The Second State of Natural Resources Report (SoNaRR2020)

SoNaRR2020 Register enclosed farmland evidence

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 Register enclosed farmland evidence**

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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 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 in March 2021

Acronyms and Glossary of terms. Published in December 2020 and updated in March 2021

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Enclosed Farmland Natural Resource Register Evidence List

SoNaRR2020

The evidence below has been extracted from the enclosed farmlands chapter unless otherwise stated.

If the original piece of evidence is not cited within this document then it can be found in the enclosed farmlands chapter or associated chapters, which will be published in March 2021. At that point this document will be superseded.

Contents

Evidence List: Drivers, Pressures and Impacts Table

Climate Change

1. **Changing Weather Patterns**

    1.1. **Will increase the risk of flooding in Wales**
    From Climate Change Chapter
    Flooding has a wide range of impacts on communities, including loss of homes, income and negative effects on mental health and well-being over long periods of time. As well as the impact on urban areas, flooding could damage valuable farmland (Keay, 2020). [Link to Enclosed Farmland Chapter] and cause detriment to water quality and subsequently impact on biodiversity and ecosystem resilience.

    1.2. **More frequent prolonged period of dry weather could lead to increased pressure on water resources, soils and the natural environment. Some areas will see an increase in productivity and others a decrease**
    From Land Use and Soils Chapter
    Some ecosystems will be more vulnerable than others. Enclosed farmland is likely to be more vulnerable to summer droughts than semi-natural grasslands.

    From Land Use and Soils Chapter
    Some areas show a reduction in the number of field capacity days (FCD) in the future, however most areas in Wales will have a similar number of FCD to the baseline period. In areas where there is little change in FCD in the future, there would be limited capacity for the soil to cope with the additional winter rainfall and increased frequency of intense winter rainfall events (Keay & Hannam, 2020)

    From Land Use and Soils Chapter
    Agricultural (and forestry) potential will improve in some areas. Some areas may see a shift from grassland to arable systems as areas become more climatically suitable for horticultural or a combination of crops. Land that is currently not graded as Best and Most Versatile (BMV) may improve sufficiently in grade in the future to be included in BMV. Changes in land use may increase the risk of soil threats such as erosion by converting from grass to arable with periods of bare soil over a growing season (Keay & Hannam, 2020).

    From Land Use and Soils Chapter
    Agricultural (and forestry) potential will decrease in some areas. In these areas the changes in overall Agricultural Land Classification grade are primarily driven by an increase in the drought criteria. This is a result of increased temperatures over the growing period and reduced summer rainfall. These areas will need to be irrigated in the future if they are to maintain productivity, particularly if they are used for higher value arable and horticultural crops. Crop selection and agricultural practices may need to change in future. This will increase competition for water resources in the future. Water capture during winter may need to be implemented to compensate for the water deficit in the summer months. Soils need to be high in OM and structurally in their best condition to be able to retain as much moisture as possible and allow unimpeded drainage (Keay & Hannam, 2020).

    From Land Use and Soils Chapter
    Agricultural (and forestry) potential will decrease in some areas. In these areas the

changes in overall Agricultural Land Classification grade are primarily driven by an increase in the drought criteria. This is a result of increased temperatures over the growing period and reduced summer rainfall. These areas will need to be irrigated in the future if they are to maintain productivity, particularly if they are used for arable and horticultural crops

From Water Efficiency Chapter
As river and groundwater levels fall, water availability will decrease. Current abstractions may become unsustainable, abstraction licences may be further constrained due to potential impacts on the watercourse ecology. Alternative water sources may have to be used such as off-line storage, filled by rainwater to be used during dry periods, which may result in a substantial loss of land available for crops.

1.3. **Area for best most versatile land predicted to substantially decrease from 2050 (high emissions scenario)**
By 2050 and 2080 the overall BMV area in Wales (Welsh border, parts of Pembrokeshire, Anglesey and north Wales) are predicted to be downgraded due to drought constraints. This assumes crops are not irrigated. The ALC droughtiness criteria is based on water availability and moisture deficit for two reference crops (winter wheat and potatoes) and is influenced by soil properties, summer temperature and summer rainfall (Keay & Hannam, 2020).

2. **Sea Level Rise**

2.1. **Will increase the risk of flooding in Wales.**
See evidence provided in 1.1

Pollution

3. **Air Pollution**

3.1. **Likely to cause a detrimental impact upon the ecosystem and its services**
Current agricultural management often generates emissions of greenhouse gases and releases nutrients to air and water, resulting in Enclosed Farmland causing net disbenefits to many services.

In 2018 agriculture is estimated to have contributed around 14% of total Welsh greenhouse gas (GHG) emissions. These are dominated by methane (62%) and nitrous oxide (28%), with only 10% of sector emissions as carbon dioxide (Welsh Government, 2019b; NAEI, 2020).

The land use sector provides a very small net sink of emissions (-42 ktCO2e), while 0.5 MtCO2e is due to fuel use in agricultural machinery and the small remainder of emissions (0.3 MtCO2e) are due to electricity use in the agriculture sector, (CCC 2013).

The GHG emissions from agriculture is dominated by livestock (largely from sheep and cattle), which accounts for 54% of the sector’s emissions in 2016. Fertiliser use for agricultural productivity is another significant source of emissions, comprising 21% of agriculture emissions. In 2016, Welsh Agriculture sector emissions increased by 5% compared to 2015. This is largely a result of a 55% increase in the amount of nitrogen fertiliser directly applied to agricultural soils on grassland (Welsh Government, 2019b).

3.2. **Resulting in acidifying and adding nitrogen to systems and causing an odour nuisance and negative impacts on biodiversity in both terrestrial and aquatic environments.**
Agricultural sources are responsible for 91% of ammonia emissions, with cattle manure management alone accounting for over 35% of emissions (Figure 22). The trend in ammonia emissions has been largely driven by decreasing animal numbers and a decline in fertiliser use, which had decreased emissions until 2010. However, increased emission from manure management practices, particularly for dairy cattle, and from the application of ammonium nitrate and digestate fertilisers to soils have seen emissions increase since reaching a minimum in 2007 (NAEI, 2019).

Many interactions between provisioning and other ecosystem services are negative, because of releases of nutrients from agriculture as greenhouse gas emissions and diffuse water and air pollution, and because of native biodiversity being displaced by crops and species-poor grassland.

4. **Water Pollution**

4.1. **Resulting in less diverse plant communities**
There is some evidence that eutrophication is resulting in less diverse plant communities. Hedgerow ground flora plots recorded in GMEP show that species that thrive in high nutrient conditions such as nettle and cleavers are becoming more frequent (16% of plots with greater than 20% eutrophic vegetation in 2007 increasing to 42% in 2016), (ERAMMP report 2020).

Changes in farming practices since the second world war, including the increased use of herbicides and inorganic fertilisers, efficient seed cleaning, more competitive crop varieties and changes from spring sown to autumn sown cropping, have taken their toll. The conversion of arable land to permanent pasture is a particular problem. As a result, arable flowers such as corn buttercup, red hemp-nettle and small-flowered catchfly are now highly endangered, (Walker et al, 2017).

From Land Use and Soils Chapter
Mycorrhizal fungi form a symbiotic relationship with plant roots essential to plant growth and health and, as they are highly affected by fertilisers and land management practices, help us understand the health of our soils. A study across large geographical scales showed higher cover of ectomycorrhiza vegetation (extra-cellular fungi) was broadly associated with greater soil C stocks in both topsoil and subsoil, while arbuscular mycorrhiza vegetation (intra-cellular fungi) was more variable, weaker and mostly had negative relationships. However, other variables such as climate, soil nutrients, especially nitrogen availability, and soil texture may affect both soil carbon and mycorrhizal plant distributions (Soudzilovskaia et al., 2019).

4.2. **Causing eutrophication of both freshwater and terrestrial ecosystems from both artificial and organic fertilisers.**
In 2019, 113 water bodies have been identified across Wales to be failing Water Framework Directive standards associated with agricultural activities (NRW Challenges and Choices Consultation, 2019).

Agriculture accounts for approximately 60% of nitrates in rivers (Hunt et al. 2004) and, consequently, influences coastal water quality and fisheries (EEA 2001).

Agriculture is also a major source of phosphorus, the primary nutrient responsible for eutrophication in freshwater (Jarvie et al. 2010), affecting the ecological balance of the aquatic environment and leading to changes in animal community structure (Maier et al. 2008; Jarvie et al. 2010).

4.3. **Affecting soil condition**
Nitrogen and phosphorous concentrations show a downward trend in arable and improved grasslands (the decrease is significant for phosphorous and nitrogen in improved grassland after 1998), mirroring the trend in artificial fertiliser use. However, P levels in mesotrophic (neutral pH) grasslands remain high for habitat support (Seaton, 2020).

There has been a significant decrease in soil pH since 2007 on improved grassland and increase on semi-improved grassland since 1978. The recorded soil pH on improved grassland is now below the optimum pH for grass growth of 6.0 (Nutrient Management Guide, Defra, 2020).

From Land Use and Soils Chapter
In 2015, soils from 11 EU Member States (including Wales) and six main cropping systems showed over 80% of the tested soils contained pesticide residues (25% of samples had one residue, 58% of samples had mixtures of two or more residues), in a total of 166 different pesticide combinations (Soudzilovskaia., 2019). Recent research suggests that the herbicide glyphosate persists in soil for longer than previously thought and to negatively affect soil organisms that are responsible for nutrient cycling and maintaining soil structure, including earthworms (Soil Association, 2016).

The results showed animal richness is negatively influenced by intensive land use and unaffected by soil properties, while microbial richness was driven by environmental properties in addition to land use (George et al, 2019).

5. **Land Pollution**

5.1. R**esulting in less diverse plant communities**
See evidence provided in 4.1

5.2. **Causing eutrophication of both freshwater and terrestrial ecosystems from both artificial and organic fertilisers.**
See evidence provided in 4.2

5.3. **Affecting soil condition**
See evidence provided in 4.3

Land Use Change

6. **Agricultural Intensification**

6.1. **Resulting in the loss of habitats**
The brown hairstreak butterfly has undergone a 43% contraction of its range since the 1970’s and monitored populations in Wales are showing large recent declines

(Figure 15). The butterfly's main habitat requirements are for young blackthorn shoots. Mechanical flailing of hedges or scrub during the September to February period has been shown to remove 80-90% of eggs. If hedges are mechanically flailed year on year, the ever-decreasing remaining population vanishes within a couple of years.

Biesmeijer et al. (2006) found significant UK landscape-scale declines in native bee species richness. Both hoverfly and bee communities have gradually become dominated by a few common species, with 29% fewer bee and hoverfly species occurring in Britain since 1980. There are a number of pressures on pollinator populations, including the loss of basic habitat requirements in our landscapes such as breeding sites, floral resources, the promotion of monocultural crops, larger fields and less traditional boundary features, and the intensive use of agro-chemicals.

Analysis of GMEP data found that although trees are often present in boundaries, trees were absent from 74 to 90% of improved and semi-improved fields that were surveyed across Wales (ERAMMP, 2020). Figure 9

Many farmland species depend upon different components in the landscape to provide the requirements for their whole lifecycle. Reduction of this diversity is contributing to significant declines in farmland species.

From Land Use and Soils Chapter
A national-scale metabarcoding analysis of soil biodiversity across 436 locations in Wales within seven different vegetation classes (crops/weeds, fertile grassland, infertile grassland, lowland wood, upland wood, moorland grass mosaic and heath/bog) was undertaken by GMEP. The results showed animal richness is negatively influenced by intensive land use and unaffected by soil properties, while microbial richness was driven by environmental properties in addition to land use (George et al.,2019)

6.2. **Results in declines in species populations. Specialist farmland species are declining the most rapidly among all the ecosystems.**
Agricultural intensification and specialisation have simplified the farmed environment and created a domain for few species where once there was abundant diversity. Of the 1,467 flowering plants in the Welsh flora, 38 are extinct and 302 (20.6%) are considered to be threatened or nearly so in Wales, 95% of which grow on productive farmland. (Plantlife, 2014).

The latest lowland farmland bird indicator for Wales (1994-2016) highlights the accelerating declines in birds of farmed habitats. The lowland farmland indicator has fallen by nearly 30% since 1994 (Figure 16). For example, between 1995-2016 starlings have declined by 72%, curlew by 63%, yellowhammers by 58% and both turtle dove and corn bunting are virtually extinct as breeding birds in Wales.

Diversity in intensive arable systems is very low; cropping relies on monocultures with extremely limited native plant cover. Alternative systems with higher crop diversity such as intercropping are rare.

Improved grassland, as the predominant land cover, has the largest impact. Although covering a large area and forming connected blocks, resilience is low due to the reliance of an extremely low number of species within the grassland and high external inputs.

From Land Use and Soils Chapter
In Wales, although the overall weight and rate of plant protection products or pesticides have declined, the area of use has increased (FERA, 2020)

The largest GHG emission sources in 2018 in the LULUCF sector are from grassland conversion to cropland (27%) and existing cropland (24%). The largest sinks are existing woodland (56%), cropland conversion to grassland (12%) and existing grassland (13%).

6.3. **The largest GHG emission sources in 2018 in the Land Use, Land Use Change & Forestry (LULUCF) sector are from grassland conversion to cropland (27%) and existing cropland (24%).**

From Land Use and Soils Chapter
The largest GHG emission sources in 2018 in the Land Use, Land Use Change & Forestry (LULUCF) sector are from grassland conversion to cropland (27%) and existing cropland (24%). The largest sinks are existing woodland (56%), cropland conversion to grassland (12%) and existing grassland (13%). (LULUCF Sector Sources 2018: NAEI, 2020)

6.4. **Results in habitat loss and increased habitat fragmentation**
Over the last half century, intensive agriculture has been the biggest driver of biodiversity decline across the UK (Burns et al, 2016). Loss of semi-natural habitats and fragmentation of those remaining has caused massive declines in farmland species.

Grazing in hedgerow can lead to gaps in base. Gaps in canopy effectively fragment habitat and reduce usefulness for navigation and movement corridors for biodiversity and ecosystem services delivered.

Current arable systems rely on high external inputs. Traditional arable land has high diversity of plants but covers an extremely small area and is highly fragmented.

7. Built Development and Infrastructure

7.1. **Urban expansion leads to the loss of high-grade soils**
Due to the co-location of urban areas and high-grade soils, urban expansion has often been at the expense of the most productive land. The total loss of BMV land over the period 1939 to 2011, was 21,300 hectares (6.7% of the resource). The predicted annual loss of BMV land to urbanisation over the next five decades is expected to be minimal when compared to historical loses: an estimated 125 hectares, on average, of BMV land will be lost to urbanisation per annum over the period 2018 to 2065 (Lewis-Reddy, L. & Behrendt, K., 2020). The largest GHG emission sources in 2018 are from grassland conversion to settlements (21%) and existing settlements (17%). The aim for a Low Carbon Wales is to significantly increase the LULUCF sink in Wales by the year 2030 by increasing tree cover, reducing carbon loss from peatlands and building carbon stores within soils and biomass. Peatland is not well represented in 2016 carbon budgets as it only considers emissions from peatland extraction for fuel or horticultural use, which is a

small component in Wales. It is expected a new methodology will be introduced which will take account of a wider range of emissions from peatland. This will alter the overall LULUCF inventory for Wales.

8. **Competing Land Use**

8.1. **Woodland Creation leads to the possible loss of land**
Welsh commitment to tree planting will take land out of agricultural production. Depending on species and location choice, new woodlands can sequester carbon and deliver improved ecosystem services, in the wrong place they can have a negative impact on both.

8.2. **Renewable energy generation including bioenergy has created a new pressure on productive land area**
Grow more bioenergy crops. This would take land out of food production. Without careful management, bioenergy crops could have negative impacts on biodiversity, soil health and water quality.

UK govt recognising the versatility of bioenergy in both heat an electricity. UKCCC highly recommends Bioenergy as possible pathway to address net zero.

INNS, Pests and Diseases

9. **Pests and Diseases**

9.1. **Tree losses are on the cusp of accelerating due to Ash Dieback (Chalara). Individual trees will be lost and gaps created in hedgerows and riverine corridors, reducing their connectivity and changing the landscape.**
Ash-die back has the potential to create more gaps in hedgerows and kill hedgerow trees, thereby reducing resilience. Hedgerow tree losses are almost certainly on the cusp of accelerating due to Ash Dieback (Chalara). Over the next 5 to 10 years losses caused by Chalara are likely to dwarf losses for other reasons.

Between 1951 and 2007, the number of hedgerow trees fell dramatically across Britain from over 56 million to less than 2 million (Carey et al., 2008); around half of these were elm trees killed by Dutch Elm Disease (Forest Research, 2010).

From INNS Chapter
The heat map of occurrence records of INNS of interest to Wales which impact on the enclosed farmland ecosystem in Wales (Fig 8e) indicates that many are not widely distributed across Wales and mainly correlate with towns and cities. Many of these species are likely to be introduced initially through areas where there is more movement of goods and people and the current distribution may represent an earlier stage of invasion after which these species will spread out from these locations into the wider countryside. The INNS of interest to Wales that primarily affect enclosed farmland ecosystems include invasive plant species that reduce productivity and are difficult to remove, INNS which directly damage or feed on crops, species which are vectors for disease and species which predate native invertebrates important for nutrient cycling and soil health (e.g. earth worms).

Over-exploitation

10. **Agricultural Intensification**

10.1. **Habitat change, diffuse pollution to water, Greenhouse Gas and Ammonia emissions**

From Land Use and Soils Chapter
Continued expansion of poultry units. There is a high density of poultry units in Powys. Most of these units are below the permitting threshold (Aazem & Bareham, 2015; CPRW, 2020; Bosanquet, 2019).

From Land Use and Soils Chapter
The latest estimates in numbers of dairy cows (females aged 2 years or more that have calved) is around 251,592 (as at June 2019) and has risen by 1.2% compared to 2016 and are 3k lower compared to 2018 (AHDB, 2020). In the last 20 years, the number of dairy farms has halved but the Welsh dairy herd has expanded such that average herd size has doubled (Welsh Government, 2020). South West area is the largest area, with a higher density of dairy cattle per hectare of grassland (HCC, 2019).

From Land Use and Soils Chapter
Estimated sheep numbers have recently declined but are still higher compared to the historical estimated numbers in the 1970s (Welsh Government, 2019) Wales.

References: Drivers, Pressures and Impacts Summary Table

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Evidence List: Assessment of SMNR

Aim 1: Stocks of Natural Resources are Safeguarded and Enhanced

Aim 1: Progress towards meeting Aim

1.1 Participation in Glastir has increased management to prevent soil erosion and run-off, specifically leaving stubble in fields over winter (59% within scheme vs 44% outside) and the establishment of buffer strips on arable land (42% within scheme vs 16% outside). Glastir has also raised the uptake of soil nutrient testing (61% vs 51%) and the calibration of fertiliser spreaders (72% vs 62%), (Anthony, 2017 – Alex Plows notes).

1.2 Greater Horseshoe bats - Studies have shown that the diet of the greater horseshoe bat is dominated by cockchafer beetles, dung beetles and moths. The use of antiparasitic drugs, such as avermectins significantly affects dung beetle populations and can therefore impact on juvenile and adult survival. By managing the usage of avermectins in the cattle which graze areas close to greater horseshoe roosts, and ensuring the rotation of grazing areas moves cattle to locations close to summer roosts and winter hibernation sites at appropriate times of year, positive trends in survival and population growth have been noted (Figure 18 Wales index of greater horseshoe bat population from Hibernation Surveys (source: ref), (Ref – ask Sam)

Aim 1: Obstacles remaining to meeting Aim

1.3 From Land Use & Soils Chapter - A lower area of land was under Glastir in 2019 compared to 2018. This is likely to be due to a reduction between the amount of active contracts areas in 2018 and 2019 as the main Glastir Schemes (Commons, Entry/Advanced & Organic) are coming to an end (5 years + 2 yr extension) and some contract holders declined their extension offers (Welsh Government, pers.comm).

1.4 Agricultural intensification and specialisation have simplified the farmed environment and created a domain for few species where once there was abundant diversity. Of the 1,467 flowering plants in the Welsh flora, 38 are extinct and 302 (20.6%) are considered to be threatened or nearly so in Wales, 95% of which grow on productive farmland. (Plantlife, 2014). A typical improved field will be home to only around seven different species of wild plant, and an intensive arable field home to about six (Figure 14 Estimates of species richness in vegetation plots from GMEP (excluding non-native species) (ERAMMP, 2020). By contrast, an established well-managed meadow could contain 160 species, a diversity that sustains a wealth of invertebrates and other wildlife.

1.5 Over 120 plant species make up the flora of arable land in Wales but, despite their role in sustaining farmland wildlife, wild arable plants are the fastest declining group of plants. Changes in farming practices since the second world war, including the increased use of herbicides and inorganic fertilisers, efficient seed cleaning, more competitive crop varieties and changes from spring sown to autumn sown cropping, have taken their toll. The conversion of arable land to permanent pasture is a particular problem. As a result, arable flowers such as corn buttercup, red hemp-nettle and small-flowered catchfly are now highly endangered, (Walker et al, 2017).

1.6 Many species of wild pollinator, including bumble bees, solitary bees and hoverflies, are under threat. Biesmeijer et al. (2006) found significant UK landscape-scale declines in native bee species richness. Both hoverfly and bee communities have gradually become dominated by a few common species, with 29% fewer bee and hoverfly species occurring in Britain since 1980.

1.7 The brown hairstreak butterfly has undergone a 43% contraction of its range since the 1970’s and monitored populations in Wales are showing large recent declines (Figure 15). The butterfly’s main habitat requirements are for young blackthorn shoots. Mechanical flailing of hedges or scrub during the September to February period has been shown to remove 80-90% of eggs. If hedges are mechanically flailed year on year, the ever-decreasing remaining population vanishes within a couple of years.

1.8 The latest lowland farmland bird indicator for Wales (1994-2016) highlights the accelerating declines in birds of farmed habitats. The lowland farmland indicator has fallen by nearly 30% since 1994 (Figure 16). For example, between 1995-2016 starlings have declined by 72%, curlew by 63%, yellowhammers by 58% and both turtle dove and corn bunting are virtually extinct as breeding birds in Wales. (BTO) Agricultural management during the period of the index has had the greatest impact on farmland birds through the loss of seed and invertebrate dietary resources.

1.9 There has been a significant decrease in soil pH since 2007 on improved grassland and increase on semi-improved grassland since 1978. The recorded soil pH on improved grassland is now below the optimum pH for grass growth of 6.0 (Nutrient Management Guide, Defra, 2020).

1.10 Soil erosion by water is an important degradation process that occurs naturally but can be accelerated by inappropriate land management. It's been reported that Wales is predominantly susceptible to water and upland erosion, and that large areas of Wales are assumed to have low erosion rates due to the predominance of grassland and rough grazing, although this has not been quantified by measurements or observations (Cranfield University, 2016). Require further validation before they can be assumed to be applicable to Welsh soils.

Aim 2: Resilient Ecosystems

Aim 2: Progress towards meeting Aim

2.1 Within Wales, 1229 km2 of productive land is on floodplain (4-9% is arable land and 50-51% improved grassland). (E. Rothero, 2018).

Aim 2: Obstacles remaining to meeting Aim

2.2 In 2019, 113 water bodies have been identified across Wales to be failing Water Framework Directive standards associated with agricultural activities (NRW Challenges and Choices Consultation, 2019).

2.3 Biodiversity in intensive arable systems is very low; cropping relies on monocultures with extremely limited native plant cover. Alternative systems with higher crop diversity such as intercropping are rare. Current arable systems rely on high external inputs. Traditional arable land has high diversity of plants but covers an extremely small area and is highly fragmented.

2.4 Evidence provided in SMNR Aim 2 Resilient Ecosystems Chapter

2.5 Evidence provided in SMNR Aim 2 Resilient Ecosystems Chapter

2.6 Evidence provided in SMNR Aim 2 Resilient Ecosystems Chapter

2.7 From Land Use and Soils Chapter - A national-scale metabarcoding analysis of soil biodiversity across 436 locations in Wales within seven different vegetation classes (crops/weeds, fertile grassland, infertile grassland, lowland wood, upland wood, moorland grass mosaic and heath/bog) was undertaken by GMEP. The results showed animal richness is negatively influenced by intensive land use and unaffected by soil properties, while microbial richness was driven by environmental properties in addition to land use (George *et al*, 2019). In 2015, soils from 11 EU Member States (including Wales) and six[1] of the tested soils contained pesticide residues (25% of samples had one residue, 58% of samples had mixtures of two or more residues), in a total of 166 different pesticide combinations. Glyphosate and its metabolite AMPA, DDTs (DDT and its metabolites) and the broad-spectrum fungicides boscalid, epoxiconazole and tebuconazole were the compounds most frequently found in soil samples and the compounds found at the highest

[1] Vera Silva, Hans G.J. Mol, Paul Zomer, Marc Tienstra, Coen J. Ritsema, Violette Geissen, 2019. *Pesticide residues in European agricultural soils – A hidden reality unfolded.* Science of The Total Environment, Volume 653, Pages 1532-1545, ISSN 0048-9697. Available from : http://www.sciencedirect.com/science/article/pii/S0048969718343420

concentrations (Silva et al., 2018).
Recent research suggests that the herbicide glyphosate persists in soil for longer than previously thought and to negatively affect soil organisms that are responsible for nutrient cycling and maintaining soil structure, including earthworms (Soil Association, 2016).

Aim 3: Healthy Places for People

Aim 3: Progress towards meeting Aim

3.1 Evidence provided in Assessment of SMNR

3.2 Wales Land Management Forum Sub Group on agricultural pollution are still committed to deliver the recommendations identified by the members to tackle and eliminate agricultural pollution (NRW pers. Comms)

Aim 3: Obstacles remaining to meet

3.3 In 2018 agriculture is estimated to have contributed around 14% of total Welsh greenhouse gas (GHG) emissions. These are dominated by methane (62%) and nitrous oxide (28%), with only 10% of sector emissions as carbon dioxide (Welsh Government, 2019b; NAEI, 2020).

3.4 Agriculture accounts for approximately 60% of nitrates in rivers (Hunt et al. 2004) and, consequently, influences coastal water quality and fisheries (EEA 2001).

3.5 Agriculture is also a major source of phosphorus, the primary nutrient responsible for eutrophication in freshwater (Jarvie et al. 2010), affecting the ecological balance of the aquatic environment and leading to changes in animal community structure (Maier et al. 2008; Jarvie et al. 2010).

3.6 Evidence presented in Assessment of SMNR

3.7 In 2018 the total treated sewage sludge produced and applied to agricultural land in Wales was 43,194 tonnes of dry solids spread over an area of 7,844 ha (DCWW, 2019). Sewage sludge containing persistent organic pollutants such as dioxins and polycyclic aromatic hydrocarbons can contaminate soils and have an adverse impact on human health.

Aim 4: A Regenerative Economy

Aim 4: Progress towards meeting Aim

4.1 Organic farming has a modest uptake in Wales with 85,000 ha of land managed organically in 2018. The organically managed area is decreasing with a 9% reduction in area between 2014 and 2018 (WG agri stats).

Aim 4: Obstacles remaining to meet Aim

4.2 Modelling of the loss of high-quality agricultural land using the Agricultural Land Classification (ALC) system was undertaken by ADAS in 2019. It estimated that in 2011 Best and Most Versatile (BMV) agricultural land (grades 1, 2 and 3a) covered

18% of the land in Wales (Lewis-Reddy & Behrendt, 2020). This does not take account of areas at risk of flooding and frost which will down grade land further as many BMV soils are alluvial in valley bottoms. The actual figures may be closer to 10-15% (WG Pers Comms, 2020). Due to the co-location of urban areas and high-grade soils, urban expansion has often been at the expense of the most productive land. The total loss of BMV land over the period 1939 to 2011, was 21,300 ha (6.7% of the resource). The predicted annual loss of BMV land to urbanisation over the next five decades is expected to be minimal when compared to historical losses: an estimated 125 ha, on average, of BMV land will be lost to urbanisation per annum over the period 2018 to 2065 (Lewis-Reddy & Behrendt, 2020).

4.3 Altered water availability due to climate change is forecast to increase the risk of more frequent, prolonged periods of dry weather during late spring and summer and higher intensity rainfall. The latter leading to an increased risk of soil saturation, standing water and flooding. These changes are likely to have an impact on all vegetation but productive grassland is particularly vulnerable because of its low diversity. Perennial rye grass (Lolium perenne), is poorly adapted to drought conditions (Cyriac, 2018) and has low survival rates following flooding events (McFarlane, 2003). Given that perennial rye grass is the predominant species in productive grasslands (often to the exclusion of all other species), drought and flooding are likely to have a large impact on the availability of forage. Prolonged periods of dry weather and higher rainfall in winter and spring are also likely to drastically alter the ability of land to grow crops.

4.4 There is a growing appreciation of soil condition and the impact it has on food production and carbon sequestration, although there are currently no agreed indicators for measuring and reporting on soil condition.

4.5 In 2019 the area of maize produced was estimated at 14,500 ha in Wales compared to 6,100 ha in 1999. Maize is mainly grown for livestock feed but is increasingly grown as a feedstock for anaerobic digestion production, although there are currently no figures separating the two uses. This is likely to have a negative impact on soil condition and soil erosion (Maize Report, 2016). Grassland conversion to cropland (27%) and cropland (24%) were the main sources of GHG emissions in the LULUCF sector in 2018.

4.6 From Land Use and Soils Chapter - Modifying and innovating current practices and supply chains could improve the productivity and resilience of agricultural production systems in a way that safeguards and enhances the environment and ecosystem resilience. Water and climate-smart production systems will become increasingly important as water scarcity is predicted to increase and as agriculture will need to seek new ways to reduce emission of greenhouse gases, ammonia emissions and the associated use of fertilizers and other agricultural inputs (FAO, 2020). Extreme weather events, market volatility, uncertainty over future trade all impair stability and production. Policies, technologies and practices that build producers' resilience to threats would also contribute to sustainability. Resilience therefore becomes central to the transition towards a sustainable agriculture, and must address both the natural (ecosystem) and the human dimensions (well-being)(FAO, 2020).

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