Centre (LERC) apps • Improvement to surveillance and access to INNS data (Wales National Biodiversity Network (NBN) INNS Portal) • Species risk assessments at both a GB and EU level • Promotion of biosecurity through campaigns and pilots at GB and Wales-wide levels. <p>Widely spread species actions:</p> <ul style="list-style-type: none"> • Management measures for species listed under Invasive Alien Species (IAS) Regulation • IAS Order licencing process <p>Further action is needed to continue to:</p> <ul style="list-style-type: none"> • Engage with other countries to improve pre-border prevention • Implement border inspections for priority species • Improve surveillance for high priority pathways • Support outstanding rapid eradication actions (excluding contingency plans) <ul style="list-style-type: none"> • Widely spread species actions: <ul style="list-style-type: none"> ○ Prioritisation of strategic action ○ Development of long-term GB management programmes ○ Support the development of bio-controls

Time Period	Indicative Assessment	Description
Outlook to 2025	Mixed picture	<p>The strategy and implementation plan will be reviewed and updated in 2020-2021 and will consider the recommendations of the Environment Audit Committees (EAC) invasive species inquiry (2019).</p> <p>It is likely that some work areas will be ongoing, and actions associated with them will expand on the work undertaken up until 2020.</p> <p>Capacity to progress INNS work has increased in Wales since 2015 with dedicated NRW staff. If this continues to be resourced, Wales will be able to support and contribute to the GB INNS Strategy in the future.</p> <p>Contributions by the Wales Resilient Ecosystems Network (WaREN) such as in coordinating strategic action could be seen if it continues to be supported.</p>
Prospect to meet policy objectives / targets in 2020	Mixed picture	<p>Many actions within the plan have been completed, while good progress has been made with others. However, there are a handful of actions which will not be completed fully and so will need to carry over into the next plan upon its renewal in 2020/2021.</p>

Robustness: Reliable information about progress in relation to the GB INNS Strategy is available. The GBNNSS regularly updates the Wales Biodiversity Partnership INNS Group, the Wales INNS Liaison Group, and GB NNSS Programme Board.

Table 2 Key message - Past trends and progress, future outlooks and prospects for the implementation of the Invasive Alien Species Regulation (IAS) 2014

Time Period	Indicative Assessment	Description
Past trends and progress (5 years)	Improving	<p>Excellent progress has been made in relation to the actions associated with the IAS Regulation:</p> <ul style="list-style-type: none"> • Competent authorities identified • List of species of Union concern agreed (additional INNS added) • GB pathways analysis • Surveillance system established • Management measures for widely spread INNS • Action plans for priority pathways • UK reported on progress to the Commission <p>There have been some minor delays in delivery.</p>

Time Period	Indicative Assessment	Description
Outlook to 2025	Improving	<p>The EU (Withdrawal) Act 2018 converted direct EU legislation, including the IAS Regulation, into retained EU law. The Invasive Non-native Species (Amendment etc.) (EU Exit) Regulations 2019 (S.I. 2019/223) made amendments to the IAS Regulation, which came into force at the end of the implementation period.</p> <p>SI 2019/233 retains the requirement to report progress, to the Secretary of State, every six years. The criteria and principles currently set out in the EU Regulation for the species listing process are retained and the list of species of Union concern which is in force on exit day will be the list of species which applies after EU exit. The Secretary of State has the power to make changes to the list, but this power can only be exercised with the consent of devolved administrations. Additions to the lists will necessitate updates to the management measures or contingency plans.</p> <p>The need to address an incursion within three months has necessitated the creation of management plans; action is needed to embed, resource, and build capacity to put these into effect.</p>
Prospect to meet policy objectives / targets in 2020	Largely on track	There have been some minor delays associated with the implementation of the IAS Regulation however nearly all actions have been discharged.

Robustness: Reliable information about progress in relation to the Invasive Alien Species Regulation is available, the GBNNSS regularly updates the Wales INNS Liaison Group and the GBNNSS Programme Board. Welsh Government and NRW have supported the implementation of several actions including risk assessments and management measures.

Table 3 Key message - Past trends and progress, future outlooks and prospects for the Invasive Alien Species (Enforcement and Permitting) Order 2019

Time Period	Indicative Assessment	Description
Past trends and progress (5 years)	Improving	<p>The Order implements the restrictions of the IAS Reg and came into force 1 December 2019.</p> <p>Welsh Government and DEFRA in consultation with the regulatory bodies in both England and Wales, have been working on developing the IAS Order since 2016. These bodies are continuing to work together to implement the Order by developing the Frequently Asked Questions (FAQ) document which is key to interpreting the Order.</p> <p>NRW is an enforcement and licensing body under the Order.</p>
Outlook to 2025	Improving	<p>Further interpretation of the new Order will be needed in future as situations arise. Action is needed to fully embed the Order into NRW and to report on progress and the resources needed to implement the Order.</p>
Prospect to meet policy objectives/targets	Largely on track	<p>All actions associated with embedding the new legislation have been completed, excluding some formalisation of the regulatory process.</p>

Robustness: Evidence for progress is good. Actions associated with the Order were developed into a work plan for NRW and this has been used to determine whether all actions have been completed.

Table 4 Key message - Past trends and progress, future outlooks and prospects for the LIFE Natura 2000 Thematic Action Plan – Invasive Species and Pathogens

Time Period	Indicative Assessment	Description
Past progress and trends (5 years)	Mixed picture	<p>There is some cross over between the actions associated with this plan and the GBNSS Strategy and therefore some progress has been made in relation to the plan. However, many of these actions relate to broader Wales or GB level action rather than specific Natura 2000 site/feature level action.</p> <p>Progress has been made in meeting some actions:</p> <ul style="list-style-type: none"> • Biosecurity • Research into control/eradication methods • Embedding species control provisions • Influence the new agri-environmental scheme <p>The deadline for some actions will not be met. A lack of governance over the plan and recent focus on the IAS Regulation/Order and the GB INNS Strategy has affected progress.</p>
Outlook to 2025	Mixed picture	<p>Action is still needed in integrating biosecurity into regulatory regimes; a part of this action may be considered as part of the work that NRW are doing to implement an internal biosecurity policy. Action is also needed to develop a strategy to assess the impact of INNS on feature condition and to prioritise action. This could be addressed as part of the evidence gaps identified in SoNaRR2020.</p> <p>It is not clear how or when Natura 2000 (N2K) pathway action plans and site-based eradication plans will be developed.</p>
Prospect to meet policy objectives/targets in 2020	Largely not on track	<p>Some of the sub actions have been delivered or are in progress, however just under half of the actions are yet to be started.</p>

Robustness: The information used to determine progress is based on an overview of current work taking place. Currently, there is no formal reporting process in relation to the LIFE Natura 2000 Thematic Action Plan – Invasive Species and Pathogens.

Table 5 Key message - Past trends and progress, future outlooks and prospects for the UK Marine Strategy

Time Period	Indicative Assessment	Description
Past trends and progress (5 years)	Mixed picture	<p>The targets for non-indigenous species (NIS) (descriptor 2) under the UK Marine Strategy are:</p> <ul style="list-style-type: none"> • Reduction in the risk of introduction and spread of non-native species through improved management of high-risk pathways and vectors. • Action plans are developed for key high risk marine non-indigenous species by 2020. <p>Current Status – good ecological status (GES) not achieved. The results suggest, with low confidence, that there was no significant difference in the number of new records of NIS detected between the two six-year periods, 2003 to 2008 and 2009 to 2014, used in the assessment. This indicates that no significant reduction in the risk of introduction of NIS over this period has been achieved.</p> <p>A limited assessment of the impact of NIS in the UK has been made between 2012 and 2019. NIS monitoring has started to be integrated into biodiversity monitoring since 2016, including the development of a target species list and a baseline dataset. However, there are significant limitations to this monitoring as it has been put in place for other purposes.</p> <p>Species Action Plans for key NIS such as <i>Didemnum vexillum</i> are currently being developed by the UK non-native working group.</p>
Outlook to 2025	Mixed picture	<p>There is a need to improve data flow and management in relation to NIS detection, and to ensure that all biodiversity monitoring programmes include the detection of NIS where possible. Work on species action plans and pathway action plans are ongoing.</p>
Prospect to meet policy objectives/ targets in 2020	Largely not on track	<p>It was estimated that GES would not be achieved in UK seas by 2020.</p>

Robustness: Low confidence, due largely to either a lack of consistent monitoring effort or reporting or both.

Table 6 Key message - Past trends and progress, future outlooks and prospects for the national measures linked to the Water Framework Directive

Time Period	Indicative Assessment	Description
Past trends and progress (5 years)	Mixed picture	<p>Good progress has been made on some national measures relating to INNS listed under the Water Framework Directive (WFD):</p> <ul style="list-style-type: none"> • Improvement in INNS distribution data • Pathway action plans • Implementing the GB INNS Strategy • Support innovative control/eradication methods • Biosecurity initiatives • Risk assessments for species at EU and GB levels • Development of two lists which identify priority species <p>Some measures need further action:</p> <ul style="list-style-type: none"> • Integrate biosecurity into regulatory regimes • Banning of all five freshwater plants in Wales (three were banned from sale by the IAS Order)
Outlook to 2025	Mixed picture	<p>As most actions are ongoing it is likely that many of the same measures relating to INNS will be carried forward into the next River Basin Management Plans due in 2021. Good progress is likely to continue to be made as there is considerable crossover with other INNS drivers.</p>
Prospect to meet policy objectives/targets in 2020	Largely not on track	<p>Wales is not on track to fulfil all the Water Framework Directive national measures that relate to INNS by 2020.</p>

Robustness: The information used to determine progress is based on an overview of current work taking place. The formal WFD report was last submitted to the EU in 2018, however there are updates in relation to measures every three months as they form part of the NRW business plan.

Distribution overview

A list of 350 INNS of priority to Wales, also referred to as the INNS of Interest to Wales (NBN Atlas, 2019a), associated with legislative or policy drivers has been compiled. This data was used in this assessment. Figure 1 summarises the current location of these INNS of priority and identifies the percentage of species occurring within Wales (Figure 1).

Many UK INNS incursions occur in England first due to the larger population and associated movement of goods and people before they spread to other parts of the UK. The pathways used by INNS to spread are complex (Booy, 2019); however, due to its proximity to Wales, many INNS present in England have a higher risk of being introduced to Wales relative to INNS located elsewhere.

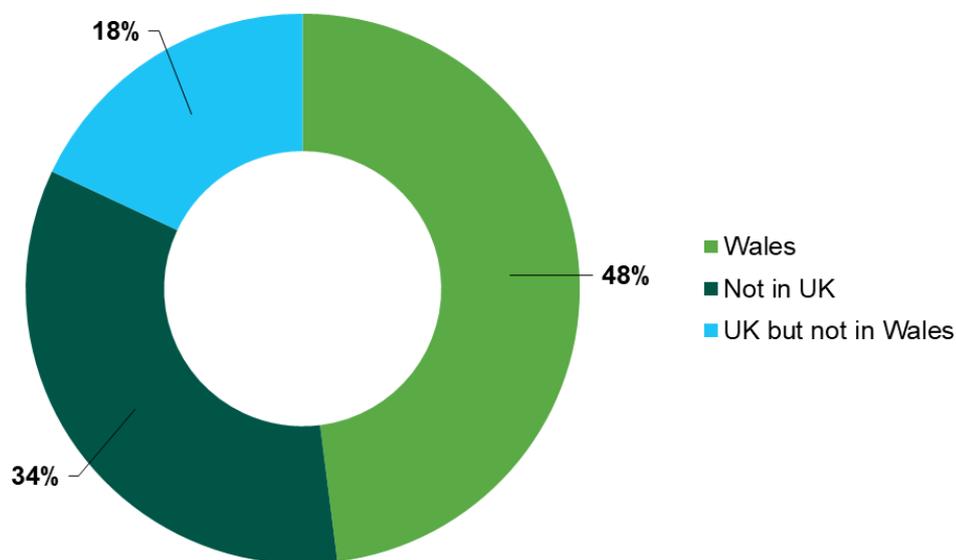


Figure 1 Percentage of INNS of priority to Wales by location (Data source: NBN Atlas)

The occurrence records of all the INNS of priority to Wales held on the NBN Atlas (NBN Atlas, 2019a) were mapped to provide an indication of their distribution within Wales (Figure 2). The records were plotted as points and the point density calculated to produce a heat map of all INNS records. They correlate with urban areas, harbours/ports, and along waterways, which reflects their pathways of introduction and spread.

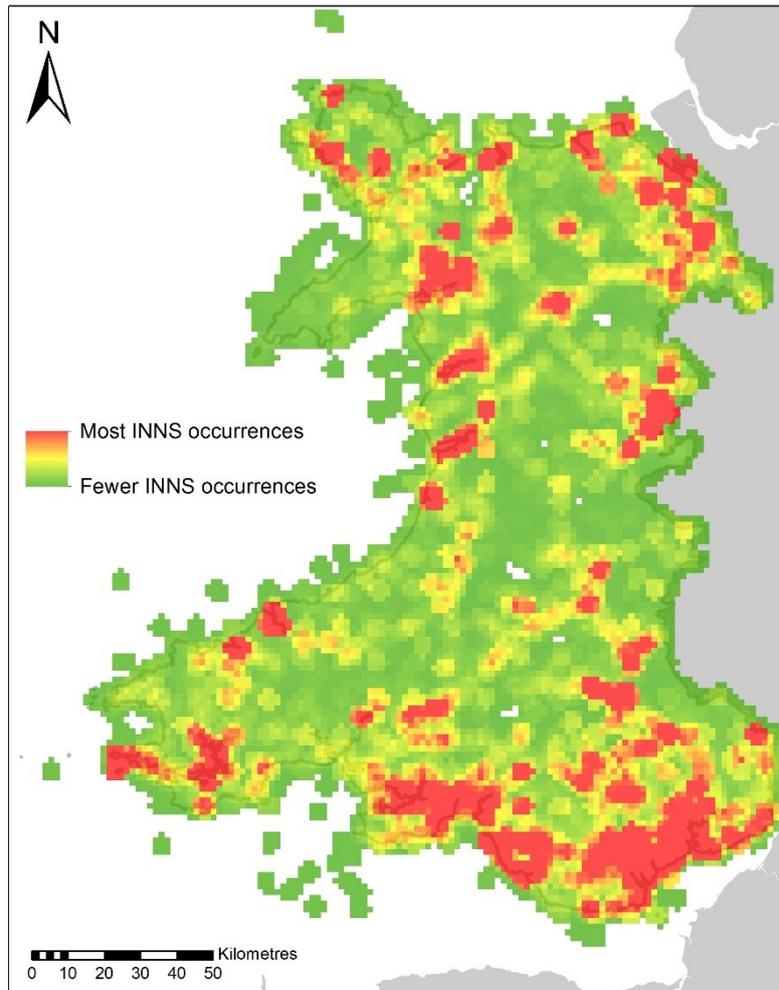


Figure 2 Distribution of occurrence records of all INNS of priority to Wales from the NBN Atlas (Data source: NBN Atlas, GBNNSS, CABI)

Impacts: Economy, well-being, and the environment

INNS have the potential to adversely affect well-being, the economy, and the environment of Wales.

The primary impact of each of the INNS of priority to Wales, in these three areas, was identified by reviewing information and literature including the GB Non-native Species Information Portal (Centre of Hydrology and Ecology, 2019), the CABI Invasive Species Compendium (CABI, 2019), academic papers and other online sources, such as databases, reports and reviews. A primary impact was assigned to each species using information from the review and professional judgement and was used in this analysis. See the StoryMap on the [environmental information hub](#) to explore this evidence further (NRW, 2021a).

Some species have multiple impacts and addressing them will provide synergies (see Section 7 Synergies and Trade-offs); 44% of the INNS of priority to Wales (present and yet to arrive) solely impact the environment, while 33% impact the environment and either the economy or well-being. Furthermore, 24% of species listed can impact the environment, the economy, and well-being.

For this analysis only the most significant impact which each INNS of priority to Wales was identified and is their 'primary impact'.

The impact of the INNS of priority to Wales, those here and yet to arrive, were analysed using the number of different species to give an indication of the potential pressure from INNS. The occurrence records (NBN Atlas, 2019a) of the INNS of priority to Wales were analysed to give an indication of current impact. The number of occurrence records does not necessarily correlate directly with the magnitude of impact as some species which have relatively low impacts may have a high number of records. However, it can provide a broad indication of overall impact.

The primary impact of all INNS listed as being of priority to Wales on the environment, economy, and well-being is presented (Figure 3) and the total number of the occurrence records for these species in Wales were analysed (Figure 4). Both analyses indicate that these species primarily affect the environment.

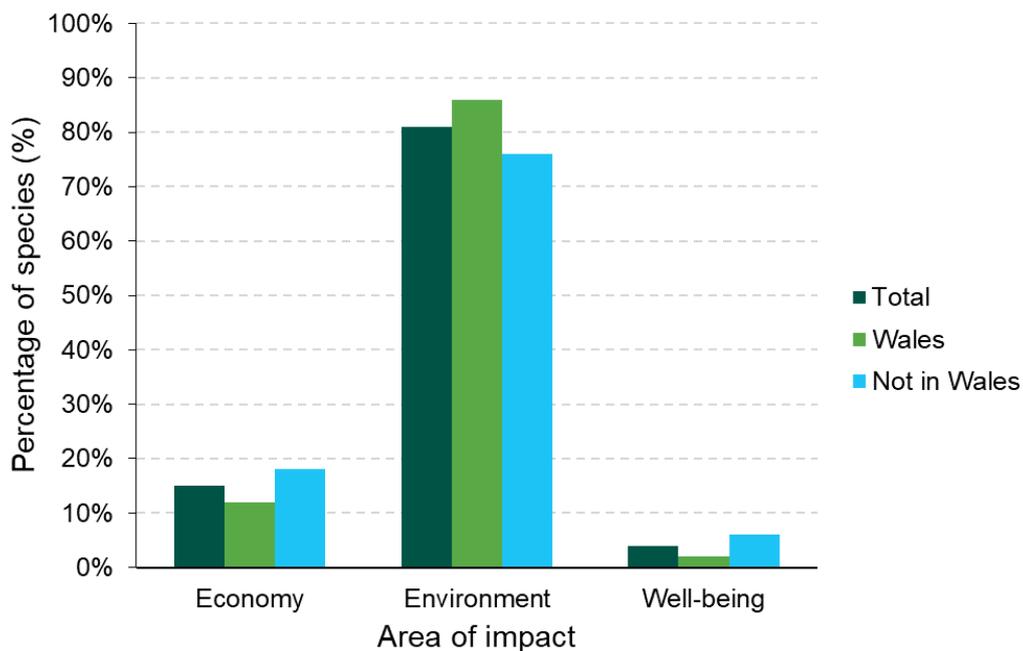


Figure 3 Percentage of Invasive Non-native Species of priority to Wales, including those already present, those not yet arrived and combined total (n=350) and their primary impacts (Data source: NBN Atlas, GBNNSS, CABI)

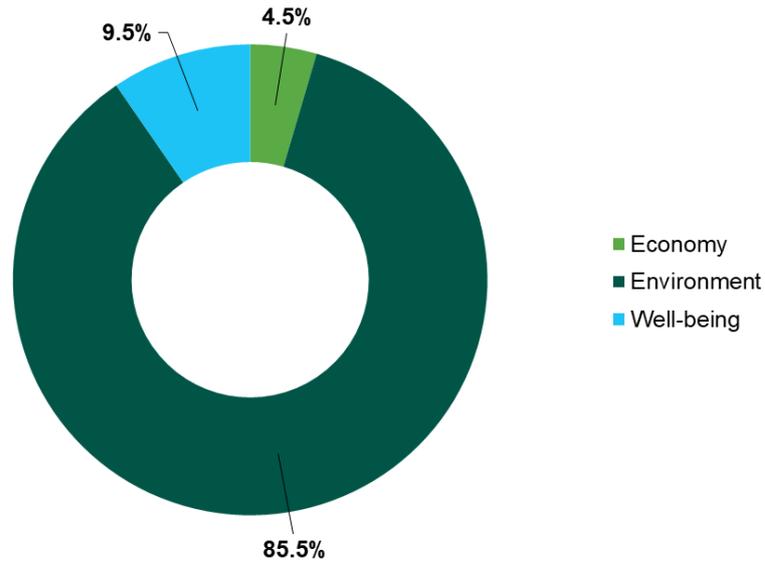


Figure 4 Current primary impact of INNS of priority to Wales (Data source: NBN Atlas, 2019)

The primary impact of INNS of priority to Wales, those here and yet to arrive, give an indication of the potential pressure from INNS on the environment, economy, and well-being of Wales, taking into account the multiple impacts that some INNS can have (Figure 5). The number of occurrence records of all INNS of priority to Wales provide an indication of their current impact in Wales (Figure 6), considering the multiple impacts that some INNS can have.

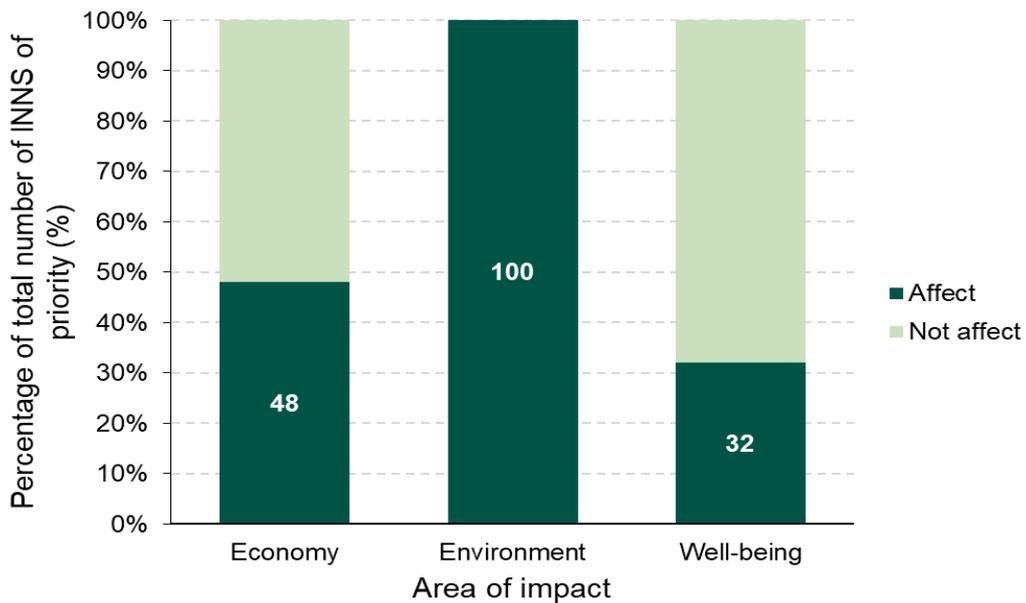


Figure 5 Percentage of total number of INNS of priority to Wales indicating the potential pressure these species have on the environment, economy and well-being in Wales (Data source: NBN Atlas, GBNNSS, CABI)

The occurrence records of INNS in Wales (Figure 6) indicate that as well as impacting on the environment, 100% of INNS present in Wales may currently be having a substantial impact on the economy, 80% of INNS, and the well-being, 61% of INNS, of Wales.

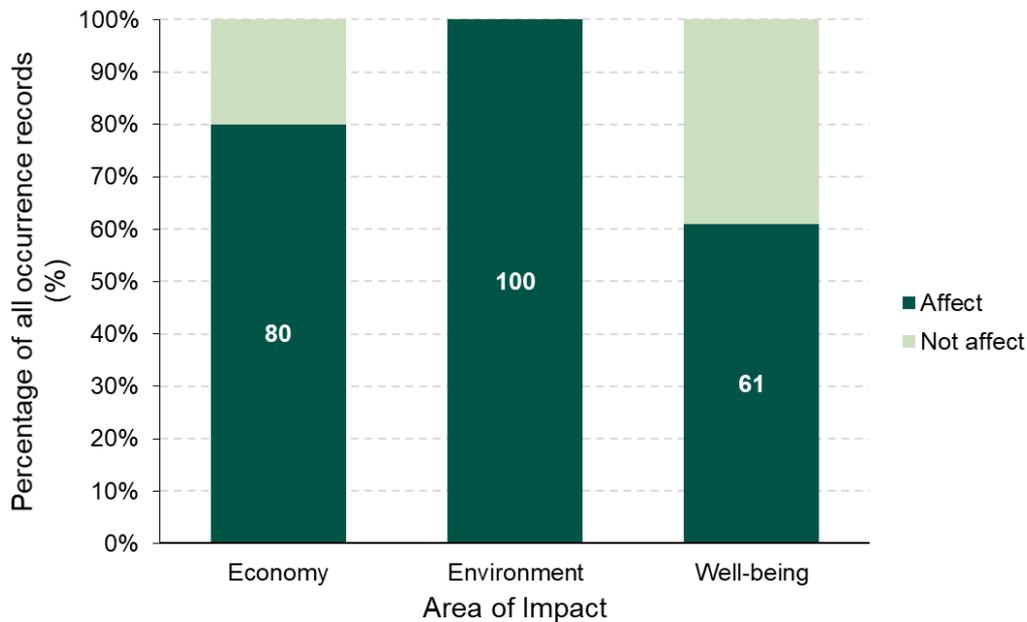


Figure 6 Percentage of all occurrence records for INNS of priority to Wales and the current impact these species can have on the environment, economy and well-being (Data source: NBN Atlas, GBNNSS, CABI)

Impacts: Ecosystems

The ecosystem which each of the INNS of priority to Wales were likely to impact was identified by reviewing information and literature including the GB Non-native Species Information Portal (Centre of Hydrology and Ecology, 2019), the CABI Invasive Species Compendium (CABI, 2019), academic papers and other online sources, such as databases, reports and reviews. Each INNS was allocated to the one ecosystem in which it has its primary impact. See the StoryMap on the [environmental information hub](#) to explore this evidence further (NRW, 2021a). Figure 7 shows the number of the different INNS of priority to Wales that are likely to most significantly impact on each ecosystem currently and in the future. It provides an indication of potential impact currently and the possible impact in the future.

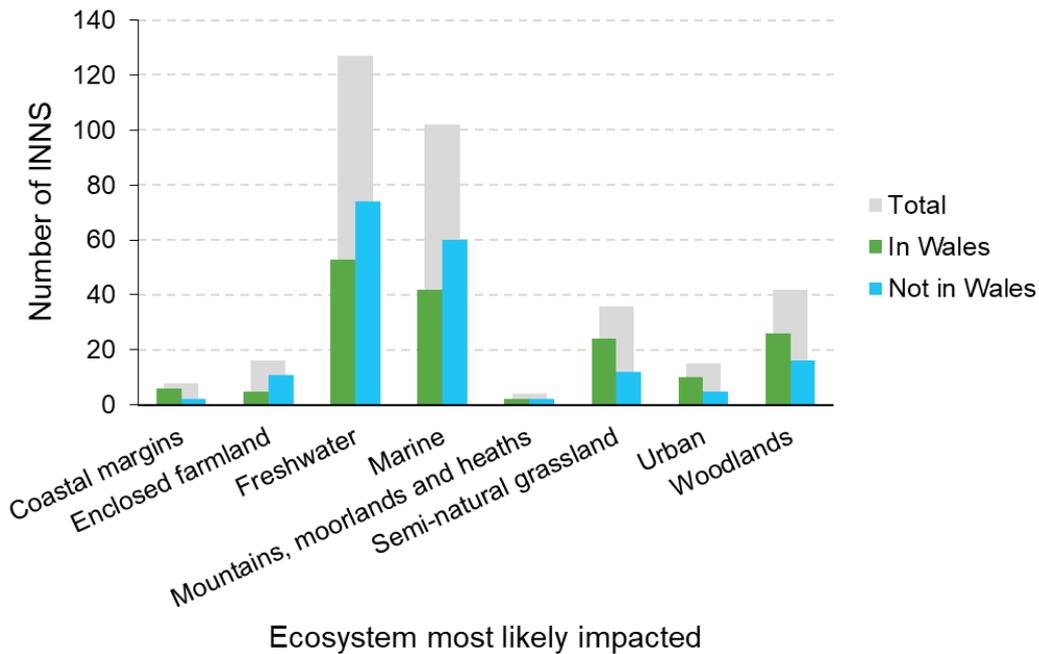


Figure 7 Number of INNS of priority to Wales, including those already present, those not yet arrived in Wales and combined total where n=350, and the ecosystem on which they are most likely to impact (Data source: NBN Atlas, GBNNSS, CABI).

The occurrence records of INNS of priority to Wales were assessed to determine which of the ecosystems they are most likely to currently impact, by considering the information from the literature review and professional judgement (Figure 8). Some species can affect more than one ecosystem, but this has not been taken into consideration in this analysis.

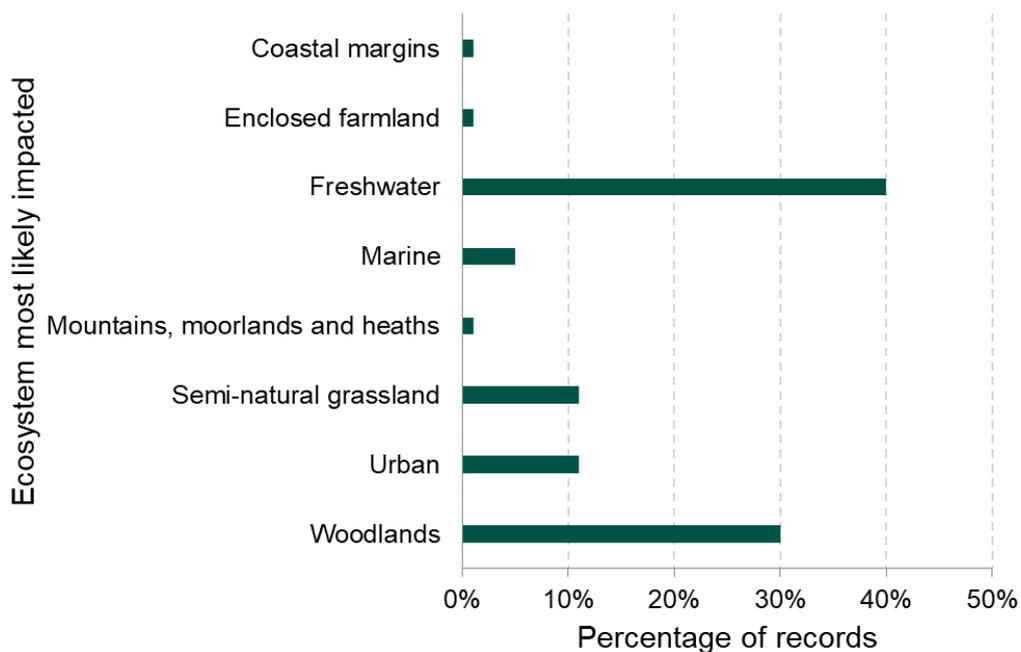


Figure 8 Percentage of occurrence records of INNS of priority to Wales and the ecosystem they are most likely to impact (Data source: NBN Atlas, GBNNSS, CABI)

The occurrence records of INNS of priority to Wales taken from the NBN Atlas (NBN Atlas, 2019a) were analysed to identify distribution patterns or hot spots. The figures below show distribution heat maps of occurrence records of INNS of priority to Wales which primarily impact each SoNaRR broad ecosystem (NRW, 2021a).

For each ecosystem the locations of occurrence records of the species identified as primarily having an impact within that ecosystem have been mapped as points. The point density has been analysed to produce a heat map of the INNS records. The higher the number of records, the higher the potential impact. This is illustrated using colour to produce 'heat' maps. The colours are relative to the density of records within each ecosystem analysis and the maps cannot be directly compared to each other.

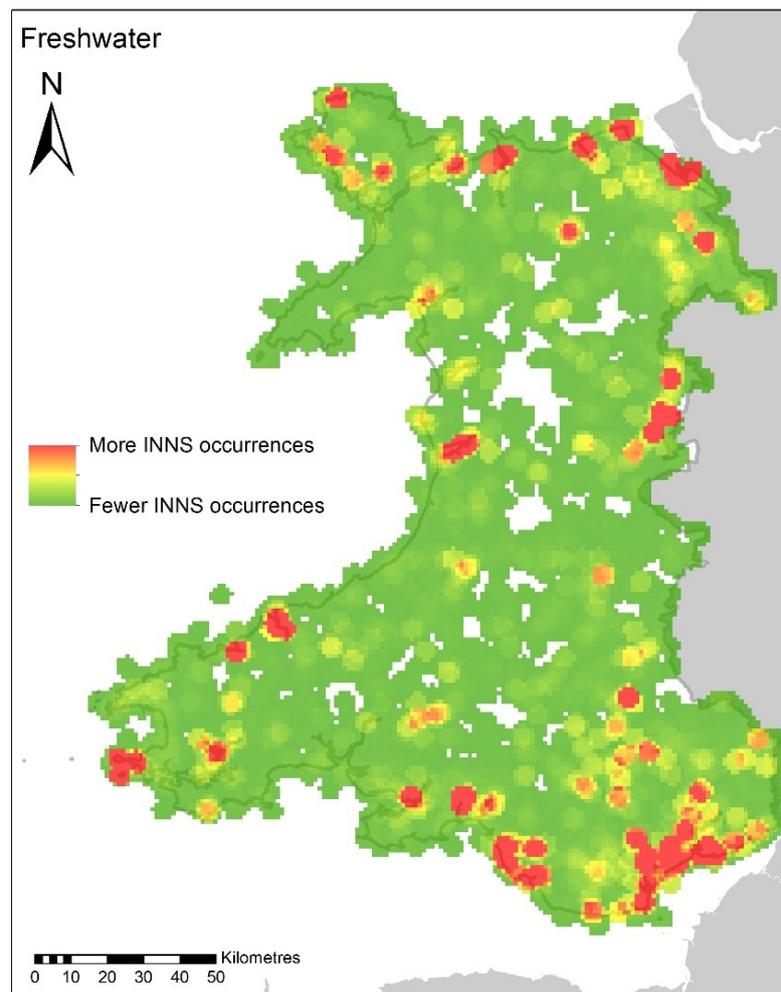


Figure 9 Distribution heat map of all occurrence records of INNS of priority to Wales which impact freshwater ecosystems in Wales (Data source: NBN Atlas, GBNNSS, CABI)

The heat map of occurrence records of INNS of priority to Wales which impact freshwater ecosystems in Wales (Figure 9) is dominated by records of Canada Goose, but includes other vertebrate species such as American Mink and plants such as Canadian Pondweed. There is a correlation with waterways, but also with population centres and some sites of conservation interest which may reflect a reporting bias rather than a higher population. These INNS can impact freshwater ecosystems by reducing biodiversity and abundance, disrupting trophic levels, acting as a vector for diseases and parasites, reducing amenity value, causing water quality

issues, blocking waterways, and structures leading to reduced access and localised flooding.

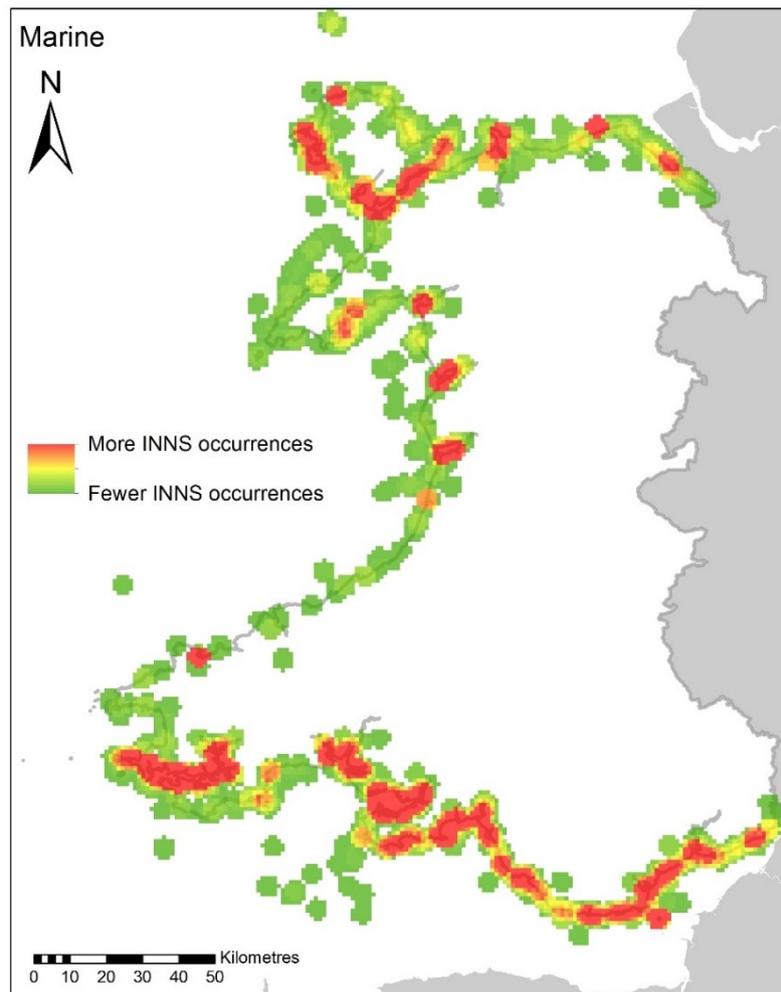


Figure 10 Distribution heat map of all occurrence records of INNS of priority to Wales which impact marine ecosystems in Wales (Data source: NBN Atlas, GBNNSS, CABI)

The heat map of occurrence records of INNS of priority to Wales which impact marine ecosystems (Figure 10) is dominated by records of Common Cord Grass, and invasive barnacles and molluscs. The coastal correlation reflects this with specific hotspots at Holyhead, Milford Haven and the Bristol Channel which suggest the importance of shipping/boating as major pathways. These INNS can impact marine ecosystems by affecting biodiversity, altering trophic levels, exacerbating water quality issues such as red tides, smothering, predating or outcompeting native fauna and aquaculture species, affecting commercial fisheries, as well as biofouling marine structures, boats, and blocking intakes/pipes.

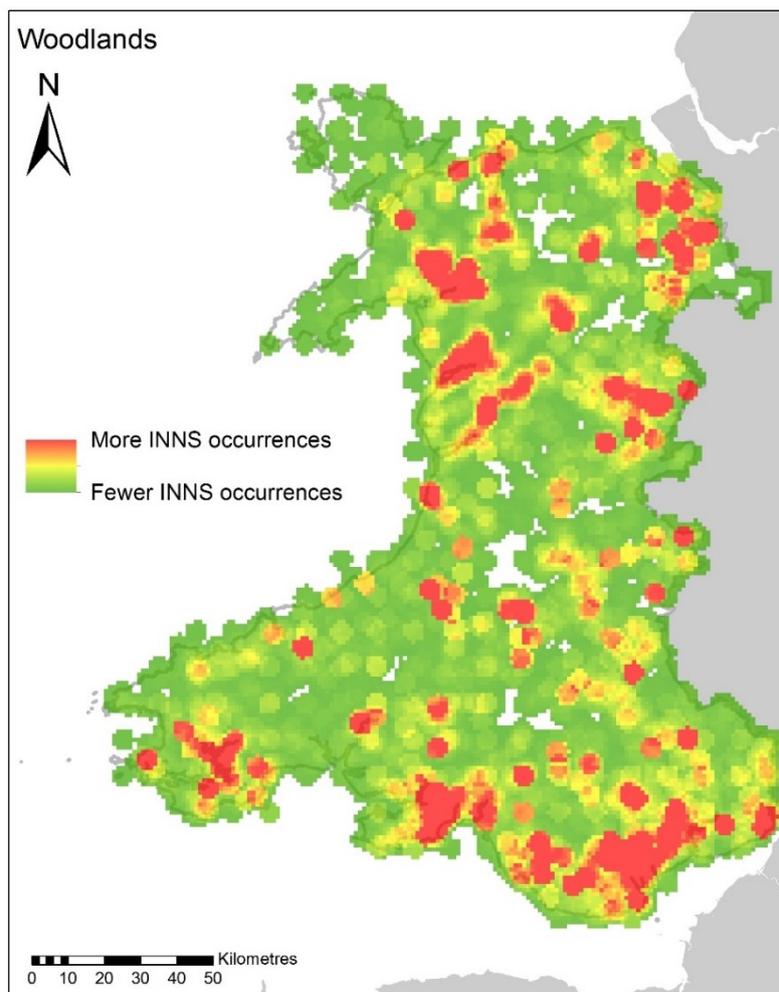


Figure 11 Distribution heat map of all occurrence records of INNS of priority to Wales which impact woodlands ecosystems in Wales (Data source: NBN Atlas, GBNNSS, CABI)

The heat map of occurrence records of INNS of priority to Wales which impact woodlands ecosystems (Figure 11) is dominated by records of Grey Squirrel and Rhododendron. It shows a distribution across Wales but with higher concentrations in south Wales, Snowdonia, and Flintshire. There is a concentration of records near large towns and cities which reflects that some INNS were originally ornamental plants or animals that escaped from gardens/parkland. Some of the more widely spread species colonised south Wales before spreading north and so, there are more records of occurrences in these areas. These INNS can impact woodland ecosystems by affecting woodland structure and productivity, directly damaging trees, act as vectors for diseases, competing and out-shading native species, and can affect the ability of other plants to grow on land by producing chemicals, called allelopathic.

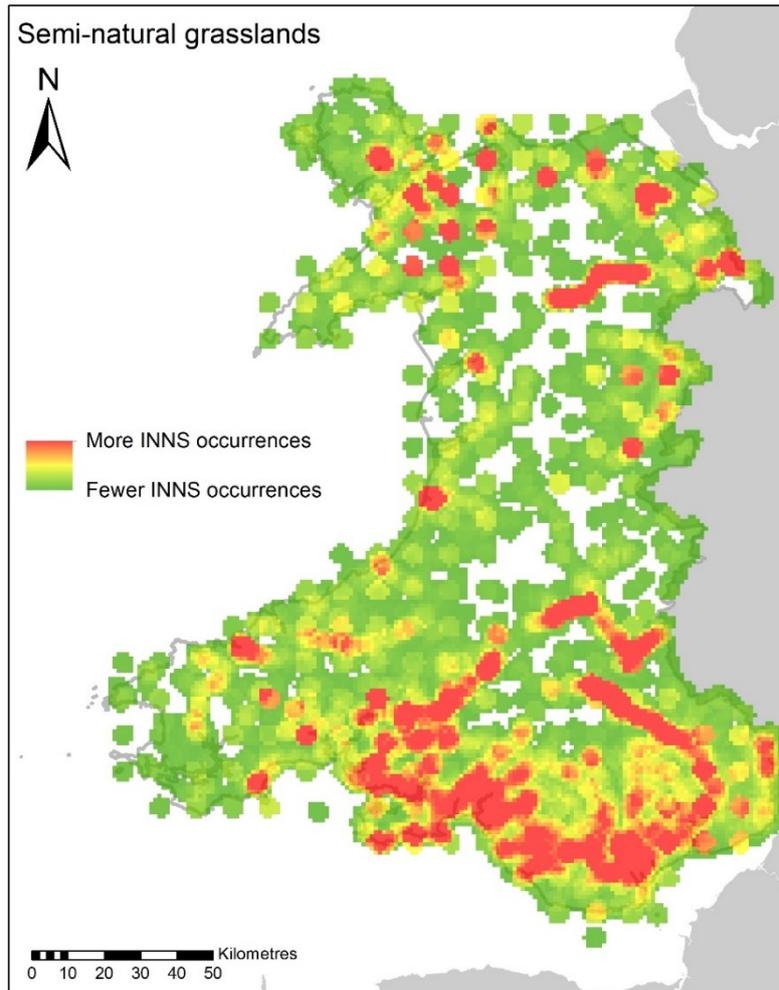


Figure 12 Distribution heat map of all occurrence records of INNS of priority to Wales which impact semi-natural grasslands ecosystems in Wales (Data source: NBN Atlas, GBNNSS, CABI)

The heat map of occurrence records of INNS of priority to Wales which impact the semi-natural grassland ecosystems in Wales (Figure 12) is dominated by records of a small number of species including Himalayan Balsam and cotoneaster. It shows that they are widely spread across Wales with a higher concentration of records in south Wales. There is a correlation with river corridors which act as a pathway for the spread of the species. The spread reflects the distribution of this ecosystem and the invasion history of the INNS that affect it. Many of the plant species have escaped from gardens and a few key species invaded south Wales first, before spreading northwards. These INNS can affect semi-natural grassland by reducing biodiversity by outcompeting or shading out native plants, can form monocultures that can have knock-on effects at higher trophic levels, can contribute to a reversion to scrub and woodland and can affect grazing productivity.

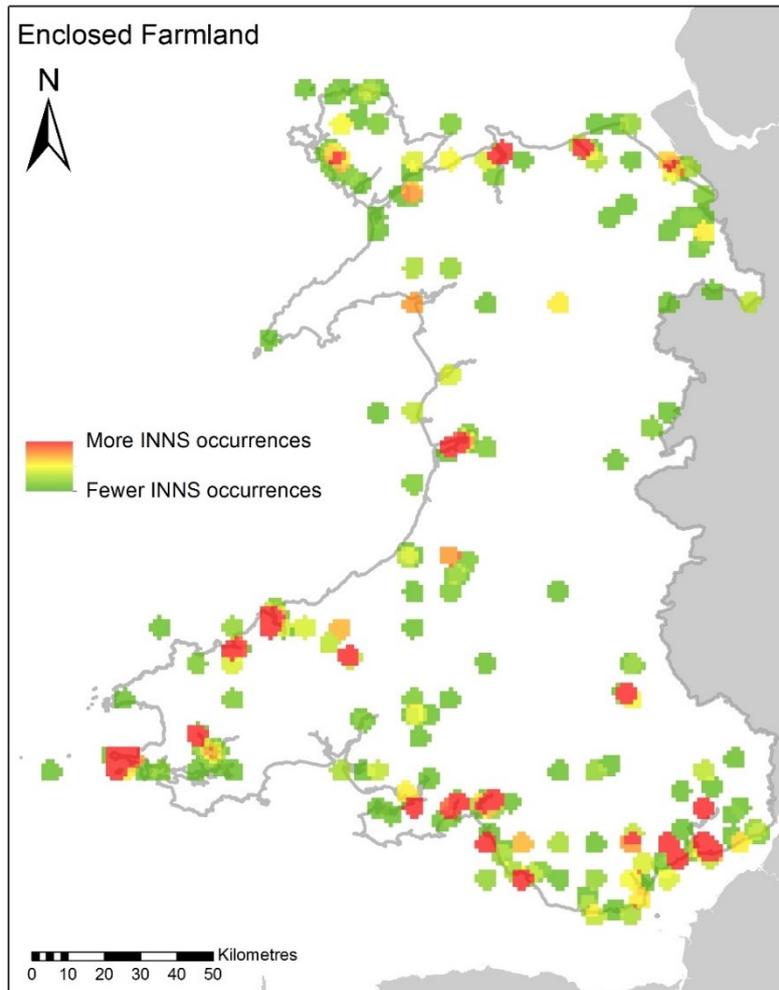


Figure 13 Distribution map of all occurrence records of INNS of priority to Wales which impact enclosed farmland ecosystems in Wales (Data source: NBN Atlas, GBNNSS, CABI)

The heat map of occurrence records of INNS of priority to Wales which impact the enclosed farmland ecosystem in Wales is dominated with records of introduced geese (Figure 13) It shows some correlation with population centres but there may also be some reporting bias with hot spots centred on areas of high biodiversity recording such as the Pembrokeshire islands and other nature reserves. These INNS can affect enclosed farmland ecosystems by reducing productivity; are difficult and costly to remove; directly damage or feed on crops; act as vectors for disease; and predate native invertebrates such as earthworms which are important for nutrient cycling and soil health.

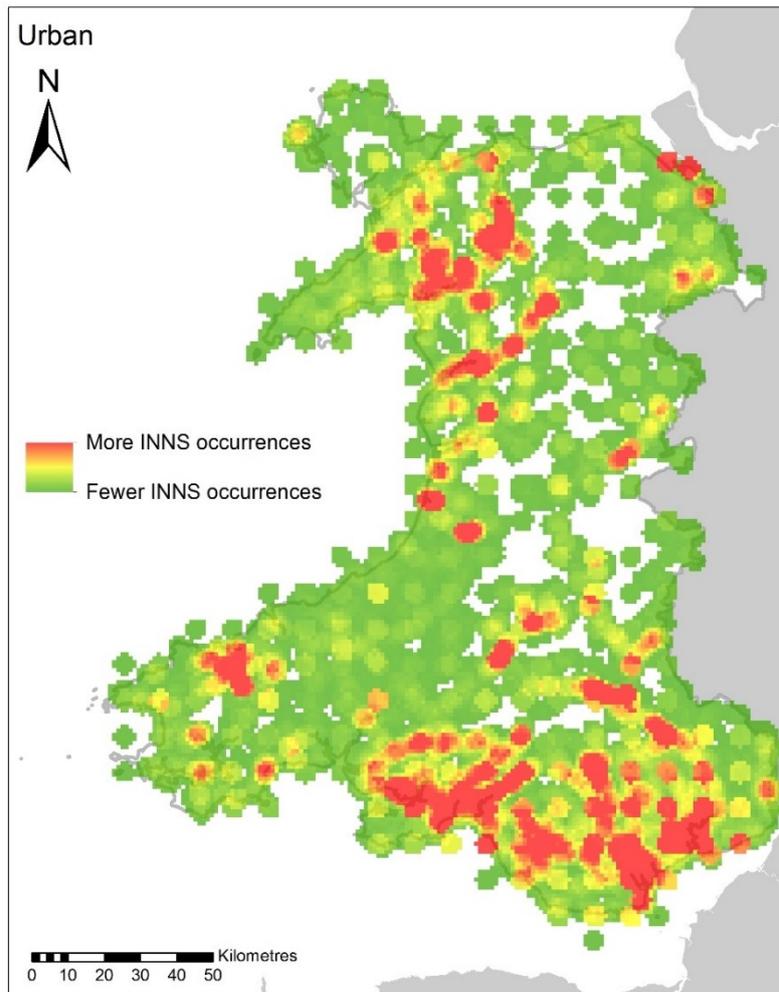


Figure 14 Distribution map of all occurrence records of INNS of priority to Wales which impact urban ecosystems in Wales (Data source: NBN Atlas, GBNNSS, CABI)

Records of species identified as primarily affecting urban ecosystems are dominated by Japanese Knotweed and Buddleia. The heat map of occurrence records (Figure 14) shows that records are spread across Wales with greater concentrations around population centres in south Wales and the Valleys and in north Wales around Blaenau Ffestiniog and Llanrwst. There is a correlation with rivers, and this illustrates that they can be a significant pathway for INNS escape and spread. These INNS can affect urban ecosystems by damaging structures and housing by taking advantage of weaknesses, which subsequently reduces the value of property due to the difficulty and cost involved in their control. They also cause direct health impacts, including photosensitivity, rashes, and blistering, act as a vector for diseases, cause nuisance by interfering with waste, invade homes, foul, cause noise pollution, reduce amenity value, and reduce access to green spaces.

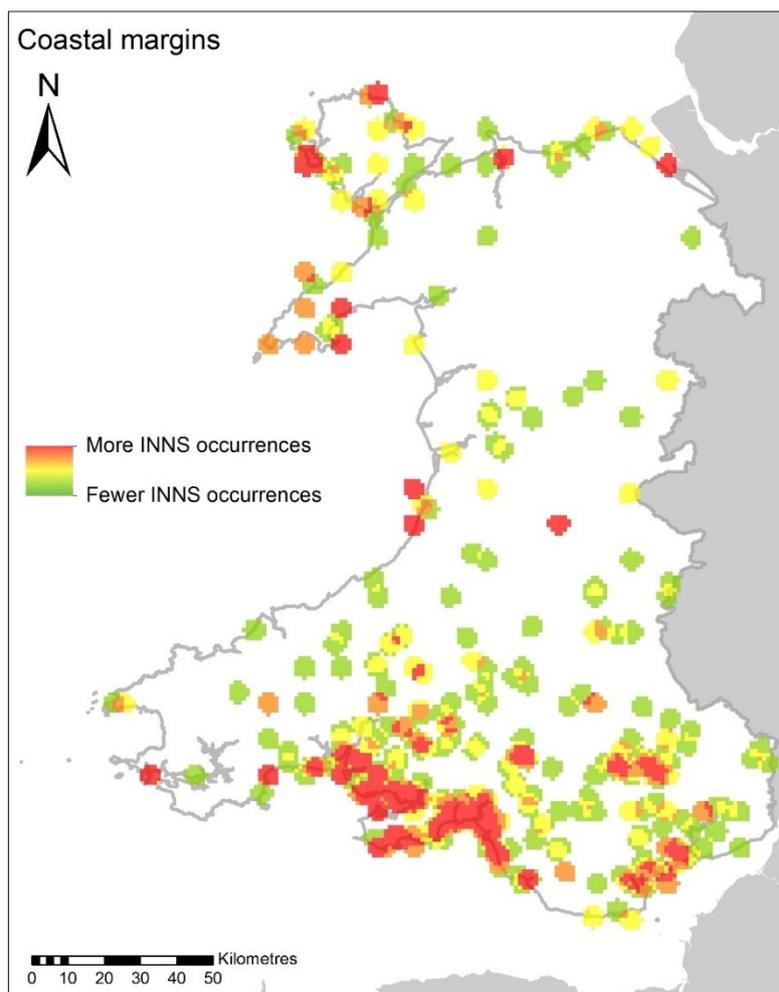


Figure 15 Distribution map of all occurrence records of INNS of priority to Wales which impact coastal margins ecosystems in Wales (Data source: NBN Atlas, GBNNSS, CABI)

The heat map of occurrence records of INNS of priority to Wales which impact coastal margins ecosystems in Wales (Figure 15) shows that there are significant concentrations around Swansea Bay, Gower and Carmarthenshire, with some hot-spots on the Llyn, Anglesey, and the north Wales coast. The majority of records are for Japanese Rose and appear to correlate to the location of dune systems. The species identified as primarily affecting coastal margins are terrestrial plants and are not confined to coastal areas, but that is where their impact is greatest. These INNS can impact coastal margins ecosystems by outcompeting native plants, forming monocultures, or reducing the functionality of ecosystems particularly within dune system by acting as stabilisers. They can also reduce access and the amenity value of these areas.

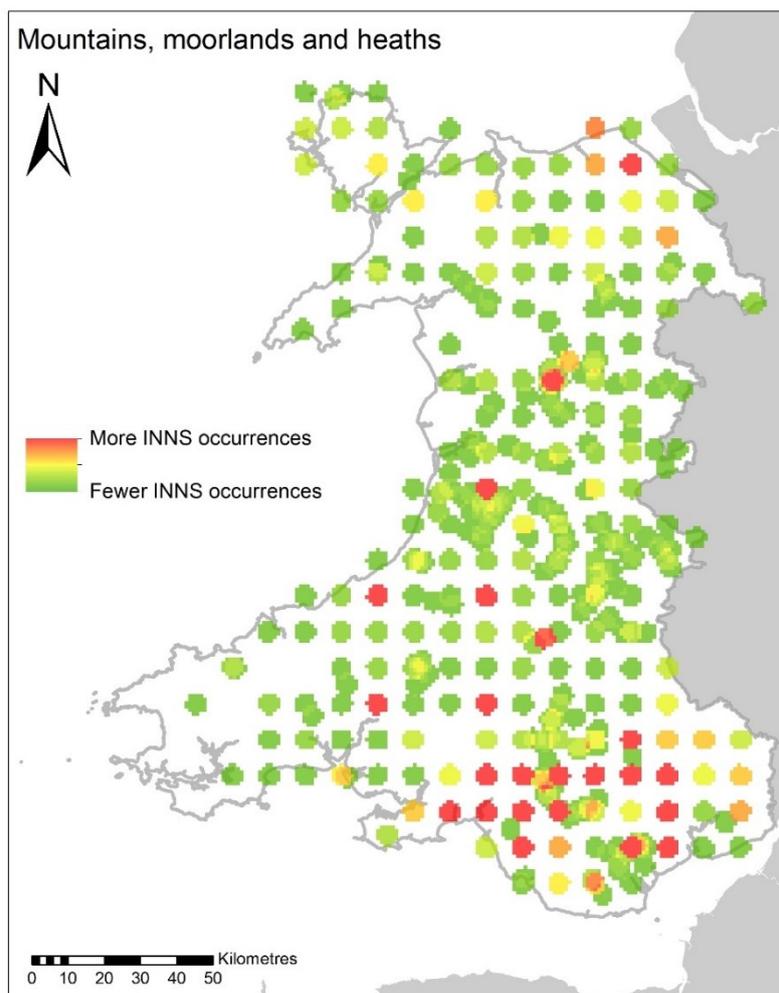


Figure 16 Distribution map of all occurrence records of INNS of priority to Wales which impact mountains, moorlands and heaths ecosystems in Wales (Data source: NBN Atlas, GBNNS, CABI)

The heat map of occurrence records of INNS of priority to Wales which impact the mountains, moorlands and heaths ecosystem in Wales (Figure 16) only identifies two species: an introduced game bird and a non-native tree of economic importance to Wales which can self-seed outside of plantations. This analysis should be treated with caution as records within plantations have not been excluded. Records are distributed across Wales with areas of higher concentration in upland areas of south and mid Wales. These INNS can affect the mountains, moorlands and heaths ecosystems by reducing grazing areas, causing woodland encroachment, peatland degradation, as well as outcompeting native flora and fauna which can disrupt higher trophic levels.

Trends, pressures, and threats

Approximately 2,000 non-native species have established in Great Britain. Approximately 1,800 are terrestrial, 80 marine, and 80 freshwater species. Between 10 and 12 new species establish in GB each year (GBNNSS, 2015). It is estimated that only 10-15% will become invasive and cause significant adverse effects (GBNNSS, 2015). The rate at which new species are establishing in GB and the impact they have has increased exponentially over the last 50 years (NNSIP, 2017). The invasion rate of INNS is anticipated to continue to increase in the future, mainly due to increases in the movement of goods and people (GB: Booy, 2019; General: Levine and D'Antonio, 2003; Seebens et al., 2015).

Key pressures affecting biodiversity which INNS benefit from are climate change and an increase in the national and global movements of people and goods. The movement of goods and people will bring an increasing number of INNS into Wales which will increase opportunity for establishment unless measures are put in place to prevent their introduction and spread. Climate change is likely to lead to more species which are already present in Wales or not yet arrived being able to establish viable populations as increased overall temperatures will enable certain species to overwinter and either successfully breed or spread or both.

A 'pathway' is the route by which an INNS can be introduced or spread. Unmanaged pathways are a current pressure and can pose a future threat to Wales. An in-depth analysis of pathways of introduction to GB was undertaken in 2019 (Booy, 2019; GBNNSS, 2019b) to identify the pathways responsible, also called priority pathways, for the introduction of the most damaging INNS. The top 5 priority pathways identified were:

1. hull fouling
2. horticulture escapes
3. contaminants of ornamental plants
4. ballast water
5. towaways on fishing equipment.

Understanding the pathways for introduction to GB is an important step forward and will enable action to be focused on tackling the pathways of highest risk to Wales and the rest of GB.

The arrival of new INNS is a threat to GB; understanding which species and how they are likely to arrive will be key to enabling action to be prioritised to prevent their introduction. A horizon scanning exercise was undertaken (Roy et al., 2019) to identify which species are of greatest threat to GB; the species have been assessed to establish which habitat they predominantly affect and what primary impacts they would have (Figure 17). The horizon scanning exercise will be used to update the national INNS lists in Wales to help prioritise action.

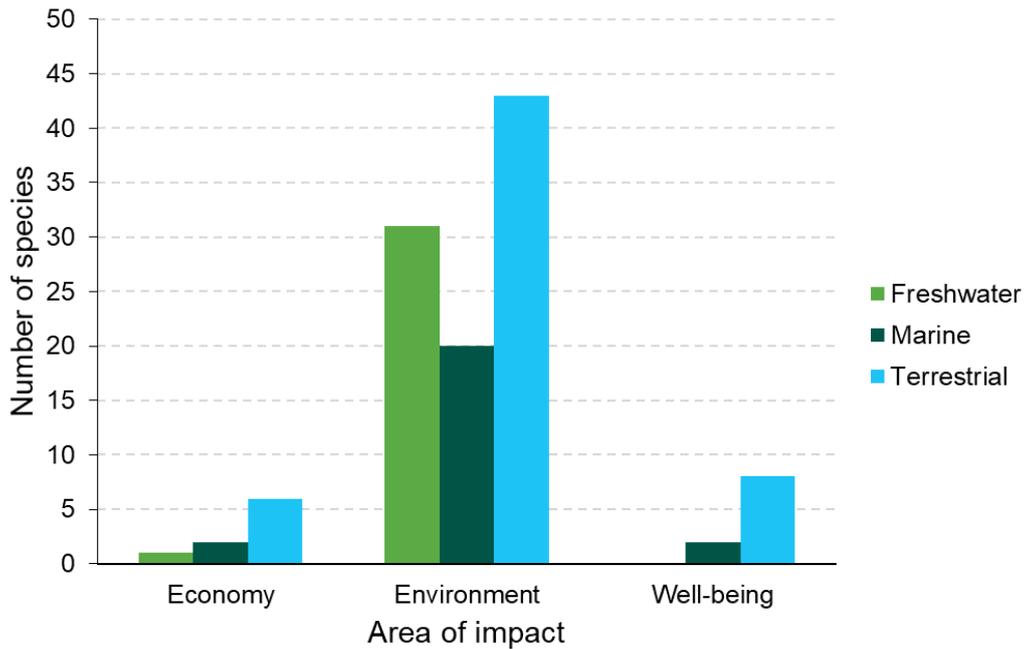


Figure 17 Primary impact species identified in the horizon scanning exercise, n=113, that relate to terrestrial, freshwater and marine habitats (Roy et al., 2019)

The lack of effective methods to either control or eradicate certain INNS is a threat. Where an effective method does exist the environmental impact or the cost can sometimes be too high to enable control or eradication to be undertaken. Further research is needed to identify or develop effective control/eradication techniques including biocontrol using an integrated pest management framework where appropriate.

4. Management Issues, responses, and prospects

Ecosystem resilience

Issue

Failure to maintain or enhance ecosystem resilience by tackling INNS due to a lack of a strategic, coordinated, evidence-based steer for action to address INNS issues in Wales

Response

The scale of the impact from INNS necessitates the coordination of action so that resources and effort is applied more effectively and sustainably. Action is needed at appropriate spatial and time scales that considers best available evidence and includes monitoring.

The GB INNS Strategy and the recent Environmental Audit Committee report into INNS (GBNNS, 2015; EAC, 2019) have identified the need to improve the coordination of INNS action so that resources can be applied more effectively and

sustainably at appropriate spatial scales. The Audit Committee report also recognised that due to the scale of the INNS issue in the UK, the involvement of the public, local action groups, and other organisations will be key to tackling INNS and preventing their introduction in the first instance.

An evidence based strategic steer and tools to help inform and guide decision making in relation to INNS action are needed to support decision makers and funders. This would help increase understanding amongst funders about the spatial and time constraints involved in addressing INNS issues and would enable more funding to be drawn down to address INNS issues in an effective way.

A Wales level steer would need to be developed in collaboration with a wide range of stakeholders using adaptive management and consider best available evidence and the three pillars of sustainability. This could inform decision makers on how and where to concentrate efforts; increase coordinated action to tackle INNS within appropriate spatial and time scales; and help inform future projects and initiatives such as the future land management scheme.

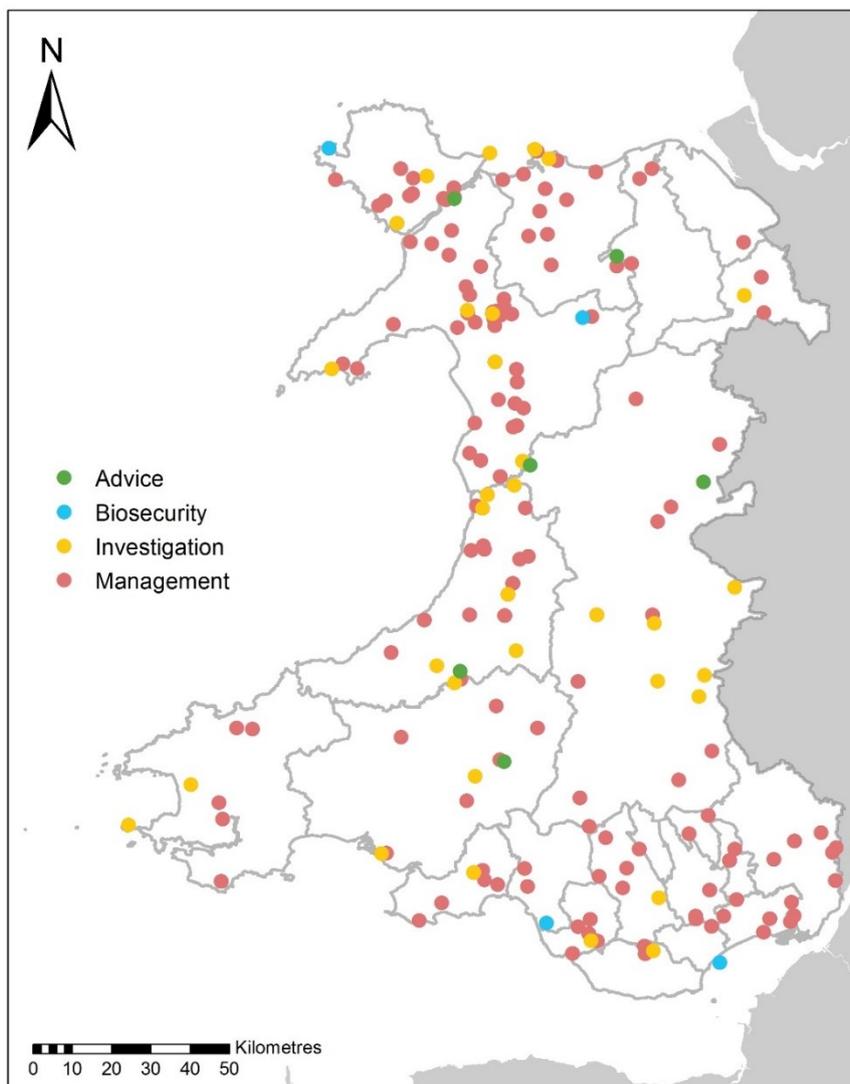


Figure 18 The location of action on the ground to tackle non-native species undertaken by stakeholders, 2014 – 2018 (Data source: NBN Atlas, GBNNS, CABI)

The action being undertaken on the ground, between 2014 and 2018, was mapped (Figure 18); it demonstrates that a considerable amount of work is being undertaken to tackle INNS in Wales. See the StoryMap on the [environmental information hub](#) to explore this evidence further (NRW, 2021a). The different drivers, most commonly: conservation, asset protection, or productivity improvement, organisations, and spatial scales, of localised, site and catchment, involved illustrate that there is likely to be room to improve the coordination of these activities across Wales.

Progress and prospects

The Wales Biodiversity Partnership (WBP) INNS group acts as the Wales Country Group for GB action and is an important hub for stakeholders interested in tackling INNS. The group have developed and adopted the INNS – Priority Species for Action in Wales list (WBP, 2018) which identifies strategic species priorities.

The Wales INNS Programme (2016-2017) was an NRW project funded by Welsh Government to support the implementation of new INNS policy and legislative drivers (NRW, 2018). The work helped to build capacity within NRW and led to a permanent dedicated INNS resource in NRW which can support Welsh Government in taking a more strategic approach to tackle INNS in Wales.

The [Wales Resilient Ecosystem Network](#) (WaREN) project was established in 2019 with the purpose of building on the work of the WBP INNS Group by forming a collaborative framework to tackle INNS, raise awareness, and begin to scope out and develop the Wales level tools that will be needed to drive strategic collaborative action to tackle INNS across Wales. WaREN has the potential to facilitate more effective action on the ground by developing evidence-based INNS management tools and a strategic steer to inform decision makers and funders to more effectively address INNS in Wales, as well as encouraging and supporting local action groups.

Outputs from WaREN in terms of strategic steer and other tools could potentially support the new land management scheme if it were to include INNS control or eradication. This could potentially increase coordinated action to tackle INNS within appropriate spatial and time scales.

The development and support of a collaborative framework for addressing INNS issues in Wales is key to more effectively tackling INNS and it is important that this work continues to be supported and resourced.

Establishment and spread

Issue

Increased risk of INNS establishing and spreading in Wales and the need to focus more on prevention and early intervention action to enable the resilience of ecosystems to be maintained

Response

The number of new INNS is predicted to increase in the future. The Convention on Biological Diversity (CBD) identified a 3-tiered hierarchical approach to managing INNS, prevention, followed by early intervention and then containment/long-term

control, which underpins the GB INNS Strategy and the Invasive Alien Species Regulation 2014.

Policy, action, and funding need to focus more on prevention, such as biosecurity, reducing the risk of INNS spread, including horizon scanning and priority pathways, and tackling newly arrived species within Wales or areas of Wales where they are not currently found, in other words rapid response. A clear process, including governance and resourcing, to tackle newly arrived INNS in Wales is needed. It is important to continue to identify or develop the necessary data and tools, including control and eradication techniques, to be able to effectively undertake early action to tackle newly arrived INNS. Given the wide range of impacts that INNS have within Wales, more needs to be done to raise awareness of the threat of INNS to better engage organisations and the public in preventative action such as reporting and biosecurity.

Progress and prospects

There have been records of new species in Wales, including Raccoon dog and American lobster, since SoNaRR2016 and the risk of certain species arriving or establishing in Wales has increased. There have been increasing records of Asian hornet incursions in England. Further action is needed to continue to improve and refine the provision of INNS data and the current surveillance system to facilitate rapid response interventions.

The identification and targeting of priority pathways of introduction and horizon scanning are key preventative measures. Action is being taken to develop GB Pathway Action Plans (PAPs) for all priority pathways identified in 2019 (Booy, 2019; GBNNSS, 2019b). Since SoNaRR2016 GB level PAPs have been developed; including for zoos, recreational angling, and recreational boating. Action is needed to continue to support the implementation of new PAPs so that pathways of introduction can be better managed, and to develop new PAPs to address the remaining priority pathways.

INNS of concern to Wales which are yet to arrive have been captured in two Wales level lists; INNS – Priority Species for Action in Wales list (WBP, 2018) and the Welsh Government Marine INNS Priority Monitoring and Surveillance Species List (Welsh Government, 2017). NNSIP undertook a GB Horizon scanning exercise in 2020 (Roy et al., 2019) and this will be used to update these lists.

The lack of a clear process, including governance and resourcing, to tackle newly arrived INNS in Wales has hindered action in the past. Since SoNaRR2016 steps have been taken to develop Wales level contingency plans, adapted from GB generic contingency plans, to help tackle newly arrived species in Wales. The plans contain a list of INNS that could have significant impacts should they establish. Further action is needed to finalise, officially adopt, embed, and resource this new process and to build capacity, including identifying existing effective control/eradication techniques and where necessary, developing new ones. Research into the biology, invasion histories, and control/eradication techniques for contingency plans species should be encouraged.

Awareness

Issue

Lack of awareness of the threat of INNS and the need for appropriate biosecurity

Response

Given the wide-ranging impact that INNS can have, awareness amongst the public and organisations should be higher. The Environment Audit Committee report, 2019, recommended that public awareness campaigns in relation to INNS and biosecurity should be revived and that there should be increased involvement and training in biosecurity for the general public to enable them to help identify invasive species and respond to biosecurity outbreaks. Professionals are needed to control many INNS; however, volunteers can assist in eradicating/controlling certain INNS provided that they have appropriate coordination, training, insurance, guidance, and equipment.

Biosecurity is key to preventing the introduction and spread of both INNS, pests, and diseases; government bodies, organisations, and businesses can play an important role in embedding biosecurity into the way they operate. To achieve this, capacity will need to be built so that individuals, organisations, and businesses can access high-quality, consistent, and relevant biosecurity guidance, advice, and training resources.

The establishment of biosecurity pilot programmes, within organisations and at sites, could be undertaken. Approaches, resources, and lessons learnt from them could potentially build capacity and improve biosecurity. Undertaking an assessment of attitudes to INNS, biosecurity, and awareness of campaigns, would help to assess and improve the implementation of action to promote biosecurity in Wales.

Progress and prospects

GB biosecurity campaigns, including Check, Clean, Dry, Be Plant Wise and Invasive Species Week, continue to be promoted in Wales by members of the WBP INNS Group and other stakeholders. Welsh Government and NRW contributed to the renewal of the GB “Check, Clean, Dry” campaign material in 2019 and developed new bilingual material for distribution amongst stakeholders in Wales. The GB “Be Plant Wise” campaign has been renewed and broadened so that it includes terrestrial and freshwater species, the new GB campaign is to be relaunched in 2020. Future action and resources are needed to promote the national campaigns within Wales amongst stakeholders and the public.

Several biosecurity pilot programmes are being undertaken currently; approaches, resources, and lessons learnt should build capacity and enable biosecurity to be improved. For example, a European Marine and Fisheries Fund project is underway to improve biosecurity within the Pen Llyn a’r Sarnau Special Area of Conservation (SAC) (Pen Llŷn a’r Sarnau, 2021).

NRW is working towards being an exemplar in biosecurity management. We have undertaken an audit, developed, and adopted a new biosecurity policy, carried out risk assessments, and developed a biosecurity policy embedding plan. This work could provide an approach that can be adopted by other bodies, organisations, or

businesses to embed biosecurity more effectively within their processes and the way they work.

Further action and resources are needed to develop more consistent, good quality, and relevant biosecurity advice and training resources for the public, organisations, and business based on the most up to date evidence and research. This needs to be promoted and made available to stakeholders and the public.

There are opportunities to embed appropriate biosecurity into national policies including planning and regulation such as public consenting processes.

Evidence

Issue

The lack of accurate and comprehensive evidence about the distribution and impact of INNS and the risk of their spread within Wales is affecting the ability to deliver nature-based solutions to tackle INNS issues and contribute towards SMNR

Response

The lack of accurate and comprehensive INNS data has affected attempts to control or eradicate INNS in Wales. SoNaRR2016 and the GB INNS Strategy identify the need to improve INNS information and distribution data. This evidence is essential to understand the distribution, risk, and impacts of INNS to develop an evidence-based strategic steer, to monitor progress, and identify future threats. Action is needed to increase the coverage and accuracy of distribution data and to address evidence gaps on the impacts of INNS. Data and evidence gaps need to be identified and filled by engaging and collaborating with stakeholders and the public to encourage them to record and upload INNS data. Action is needed to encourage further research in areas where there are data gaps in relation to impacts, and to review and gather additional research for future SoNaRRs to improve understanding of the impact of INNS in Wales.

Progress and prospects

Important steps have been taken since SoNaRR2016 to improve access to INNS data in Wales and to improve the surveillance system for INNS. The INNS portal hosted on the National Biodiversity Network Atlas Wales website was developed in 2018 and is a Wales specific public access facility. The portal supplements the GB Non-native Species Information Portal and its alerts mechanism and helps to implement the GB NNS Strategy by improving open access to existing data.

Work has been ongoing to promote recording within Wales through the WBP INNS group members including the Local Record Centres using the iRecord and Local Environmental Records Centre (LERC) mobile applications.

Available INNS data provides an indication of the state of INNS in Wales; however, some shortcomings have been identified including reporting bias, under recording, lack of eradication records. Action is needed to encourage the capture of accurate INNS records. This will improve the overall picture of the distribution of INNS so that their impact can be more accurately assessed. Wide stakeholder involvement in reporting will be key to this work. Further research and improvements in the

application of aerial photography using drones and satellite imagery could potentially improve the provision of distribution data for some plant INNS.

Data gaps have also been identified in the work for SoNaRR2020. These could be addressed by encouraging or commissioning new research. Currently there are a number of research institutions in Wales which are involved in ongoing Welsh INNS research studies. The GB Non-Native Species Secretariat (the coordinating body for INNS action in GB) has recently established a research group which may be able to assist with some of this work. The WaREN may also provide an opportunity to improve recording within Wales in future.

Risk assessments for species yet to arrive/establish in the UK have been undertaken for species at an EU, species proposed to be listed as Species of Union Concern under the Invasive Alien Species Regulation, and Great Britain level. Action is needed to continue to support this work.

5. Ecosystem Services for Well-being

Some INNS are introduced because of the expected benefits they can provide, including ornamental and economic benefits. (Sladonja et al., 2018). but are subsequently found to be invasive if not managed appropriately. Others such as the zebra mussel are introduced unintentionally through commercial or recreational activities (GBNNSS, 2020).

In recent years there has been an increasing amount of research undertaken to improve understanding of the mechanisms and potential impact that INNS have on ecosystem services (Charles and Dukes, 2008; Walsh et al., 2016; Vila and Hulme, 2017; Martinez-Cillero et al., 2019). A comprehensive economic impact assessment of INNS at a GB and Wales level was undertaken in 2010 (Williams et al., 2010) - this assessment provided a good indication of the main sectors that are affected by INNS and correlates with the impact on provisioning ecosystem services.

To gain an indication of the main effects on ecosystem services that INNS are having in Wales a review of available data on the species of priority to Wales (those already present and those yet to arrive) was undertaken using online resources and academic research. Figure 19 shows the number of INNS present and yet to arrive in Wales and the ecosystem services they primarily impact.

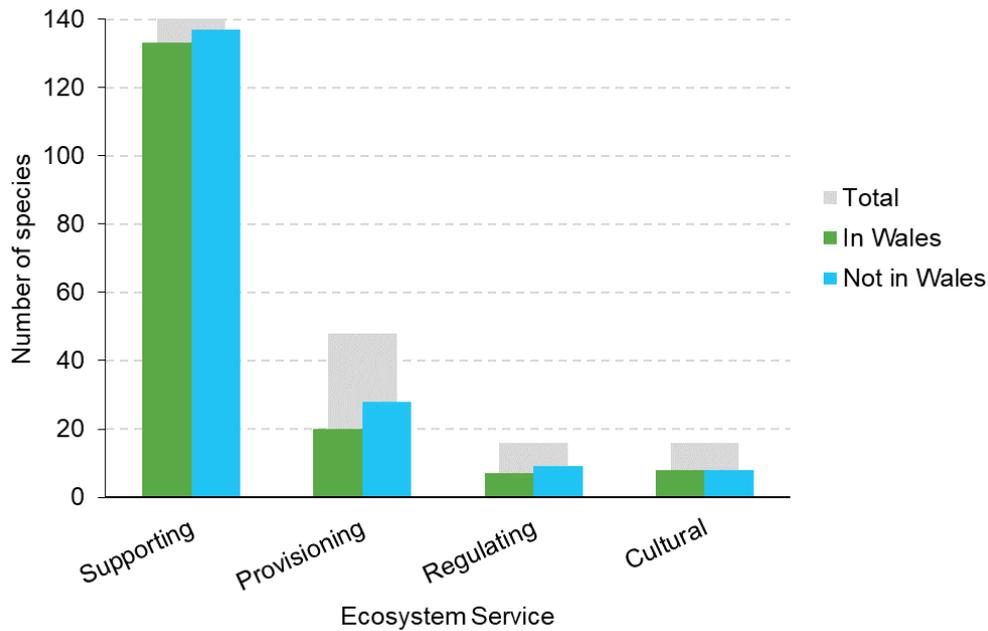


Figure 19 Number of species of priority to Wales, already present, not yet arrived, and combined total, and the type of ecosystem service they primarily impact (Data source: NBN Atlas, GBNNSS, CABI)

Occurrence records for INNS listed as being of priority to Wales, held on NBN Atlas Wales, were analysed to provide an indication of the number of INNS present in Wales which affect each ecosystem service (Figure 20). The number of occurrence records of INNS in Wales that could impact on each ecosystem service does not necessarily correlate directly with impact, however it can provide a broad indication of current overall impact.

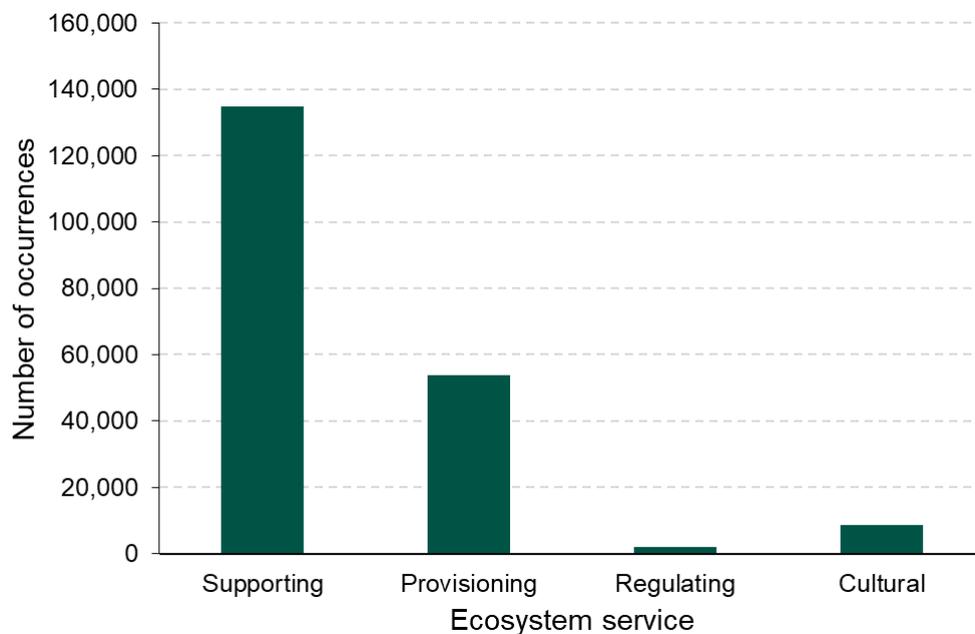


Figure 20 Number of occurrence records for species of priority to Wales that are already present and the type of ecosystem service they primarily impact (Data source: NBN Atlas, GBNNSS, CABI)

Supporting Services

INNS of priority to Wales could potentially impact several supporting ecosystem services: provisioning of habitat, biological diversity, photosynthesis, primary productivity, nutrient cycling, and soil formation. But are unlikely to significantly impact water cycling, maintenance of fertility, or atmospheric composition.

The main impact INNS have on supporting services worldwide is through a reduction in the provisioning of habitat by affecting its condition, extent, and function (Gutierrez, 2017). They can significantly reduce biological diversity by forming monocultures which outcompete other species, for example the impact of Cotoneaster on calcareous grassland. They can also contribute significantly to the decline or extinction of some species through competition, predation, or acting as vectors for disease such as crayfish plague (Manchester and Bullock, 2000; Tompkins et al., 2003; Roy et al., 2012; Morand 2017; Pyšek et al., 2017).

Some INNS listed as being of priority to Wales can significantly modify the environment in which they live causing disruption to nutrient cycling, photosynthesis, and primary production. Some aquatic plants can cause anoxic conditions. Some INNS, such as Broad-leaved everlasting-pea and False-acacia, can increase nutrient fixation in the soil, so reducing biodiversity as more robust plants outcompete rarer species. Nutrient cycling can be altered by changes in the trophic structure of ecosystems (Castro-Diz and Alonso, 2017).

If they were to become widespread; some invasive non-native flat worm species, such as the New Zealand flatworm, could disrupt soil processes by having an impact on native earthworm populations. This would reduce the recycling of organic material, the availability of nutrients, and impact soil structure.

Some self-seeding non-native trees and shrubs can affect atmospheric composition by causing changes in net ecosystem carbon exchange; by degrading bogs and inhibiting peat formation which reduces carbon sequestration (Nie et al., 2017).

Provisioning services

Provisioning services are products obtained from ecosystems, they include food, such as livestock, fisheries and crops, fibre, biochemicals, pharmaceuticals, freshwater, fuel, and ornamental resources.

Agricultural and horticultural crops used to produce food, fibre, biochemicals, and pharmaceuticals can be outcompeted, contaminated, damaged, or consumed by INNS (Williams et al., 2010; Fried et al., 2017). Where INNS such as feral goat and non-native deer disrupt the quality and quantity of grazing, livestock production can be affected.

INNS can act as vectors for pathogens (French, 2017). Freshwater and marine fisheries can be affected by predation, competition, and pests/pathogens (Gozlan, 2017). Effects on aquaculture include fouling of marine structures, equipment, and shellfish. For example, Slipper limpet affecting mussel beds, which increases processing costs and impacts on trophic levels.

Forestry crops used for fibre and fuel are vulnerable to INNS during replanting as they can outcompete, shade, or release allelopathic compounds into the soil which prevent saplings from establishing. Forestry crops are vulnerable to pests and diseases, such as *Phytophthora* spread through rhododendrons, and physical damage from invasive non-native mammals.

Some species of INNS, such as Chinese mitten crabs can affect water quality by increasing erosion and sediment loading and can contribute to eutrophication or red tides (Costa et al 2017).

Ornamental resources such as trees and shrubs are affected by diseases or non-native pests such as Oak processionary moth.

The genetic, pharmaceutical, and biochemical industries utilise species to produce products. Therefore, a loss in biodiversity through extinction can affect the ability for these industries to produce effective products in future. Species endemic to islands and isolated water bodies are particularly vulnerable to INNS.

Cultural services

Cultural ecosystem services are nonphysical benefits that humans obtain from ecosystems. They include tourism, education, spiritual, religious, aesthetic and cultural heritage values.

The impact of INNS on these ecosystem services are difficult to quantify however there are some species which can affect Welsh landscapes. Rhododendron covers hillsides in Snowdonia; Himalayan balsam and Japanese knotweed are found along some river systems (Beerling, 1990) and affect access. Other INNS have contributed, or could contribute, to major declines in iconic wildlife species through hybridisation, competition, consumption, or acting as vectors for disease. For example, American mink impact water vole populations and Spanish bluebell are a threat to native bluebell populations.

INNS can also affect human health by acting as vectors or reservoirs for pathogens, or by emitting toxins and triggering allergic reactions, for example Giant hogweed (Rabitsch et al., 2017; Nentwig et al., 2017).

Managing INNS can have positive effects on tourism by increasing the ability to observe rare species. Management of Grey squirrel protects Red squirrel populations and controlling INNS in water bodies improves access and conditions for recreational fishing and boating.

Regulating services

Regulating services are obtained from the regulation of ecosystem processes, they include air quality, climate, disease, and water regulation as well as water purification, waste treatment, pest control, pollination, erosion control, and storm protection. INNS have the capacity to affect these ecosystem services in Wales.

There are some key species on the horizon, but not yet in Wales, which could impact regulating services if they were able to establish and spread. Some invasive non-

native plants, such as Kudzu (*Pueraria montana*), emit chemicals (isoprene) which contribute to the production of air pollutants (Wolfertz et al., 2003).

Some INNS impact bogs by inhibiting peat formation, which subsequently affects their ability to sequester carbon and can impact climate regulation.

INNS can affect the management of surface water leading to localised flooding. For example, floating pennywort can block channels; Chinese mitten crabs can damage flood defences (Booy et al., 2017). Signal crayfish burrow into river banks (Harvey et al., 2011) and plant species form large monocultures which die back in winter, leaving bare soil banks vulnerable to erosion (Greenwood et al., 2020). It costs approximately £400,000 per annum to control INNS on flood risk assets in Wales (NRW, 2019a).

Some INNS, including Common Carp, can affect water purification processes by increasing nutrient concentrations (Costa et al., 2017), turbidity and sediment erosion, (Angeler et al., 2002). INNS can also cause anoxic conditions in water bodies which prevent the breakdown and recycling of waste matter.

INNS can act as a vector for plant, animal, and human diseases (Morand, 2017; Rabitsch et al., 2017). Natural pest control can be disrupted as INNS compete or consume beneficial insects, leading to imbalances in ecosystems or by acting as a vector for pests.

INNS can disrupt pollination by displacing native fauna (Spira, 2001; Morales et al., 2017), by directly preying on native pollinators or by luring pollinators away from native species (Chittka and Schurkens, 2001).

6. Relationship to the Sustainable Management of Natural Resources and Ecosystem Resilience

Aim 1: Natural resources are safeguarded and enhanced

Natural resources are the natural wealth of a country and include minerals, energy, soil, water, and biological resources.

There is limited evidence that INNS affect minerals or fossil fuel extraction. However, INNS can affect energy production by reducing the productivity of forestry and by restricting the movement of water in pipes which can inhibit the production of hydropower and affect cooling water intakes on power stations.

INNS such as predators of native earthworms can affect the health of soil and increase erosion.

INNS can affect water quality in enclosed waters by increasing turbidity, altering nutrient cycles and lead to anoxic conditions. In river systems they can increase suspended sediment due to increased erosion through burrowing into riverbanks.

INNS can have significant impacts on biological resources by outcompeting, predating, or hybridising with them; reducing abundance, range, and diversity, at a species and genetic level (see Provisioning services. for more in-depth description of the impact that INNS have on provisioning ecosystem services). Tackling current INNS issues in Wales and preventing INNS from establishing and spreading in future will help to safeguard and maintain natural resources in Wales.

Aim 2: Assessment of Resilience

Resilience is assessed against the categories of Diversity, Extent, Condition, Connectivity See the [SoNaRR Aim 2](#) webpage for a short guide to the definition and assessment of ecosystem resilience.

Diversity

The impact of INNS on the diversity of species, communities, and ecosystem has been extensively researched worldwide (Pyšek et al., 2012; Hejda and Pyšek, 2006; Hejda et al., 2009; Lishawa et al., 2019; Hejda and de Bello, 2013; Seeney et al., 2018; McGeoch et al., 2010).

INNS alter ecosystem processes (Raizada et al., 2008) which can affect biodiversity through predation, competition, acting as a vector for pests and diseases, hybridization (Blackburn et al., 2004; Gaertner et al., 2009; Vilà et al., 2000), altering

community structure (Hejda et al., 2009), and genetic diversity (Ellstrand and Schierenbeck, 2000; Schierenbeck and Ellstrand, 2009).

INNS can reduce species diversity so reducing the distinctiveness of biological communities at different spatial scales (Sax and Gaines, 2003; Winter et al., 2009). INNS are causing significant impacts on certain species in Wales such as the impact of Signal crayfish on native White-clawed crayfish; or more general disruption to trophic levels for example the effect of Himalayan balsam on native invertebrate communities.

Extent

INNS can negatively affect the extent of species and habitat which in turn can cause impacts on the extent of ecosystems. Invasive non-native plants can dominate and outcompete native flora and can form monocultures which completely prevent native plants from growing underneath (Peterken, 2001). This can lead to direct loss of the extent of habitat, for example, by turning semi-natural grasslands or heath into non-native scrub, altering riparian habitat, or preventing new saplings from establishing in woodlands (Gaggini et al., 2016; Gerber et al., 2008).

Invasive non-native animals can reduce the extent of habitat, for example, grazing pressure from invasive non-native herbivores such as non-native deer and goat can reduce the extent of heathland and prevent woodlands from regenerating (Cooke and Farrell 2001).

Condition

INNS can affect the condition of ecosystems and their supporting habitats by affecting their structure and function. The condition of ecosystems is not specifically assessed in Wales, however, the condition of some of the supporting habitats are assessed as part of the EU Habitats Directive Article 17 reporting process (JNCC, 2019). This information has been summarised to give an indication of the impact that INNS are having on the condition of ecosystems in Wales (Figure 21, Table 7, Figure 22). This was carried out as follows: the habitat features listed in Annex 1 of the Habitats Directive assessed in the Article 17 report were aligned to the SoNaRR ecosystems. The percentage of the Annex 1 habitats that are affected by INNS that align with each ecosystem was calculated (Figure 21).

The Article 17 report contains data about the condition of Annex 1 habitat features in Wales expressed as an area. The 'predominant' condition of each Annex 1 habitat is the condition category (favourable, unfavourable, unknown) applied to the largest area of each Annex 1 habitat. To provide an indication of the condition of each ecosystem the 'predominant' condition of the Annex 1 habitats affected by INNS that aligned to each SoNaRR ecosystem were summarised (Figure 22).

The pressure and threat scores associated with INNS for each SoNaRR ecosystem was calculated by determining the average pressure and threat scores of the Annex 1 habitats affected by INNS that align with each ecosystem. This was done by assigning a numerical value to the pressure and threat scores for each Annex 1 habitat affected by INNS and averaging the numerical value of the scores (Table 7).

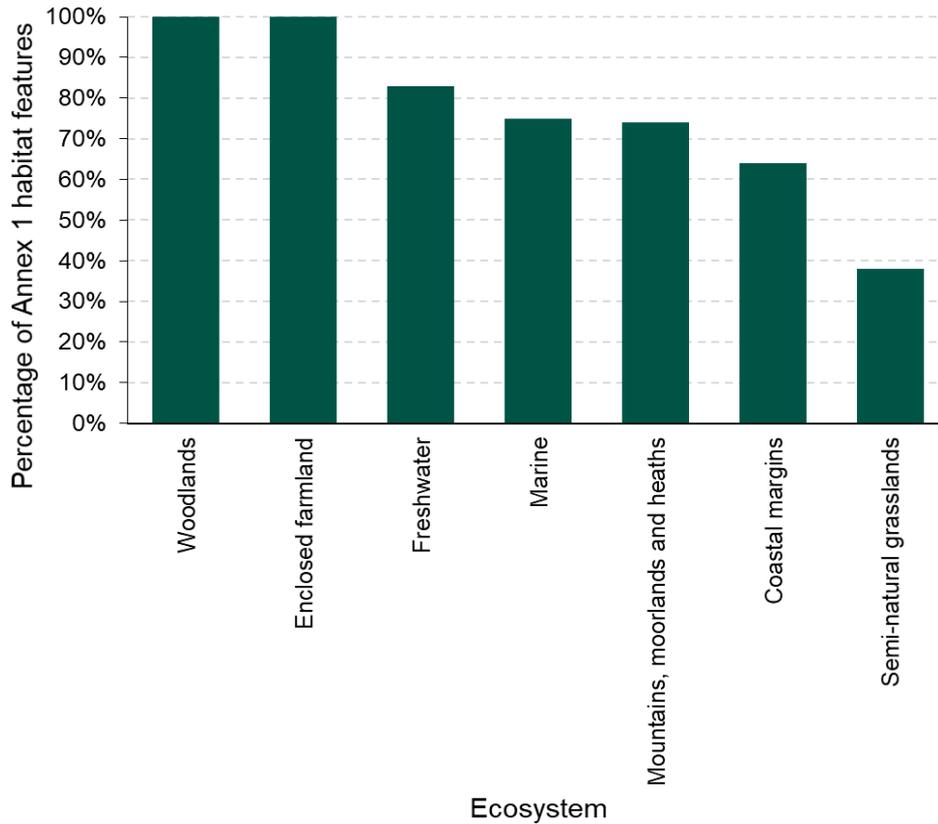


Figure 21 Percentage of Annex 1 habitat features impacted by INNS that in Wales that align with each ecosystem (Data source: JNCC, 2019)

Table 7 Average INNS-related pressure and threat scores for the Annex 1 habitats aligned with SoNaRR broad ecosystems in Wales (Data source: JNCC, 2019)

SoNaRR ecosystem	Pressure	Threat
Woodlands	High	High
Enclosed farmland	Low	Low
Freshwater	Medium	High
Marine	Medium	Medium
Mountains, moorlands and heaths	Medium	Medium
Coastal margins	Medium	Medium
Semi-natural grasslands	High	High

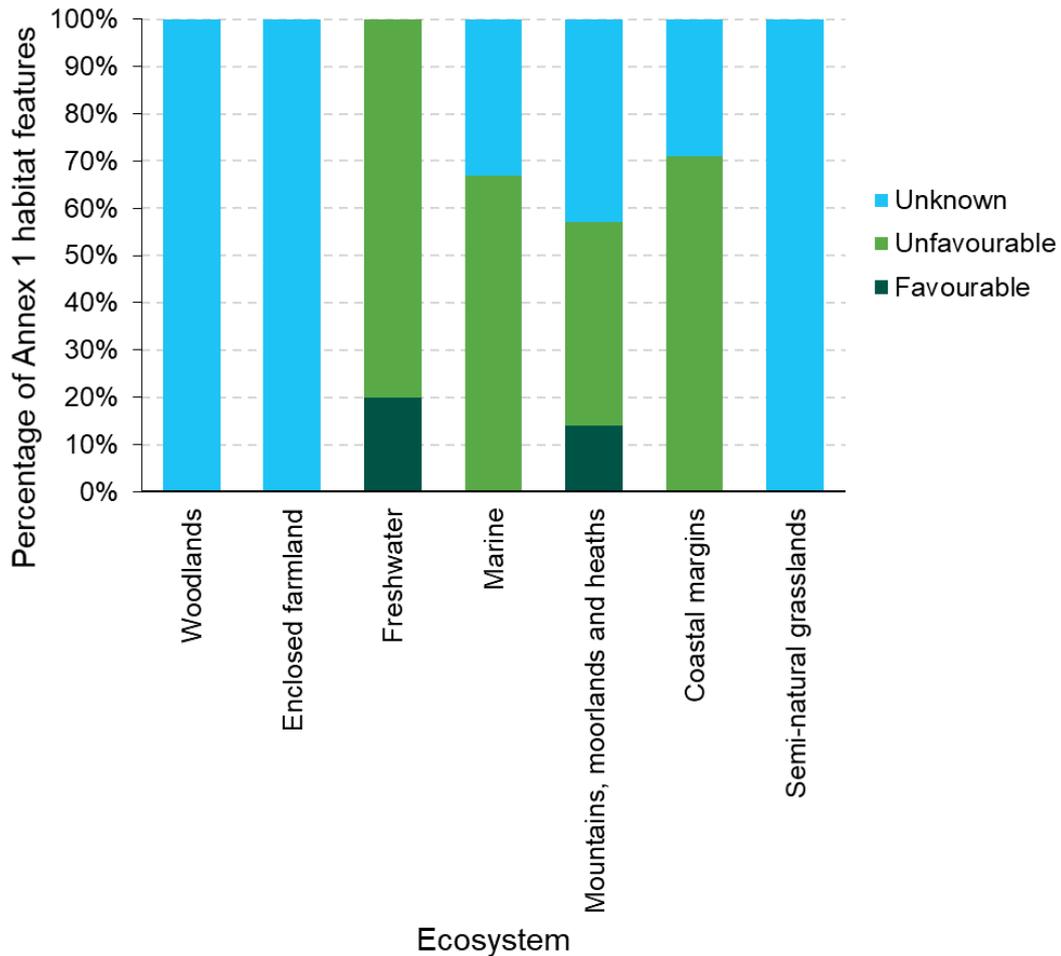


Figure 22 Condition of Annex 1 habitat features in Wales affected by INNS aligned with each SoNaRR broad ecosystem (Data source: JNCC, 2019).

An analysis of the Natural Resources Wales Actions database for protected sites was undertaken to establish which INNS currently affect protected sites in Wales, and how many sites are affected to give an indication of the impact of INNS on the current condition of priority habitat in those sites (NRW, 2019b).

719 management units covering a total area of at least 56,350 hectares of protected sites in Wales have been or are currently being affected by INNS; they are located within 238 Sites of Special Scientific Interest, 67 Special Areas of Conservation, 9 Special Protection Areas and 6 Ramsar sites.

The actions recorded on the database include physical management, investigation, monitoring, and prevention. The data therefore encompasses action on some species which are yet to establish within protected sites as well as those currently impacting them. Figure 23 shows the most frequently recorded INNS associated with actions to be undertaken on the management units of protected sites in Wales.

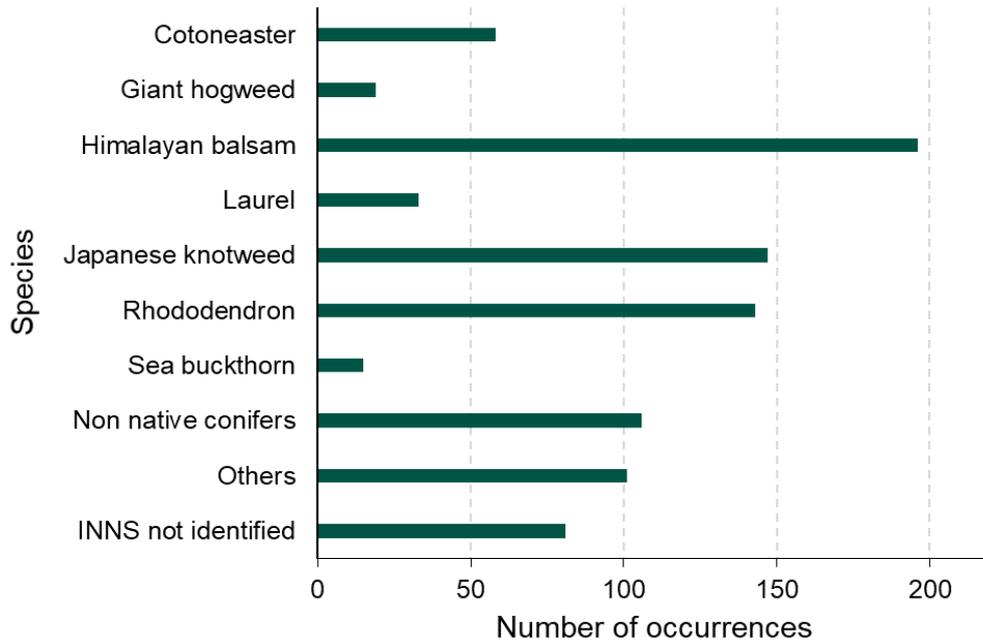


Figure 23 Number of occurrences of INNS associated with actions to be undertaken on management units of protected sites in Wales (NRW Actions database)

Connectivity

INNS can inhibit connectivity by altering or degrading habitat (Rudnick et al., 2012; Vilà and Ibáñez, 2011; With, 2002; Pyšek et al., 2012). This can create barriers to movement or reduce the ability of native species to be able to move and colonise new areas as the extent and condition of habitat is reduced. The presence of some INNS can prevent isolated strongholds of native species, such as Red Squirrels, from moving between areas leading to genetic isolation.

INNS often rely on ecological and physical connectivity in a landscape to be able to spread (Haddad et al., 2014; Jaspers et al., 2018; Chapman et al., 2019). It is important that the connectivity across landscapes and within ecosystems is considered in the management of INNS (Glen et al., 2013; Perry et al., 2017). This will rely on the availability of distribution data of sufficient spatial and temporal resolution and best practice guidance for the selection of effective and sustainable management tools.

Healthy places for people (Aim 3)

Human health issues caused by, or relating to, INNS were estimated to cost Wales approximately £5.8m per year in 2010 (Williams et al., 2010).

INNS can affect human health directly:

- By acting as a vector or a reservoir of human diseases; for example, Canada geese can host and transmit pathogens such as E.coli and Legionella (Rabitsch et al., 2017).
- By poisoning, stinging, biting, causing rashes, for example Giant hogweed,
- By exacerbating or triggering allergic reactions (Nentwig et al, 2017).

INNS can also affect well-being:

- By causing a nuisance - invading homes, depositing faeces, damaging crops, causing distress and noise, for example Ring-necked parakeets
- By adversely affecting the amenity of green spaces, access, culturally important species, and landscapes (Pejchar and Mooney, 2009). For example:
 - Affecting access for recreation by contributing to water quality issues, clogging up waterways, or overgrowing riverbanks
 - INNS have in the past led to declines and extinctions of culturally important plants and animals such as Red squirrel, which could carry on in the future.
 - INNS can impact landscapes, for example Rhododendron in Snowdonia, (Kueffer and Kull, 2017).

Regenerative Economy (Aim 4)

INNS have a downward pressure on the economy and the environment as they can reduce productivity and cause environmental degradation. An assessment of the economic impact of INNS in 2010 (Williams et al., 2010) estimated the cost of INNS to the economy of Wales as £125 million per year - a figure that is likely to have increased since due to increases in inflation and the increasing impact of INNS. Below is a summary of the costs to the economy of Wales per year broken down by sector (Figure 24).

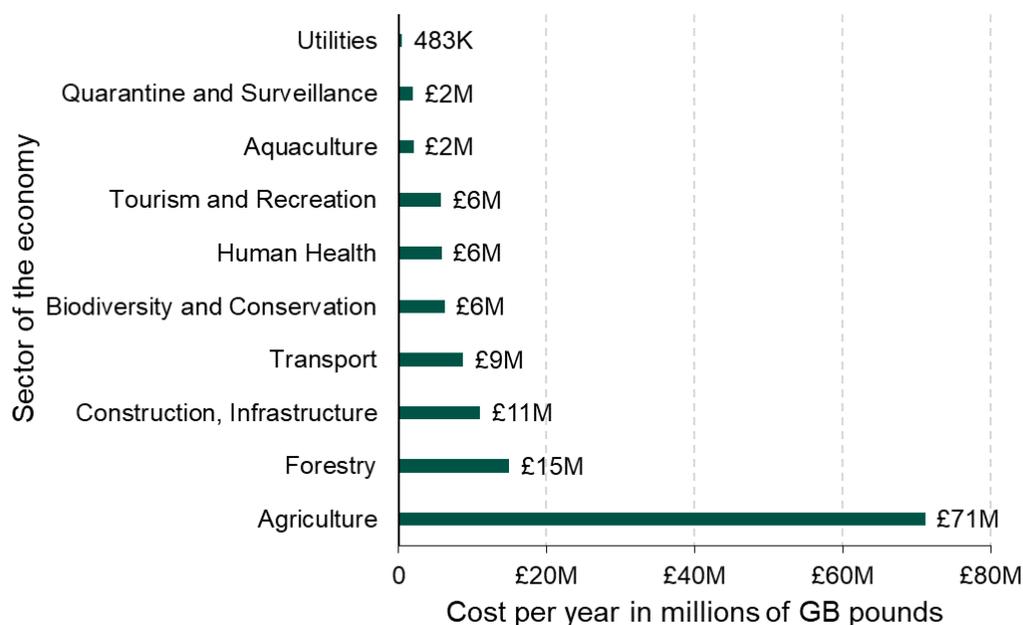


Figure 24 Cost per year, in millions of GB pounds, on sectors of the Welsh economy (Williams et al., 2010)

Tackling INNS that are affecting or could affect economic sectors of Wales will help to maximise productivity and maintain the provision of resources, thereby contributing to a circular economy.

The increasing trend in terms of the numbers and rate of INNS arriving in GB is set to continue unless action is taken to prevent this from occurring. INNS can be accidentally introduced and spread through the production and distribution of goods.

For example, the discovery of an Asian hornet at a food distribution facility in 2017 in Scotland. As a globally responsible country, it is important to ensure that production in Wales does not lead to the movement of INNS to other countries.

The Invasive Alien Species Regulation 2014 is an example of international cooperation in tackling INNS at an EU level to prevent them from spreading. Improving international cooperation, increasing action to reduce the risk of spreading INNS through imports/exports, and improving biosecurity within businesses to reduce the spread of INNS are likely to become more important as Wales trades with new markets or countries in the future.

7. Synergies and trade-offs

Trade-offs

Most INNS have arrived in Wales due to the movement of people and goods. Some have been introduced on purpose because of the ecosystem services they provide while others have been introduced accidentally, as a contaminant or hitch-hiker through trade, transport, or tourism. INNS can be difficult and costly to control or eradicate, and a balance must be struck between this cost and the impact that they have.

This has resulted in the following key conflicts or trade-offs in managing INNS in Wales:

- The efficient movement of people and goods to stimulate economic growth can increase the risk of introducing new INNS, as well as pests and diseases. A balance needs to be struck to ensure that the legal requirements preventing introduction of INNS are met while not significantly inhibiting trade or the movement of people and goods.
- Some non-native species can become invasive if not managed properly, for example, cotoneaster or some non-native pine species. However, the economic significance of them means that they will continue to be sold, kept, bred/cultivated, or planted because their benefits to the economy of Wales are considered to outweigh their potential impacts.
- Some non-native species can act as effective biocontrol. The risk of them becoming invasive is assessed when they are granted a licence to be released into the environment. There is always a small risk that there may be unforeseen impacts, however, the benefits are considered to outweigh any potential risk of impact.
- The economic impact of eradicating some species is likely to be very high due to the technical difficulties involved or because the species is widely spread. The impact that some INNS have on sensitive sites, provisioning ecosystem services, or culturally significant species means that continued long term control is needed to reduce their population size, or to eradicate them from certain locations to protect biodiversity or crops. Long-term control by applying an integrated pest management approach is often more achievable and cost effective for widely spread INNS than eradication (Myers et al., 2000; Robertson and Gemmill, 2004).

- Biosecurity is key to reducing the spread of INNS, pests, and diseases; currently it is not fully integrated into best practice or regulatory processes in Wales for businesses or organisations. Increasing the burden on business and other organisations to improve biosecurity may affect their ability to operate and increase costs. However, preventing the spread of INNS may also be key to protecting their interests/business.

Synergies

Developing an approach to tackling INNS that is informed by the best available evidence, taking into account social, economic and environmental issues will help to improve the resilience of ecosystems and their ability to deliver ecosystem services (Catford, 2017; Nie et al., 2017; Vilà and Hulme, 2017; Charles and Dukes 2008).

Synergies

- The [coastal margins ecosystem chapter](#) identifies constraints on physical processes, climate change, and insufficient protection and management of important sites as major issues. The presence of certain INNS has led to the increased stabilisation of dune systems. Addressing INNS affecting dunes will improve their condition and help address constraints to their physical processes and improve their resilience to cope with climate change.
- The [enclosed farmland chapter](#) identifies the need to implement sustainable food production and address biodiversity loss. INNS can affect the productivity of enclosed farmland (Fried et al., 2017; French, 2017; Williams et al., 2010) and adversely affect biodiversity. Tackling INNS will help to address these issues.
- The [freshwater chapter](#) identifies the need to improve water quality and to address biodiversity loss. INNS can affect water quality (Costa et al., 2017) and biodiversity, for example Signal crayfish affecting native crayfish and burrowing into banks causing erosion Tackling them will help to improve water quality, biodiversity, and will contribute to the restoration of habitats in order to increase connectivity between rivers and their flood plains.
- The [marine chapter](#) identifies the need to improve the condition of protected areas and for better evidence to support management. INNS can affect the condition of protected areas. Addressing INNS issues will contribute towards improving feature condition. Improving the provision of data in relation to marine INNS will contribute to improving the evidence base to support management.
- The [semi-natural grasslands chapter](#) identifies insufficient management or abandonment and insufficient protection and management of important sites as being major issues. INNS are contributing significantly to the decline in the condition, and sometimes the extent, of semi-natural grasslands in some areas, including habitat within protected sites, for example Cotoneaster on calcareous grasslands in north Wales. They have exacerbated impacts caused by insufficient management and abandonment. Therefore, there are synergies in addressing INNS issues and addressing the major issues identified above.
- The [urban chapter](#) identifies the need to improve the resilience of ecosystems to adapt to climate change and the lack of resources for managing green spaces as major issues. INNS can affect the resilience of ecosystems to adapt to climate change by contributing to localised flooding, therefore addressing INNS should help to tackle this issue. INNS can impact on access and the amenity value of

green spaces. Reducing the impact and spread of INNS could help to reduce the cost of managing green spaces in the future.

- The [woodlands chapter](#) identifies the need to improve the resilience of woodlands. INNS can affect all aspects of the resilience of woodlands and their productivity (Kenis et al., 2017), consequently there are synergies in addressing INNS issues and improving the resilience of woodland ecosystems.
- The [mountains, moorlands and heaths chapter](#) identifies reductions in the quality and extent of habitat, and key associated species, and the need to improve information about the quality of habitat as major issues. INNS can adversely affect the condition of habitats and species. There are synergies in both addressing INNS issues and collecting information about the distribution and impact of INNS and addressing these major issues.

8. Opportunities for action to achieve the sustainable management of natural resources

This section provides a summary of the main opportunities for improving action to tackle INNS in Wales, what the barriers are to improving action, and how these barriers can be overcome.

Collaboration

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 for addressing INNS across Wales that will build on the work of the Welsh Biodiversity Partnership INNS Group is being established, the Wales Ecosystem Resilience Network (WaREN), it has the potential to provide opportunities to increase stakeholder and public participation in decision making and increase opportunities for collaboration. The framework will scope tools and gather the evidence needed to drive collaborative action to tackle INNS and work towards improving strategic steer in relation to addressing INNS issues in Wales. The current legislative and policy drivers will help to inform the strategic steer, but it will also consider best available evidence and the three pillars of sustainability. The project also aims to engage with funders and to be able to draw down more funding in future to tackle INNS issues on the ground and to prevent INNS from arriving and establishing in the first instance.

Well scoped and costed projects with clear deliverables can meet policy objectives and demonstrate that INNS control or eradication can be done sustainably and can help to engage stakeholders and funders in the framework. The potential for peer-reviewed journal project outputs would lend credibility, provide a way of communicating findings and engage academic stakeholders in the framework.

Additional support, resources and advice for the WaREN project would help to develop these tools, and fully embed the collaborative framework for the long term.

Address INNS through land management schemes

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

INNS have multiple impacts and were estimated to cost the agriculture sector in Wales £71 million per annum in 2010 (Williams et al., 2010). The GB INNS Strategy identifies that INNS can affect agricultural and horticultural productivity, directly damage crops, act as vectors for pathogens, affect soil health, and exacerbate soil erosion (Fried et al., 2017; French, 2017).

Widely spread INNS need to be tackled at appropriate spatial scales to ensure that action is effective and sustainable in the long term. This may involve the engagement and coordination of multiple landowners in a catchment or landscape. Ensuring that eradication is effective needs long term action, including monitoring and funding (Jones et al., 2018).

INNS are highlighted in the Brexit and Our Land – public goods and economic resilience scheme consultation documents (Welsh Government, 2018). The inclusion of action to tackle INNS in any future land management scheme has the potential to significantly increase coordinated action to tackle INNS within appropriate spatial and time scales, as the funding from agricultural schemes has historically been longer than the grant funding cycle of 1-3 years. This could act synergistically with the action to support the collaborative framework, WaREN, which will be developing tools and a strategic steer to address INNS issues more effectively within Wales at appropriate spatial scales.

Promote biosecurity

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

Historically within Wales proportionally more effort and resources have been directed at tackling widely spread INNS as opposed to improving biosecurity and preventing INNS from arriving in the first instance. It is generally accepted that prevention of new INNS arriving is the most cost-effective way to address INNS issues.

Biosecurity is key to preventing the introduction and spread of INNS, pests, and diseases. A cultural shift is needed in the awareness and attitudes of individuals, business, and organisations in relation to INNS and biosecurity. Preventing the arrival of INNS is essential to protect biodiversity in Wales and to ensure ecosystem resilience is maintained so that they are better able to cope with existing and future threats such as climate change.

This can be achieved by raising awareness through more active promotion of the GB biosecurity campaigns in Wales. The "[Check, Clean, Dry](#)" campaign was renewed in

2019 and the “[Be Plant Wise](#)” campaign was renewed in 2020 by extending the scope to include terrestrial plants and refreshing the campaign material to reflect this. GB Invasive Species Week is being adopted by all members of the British Irish Council which is increasing the ability to coordinate action and initiatives at broader geographic scales and share ideas to promote biosecurity.

More resources and action are needed to promote these campaigns within Wales through the WBP INNS group and among other stakeholders. The development and implementation of a communications plan to promote these GB campaigns within Wales could improve awareness. Action is being undertaken to improve biosecurity at sensitive sites, such as Biosecurity Planning for Pen Llŷn a'r Sarnau Special Area of Conservation 2019-2022. Biosecurity is also being improved within organisations, for example action to make NRW an exemplar in biosecurity. Further action is needed to ensure that information, tools, and lessons learnt from these 'pilot projects' are shared so that the approaches can be adopted elsewhere.

To improve biosecurity implementation, accessible advice, guidance and training resources for all sectors are needed. They should be consistent, high quality and relevant and based on the most up to date evidence.

Driving Action

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

There are several INNS policy and legislative drivers within Wales, including WFD, MSFD, LIFE Natura 2000 Thematic Action Plan, Infrastructure Act 2015, Wildlife and Countryside Act 1981 and Woodlands for Wales Strategy. The most important drivers are the Invasive Alien Species (IAS) Regulations 2014, the IAS Enforcement and Permitting Order 2019 and the GB INNS Strategy 2015.

Work is ongoing to support the actions associated with the IAS Regulation including embedding the IAS Enforcement and Permitting Order 2019 and GB INNS Strategy which is due to be reviewed and updated shortly, review planned for 2021.

Initially there was a lack of capacity in Wales to support and implement actions associated with these drivers. However, these drivers have necessitated an increase in capacity to support actions associated with them.

The implementation of actions associated with these drivers and the powers provided by them allow action in tackling INNS within Wales in a strategic and collaborative way with the rest of GB.

These drivers will also encourage preventative action including supporting the development of pathway action plans for priority pathways and promoting recording and improving the provision and access to INNS records. Further action includes early intervention in developing and embedding contingency plans at a Wales level to tackle newly arrived INNS, and in building capacity to respond to newly arrived species listed under the Invasive Alien Species regulation.

9. Evidence Needs

A considerable amount of work has been undertaken to gather and analyse information about INNS and their impacts in Wales as part of SoNaRR2020.

The broad evidence needs that have been identified are:

- What impact are/will INNS of Interest to Wales have on SoNaRR ecosystems, their resilience and the ecosystem services they provide in Wales, currently and in the future?
- How are INNS of interest to Wales being tackled in Wales?
- How effective we are at meeting SMNR in relation to INNS management?

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