The Second State of Natural Resources Report (SoNaRR2020)

Assessment of the achievement of sustainable management of natural resources: Semi-natural grasslands

Natural Resources Wales

Final Report

About Natural Resources Wales

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- 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: Semi-natural grasslands

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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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Contents

Tables and Figures

1. Headline Messages

Key issues

Agricultural intensification

Intensive farming practice is still resulting in loss of lowland semi-natural grassland, decline in grassland diversity and condition, and fragmentation of habitat patches. Ongoing, 21st century, losses are in the context of more than 90% loss of lowland grassland habitat in the latter part of the 20th century.

Insufficient management and abandonment

Lack of or insufficient grazing or in some cases insufficient cutting management are resulting in declining species-richness and condition, over-dominance of tall, robust species and, over time, loss of semi-natural grassland to scrubland.

Insufficient protection and management of important sites

Some important grassland sites need statutory protection, and existing protected sites are in many cases not being appropriately managed, which leads to poor condition. Protected sites need to be part of ecological networks rather than being isolated.

Land-use change

Increasing land-use pressures from, for example, woodland creation, growing of bioenergy crops and expansion of the built environment.

Climate change and air pollution

Higher temperatures, drier summers and extreme rainfall events caused by climate change are likely to lead to harmful changes to grassland hydrology and decrease the frequency and abundance of certain grassland species, as well as promoting damaging land use and land management changes. Atmospheric pollution, from nitrogen oxides and ammonia, causes increased soil nutrient levels and acidification of grassland.

Potential responses

Sustainable land management and multiple benefits

Grassland management focused away from maximising food production to multiple ecosystem benefits delivered by low-intensity management: for example reduced pollution levels, improved soil quality, provision of pollinator habitat, and reduced flood risk, along with provision of high-quality food in a sustainable way. Provide sufficient incentives, for example agri-environment schemes. Improve resilience in face of climate change.

Protect and improve condition of important sites

Provide resources to enlarge grassland statutory protected sites network and improve site management to achieve favourable condition.

Targeted grassland restoration and creation

To improve ecological connectivity and increase ecosystem resilience, for example around protected sites.

To improve ecosystem service provision, for example on flood plains: reducing water pollution levels and flood risk; close to habitation: cultural and educational services; or close to pollinated crops: pollinator service.

Improve regulatory approach

Prevent loss of or damage to grassland habitat, for example in Environmental Impact Assessment (EIA) (Agriculture) Regulations, EIA (Forestry) Regulations, and planning decisions. Eliminate damaging regulatory gaps. Improve regulation of damaging emissions, including from poultry units. Provide clear guidance and incorporate SMNR objectives and principles into regulation.

2. Introduction

Semi-natural grasslands are characterised by mixtures of grasses and herbaceous plants, along with varied amounts of sedges, rushes, mosses and lichens, see ecosystem definitions in the glossary. They are of particular importance for higher plants, fungi and invertebrates, including many species which, until recently, were far more common and widespread. They also support a range of mammals, birds and other vertebrates.

Semi-natural grasslands occupy about 9% of the land area of Wales. In contrast, agriculturally 'improved' grasslands extend over more than 1 million hectares, over half of the land area (Figure 1). These and semi-improved grasslands are covered in the Enclosed Farmland chapter. The semi-natural grasslands covered here include six grassland Priority Habitats (see Figure 2 and Figure 3) and upland acid grassland. Upland marshy grasslands are included in the Mountains, Moorlands and Heath chapter.

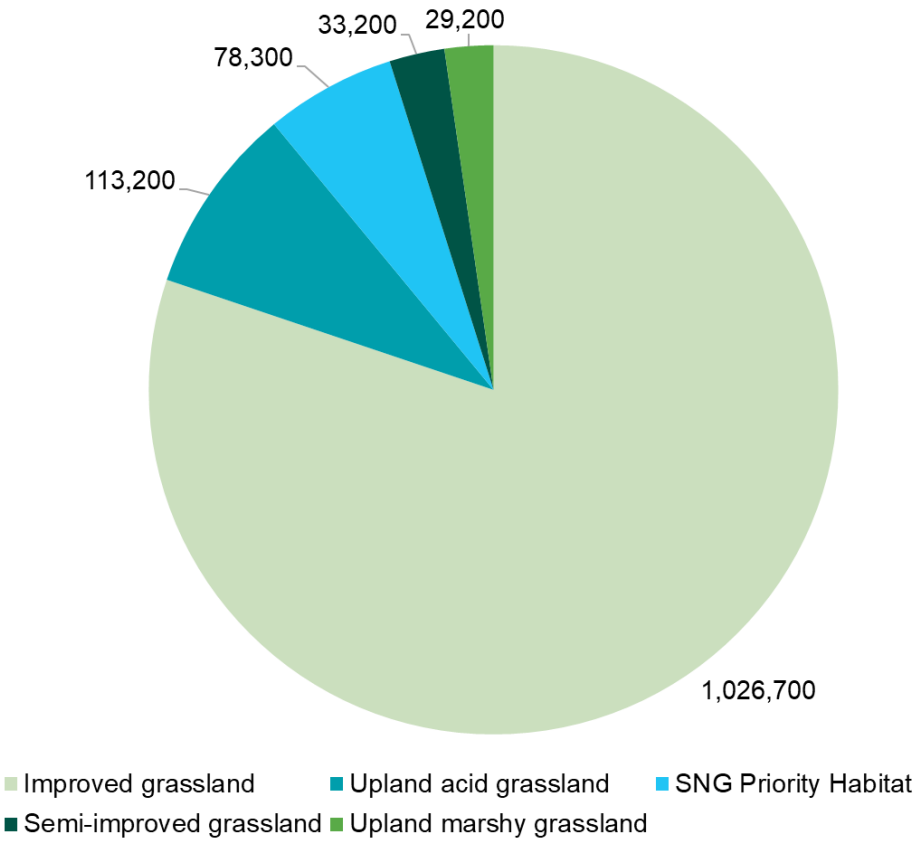

Figure 1 Grassland areas in Wales in hectares
Source: Blackstock et al., 2010

Semi-natural grasslands dominated the Welsh lowland landscape less than 100 years ago, but declined by more than 90% during the latter part of the 20th century, driven by land-use policies focused on agricultural production. Remaining areas of the ecosystem are often small and highly fragmented.

They are mostly found within the farmed countryside, associated with low-intensity management, including nil or very low usage of artificially-manufactured fertilisers. They are usually grazed by livestock for the production of meat or other animal products, although some examples are managed primarily for biodiversity conservation, landscape or recreation value. They have been a principal focus for agri-environment schemes in Wales.

Most ecosystem services are higher in semi-natural grasslands than in agriculturally improved grassland, particularly those relating to biological diversity, crop pollination, carbon storage, pollution control, and cultural heritage. Compared with other semi-natural habitats, grasslands score particularly well for crop pollination and higher food production levels. More sustainable management of grassland in Wales would help advance Wales's well-being goals related to Resilience, Health, Culture and Global responsibility and contribute to targets in the Action Plan for Pollinators in Wales (Welsh Government, 2013).

Figure 2 An example of ‘lowland meadow’ Priority Habitat (left) and an agriculturally ‘improved’ grassland (right).
Photos: Stuart Smith/NRW

The principal threats to semi-natural grasslands include agricultural intensification, abandonment or under-management, atmospheric pollution, and habitat fragmentation. Lack of ecological connectivity of semi-natural grasslands leads to isolation of less mobile species, making them at much greater risk of extinction, especially as the climate changes.

Climate change will have a direct impact on semi-natural grassland ecosystems, for example through increased summer droughting and hydrological changes to wet grasslands. However, the indirect effects of climate change, such as changes to land use and management, are also likely to be very significant. Semi-natural grasslands are, however, more resistant to the effects of severe drying and over-wetting than ‘improved’ grasslands.

These threats are affected by a range of wider system pressures such as farm economics, changing land-use priorities and consumer behaviour.

Ecological resilience of semi-natural grasslands would be enhanced by wider application of low intensity management and increased grazing or cutting of neglected and abandoned grasslands. Opportunities to create semi-natural grasslands should be investigated; although new grasslands are fundamentally different to ancient examples, they can provide a range of ecosystem services and improve ecological resilience.

3. State and Trends (Aim 1)

Summary assessment of state and trends

The following tables (Table 1, Table 2 and Table 3) give a brief description of the past trends and future prospects for the Semi-natural Grassland Ecosystem. These are assessed to be:

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

Further information is provided to put this in context.

Table 1 Past trends and future prospects for Extent of Semi-natural Grasslands

Time Period	Rating	Description
Past trends (1992-2019)	Deteriorating	The available evidence suggests recent significant decline in lowland semi-natural grassland extent outside the protected sites series; this is in line with recent more extensive surveys in England and Scotland. Grassland habitat extent on protected sites appears to be more or less stable or has declined only slightly. Recent decline is in the context of huge historic, late 20th century, decline in lowland semi-natural grassland extent in Wales. Decline has continued for notable grassland species such as lapwing and curlew. Extent of semi-natural upland grassland is likely to be stable.
Future Prospects (Outlook to 2030)	Mixed Picture	Evidence suggests that future prospects are poor. However, there are likely to be major land use and land management changes following the UK's exit from the European Union. It is unclear what the implications of these will be or whether they will address key semi-natural grassland pressures leading to loss of extent, such as agricultural intensification and scrub expansion due to insufficient management. Other land-use pressures are almost certain to increase, such as from increased afforestation and bioenergy cropping, and ongoing land development.

Robustness: The available information on recent trends is incomplete and insufficient to show the level of recent decline in semi-natural grassland extent. However, the available evidence indicates continued decline in extent of the habitat outside protected sites.

Table 2 Past trends and future prospects for Condition of Semi-natural Grasslands

Time Period	Rating	Description
Past trends (2004-2019)	Deteriorating	Condition of semi-natural grassland on protected sites is mostly poor, to a large extent due to under-management. Over-grazing is also a significant cause of poor condition, especially in upland grasslands. There is limited information on condition of semi-natural grassland outside the protected sites series, and trends are hard to evaluate due to contradictory evidence, but widespread under-management and other unanswered pressures are likely to have driven a net deterioration in condition.
Future Prospects (Outlook to 2030)	Mixed Picture	The immediate prospects for condition of semi-natural grasslands appear to be poor, given the limited availablilty of resources for management and the low coverage of management agreements on statutrory sites. The future availability of resources for improving management of protected sites remains unclear. In addition, future changes to land-use, policy and economics are expected to play a critical role, leading to uncertainty.

Robustness: Evidence is sufficient to show that most grassland features on protected sites are in poor condition, but is insufficient to show whether this represents any improvement in recent years.

The evidence is limited and contradictory for unprotected sites.

Table 3 Key message – past trends and future prospects for Connectivity of Semi-natural Grasslands

Time Period	Rating	Description
Past trends (2004-2019)	Deteriorating	As a result of the huge decline in extent of lowland semi-natural grassland during the latter part of the 20th century, the habitat is the most fragmented of all ecosystems, with major implications for species which cannot move easily through the landscape. There is no evidence of recent improvements in semi-natural grassland connectivity in the lowlands and it is likely the situation has become worse, given the ongoing losses of habitat described above. Upland grassland connectivity is comparatively good and stable, but includes little grassland Priority Habitat.
Future Prospects (Outlook to 2030)	Deteriorating	The impact on connectivity of land use and land management changes following the UK's exit from the European Union is hard to predict, with both significant risks and opportunities. Tackling fragmentation in the lowlands will require some targeting of restoration and creation to strengthen and link existing areas of habitat, if habitat areas are to be made resilient. Given the current situation, a major improvement in grassland connectivity in the lowlands by 2030 is unlikely.

Robustness: Lowland semi-natural grassland connectivity is certainly poor at present and is likely to have worsened due to ongoing habitat loss, but there has been no thorough assessment of this.

Extent

Semi-natural grasslands are estimated to occupy nearly 192,000 ha in Wales, *circa* 78,000 ha in the lowlands and *circa* 114,000 ha in the uplands. Six forms of Semi-natural grassland are listed as being of "principle importance", Priority Habitats, in the Environment (Wales) Act 2016, which together form *circa* 78,300 ha (SoNaRR2016) (Figure 3). Some 99% of grassland Priority Habitat is in the lowlands.

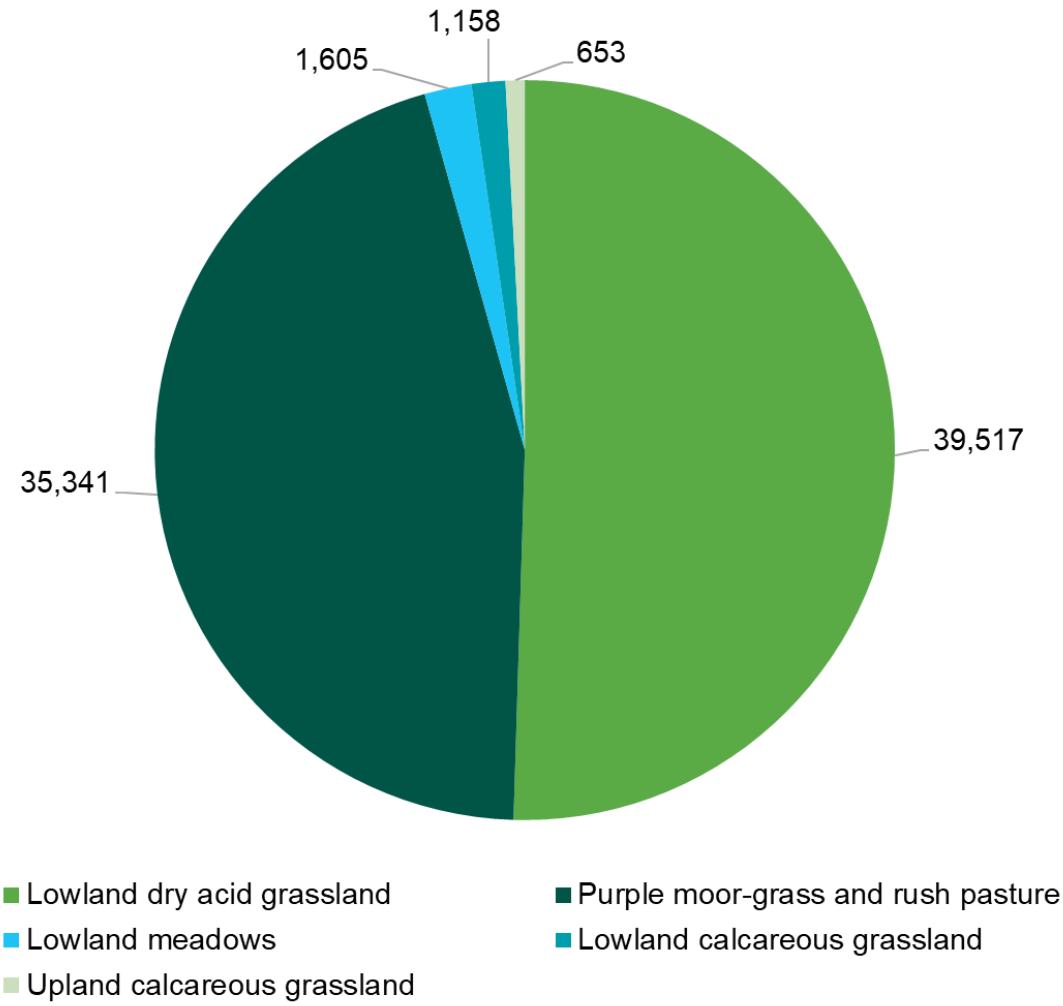

Figure 3 Semi-natural grassland Priority Habitat areas in Wales in hectares
Source: Blackstock et al., 2010, except for lowland meadows (Stevens et al., 2010a) and calaminarian grassland (JNCC, 2019)

In the Welsh lowlands, a greater than 90% reduction in extent of semi-natural grassland is thought to have occurred over the last 70 years of the 20th century, with drier forms declining by an estimated 97% in that period (Stevens et al., 2010a). The current 'baseline' therefore represents a much depleted habitat resource.

Losses of grassland habitat are thought to have slowed across the UK since the turn of the century (Bullock et al., 2011), but two recent assessments in Wales show continuing loss outside the protected site network:

1. Revisits to 61 unprotected grassland sites between 2008 and 2017 recorded loss of grassland Priority Habitat, such as from ploughing or fertiliser application, at 27 sites, 48%, since the previous site visits in the early 2000s (Smith et al., in prep). Losses were partially offset by grassland habitat expansion at 5 sites, 8%, for example where scrub had been cleared, but mapped loss of the habitat was 31.7 ha and mapped gain 5.5 ha, meaning more than five times as much loss than gain.

2. A desk-based assessment of 'purple moor-grass and rush pasture', marshy grassland, Priority Habitat using time-series aerial imagery estimated a 22% loss of habitat area over a 22-year period, 1992-2014, (see Smith et al., in prep). This study looked at around 2000 randomly-chosen, unprotected habitat patches across Wales which had been previously mapped by the Phase 1 Habitat Survey of Wales (Blackstock et al., 2010), comprising 10% of all mapped patches of the habitat. Losses of grassland habitat were observed across the whole period, including post 2013 (Figure 4).

Figure 4 Aerial photographs illustrating recent loss of grassland Priority Habitat: a group of small fields with 'purple moor-grass and rush pasture' Priority Habitat in 2013 (left) replaced by larger fields of 'improved' grassland by 2017 (right)

Surveys on unprotected semi-natural grassland elsewhere in the UK have recorded similar evidence of recent loss of semi-natural grassland habitat, for example Dadds and Averis (2014) recorded 16% loss of unprotected grassland Priority Habitat between 1983 and 2011 in Scotland, and Wheeler and Wilson (2018) recorded loss of a third of areas of unprotected 'lowland meadow', unimproved neutral grassland, Priority Habitat in England between 2003 and 2017.

Small, additional areas of semi-natural grassland occur in refugia both within and outside the farmed countryside, for example along watercourses, in amenity areas and, notably, on road verges. Welsh Government estimate that road verges cover at least 10,000 ha in Wales (Welsh Government, 2017a). Surveys in other parts of Britain have shown that generally around 5% of verges are botanically diverse, suggesting that around 500 ha of semi-natural grassland and other species-rich habitats may be present on Welsh road verges, although this area could be

increased by improved verge management (Jakobsson et al., 2018; Bromley et al., 2019).

Extent of semi-natural grassland in the uplands and upland fringes currently appears broadly stable. However, an increase in upland acid grassland, not a Priority Habitat, in the latter part of the 20th century due to over-grazing of heathland was noted (see Mountains, Moorlands and Heath chapter). Upland acid grassland comprises more than 99% of the upland semi-natural grassland total, the remainder being upland calcareous grassland (Figure 1 and Figure 3). Upland marshy grasslands are included in the Mountain, Moorlands and Heath ecosystem.

Statutory site protection greatly limits loss of semi-natural grassland habitat. Ridding et al. (2015) recorded a 9% loss of grassland habitat area on Sites of Special Scientific Interest (SSSIs) in England between 1960 and 2013, compared to 73% loss on unprotected sites in the same period (see also SoNaRR2016, section 3.7). In Wales, of 26 grassland qualifying features on Special Areas of Conservation (SACs) assessed between 2005 and 2017, no losses in extent were recorded; of 124 SSSI grassland qualifying features assessed between 2004 and 2017, seven, 5%, had been impacted by some loss of extent, mainly through small-scale scrub expansion (Smith et al., in prep).

Condition

Recent structured condition monitoring on grassland SSSIs shows a pattern of mostly poor condition: 91, 72%, of 124 lowland semi-natural grassland SSSI features assessed between 2004 and 2017 were in unfavourable condition, with under-management being the main cause, affecting 80% of features (Figure 5). During the most recent SAC monitoring, all but one of the 23 lowland grassland SAC features in Wales was considered to be in unfavourable condition (Smith et al., in prep). Unfortunately, there is insufficient repeat data to reveal whether grassland condition is improving on statutory sites.

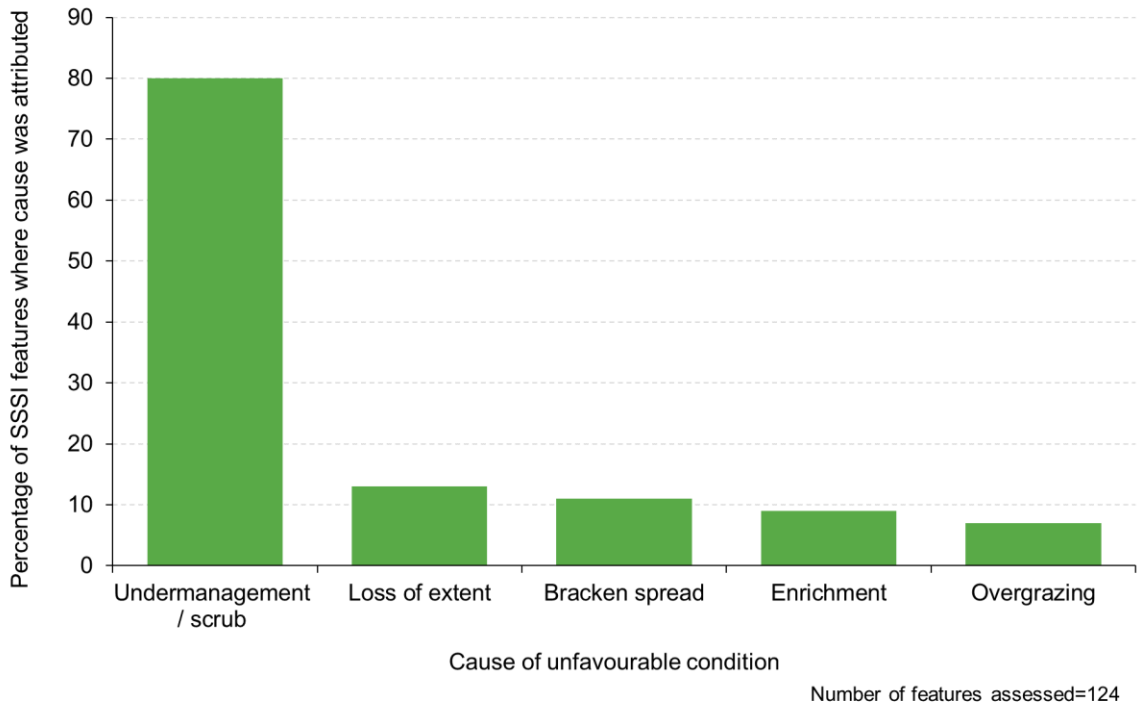

Figure 5 Causes of unfavourable condition of lowland semi-natural grassland SSSI qualifying features in Wales (2004-2017) Source: Compiled NRW condition monitoring results

There is insufficient data available to provide a full assessment of semi-natural grassland condition outside protected sites, and there has been no recent structured monitoring. However, Smith et al. (in prep) estimated poor condition on 42, 69%, of 61 grassland sites. Recent results from ERAMMP (Emmett et al., 2019) give a more encouraging picture, suggesting a recent trend of improving condition of semi-natural grassland, although a more thorough analysis of the data, and a refinement of the categories, suggests that condition of semi-natural grassland has been stable across Wales in recent decades, based only on results for acid and marshy grassland (Alison et al., 2020).

Connectivity

Semi-natural grassland is the most fragmented ecosystem in the Welsh lowlands (Blackstock et al., 2010). Remaining habitat patches are invariably small, ranging from an average of 6.2 ha, acid grassland, to just 1.8 ha, neutral grassland, and are widely scattered within landscapes dominated by 'improved grassland' (SoNaRR2016; Enclosed Farmland chapter; Figure 6).

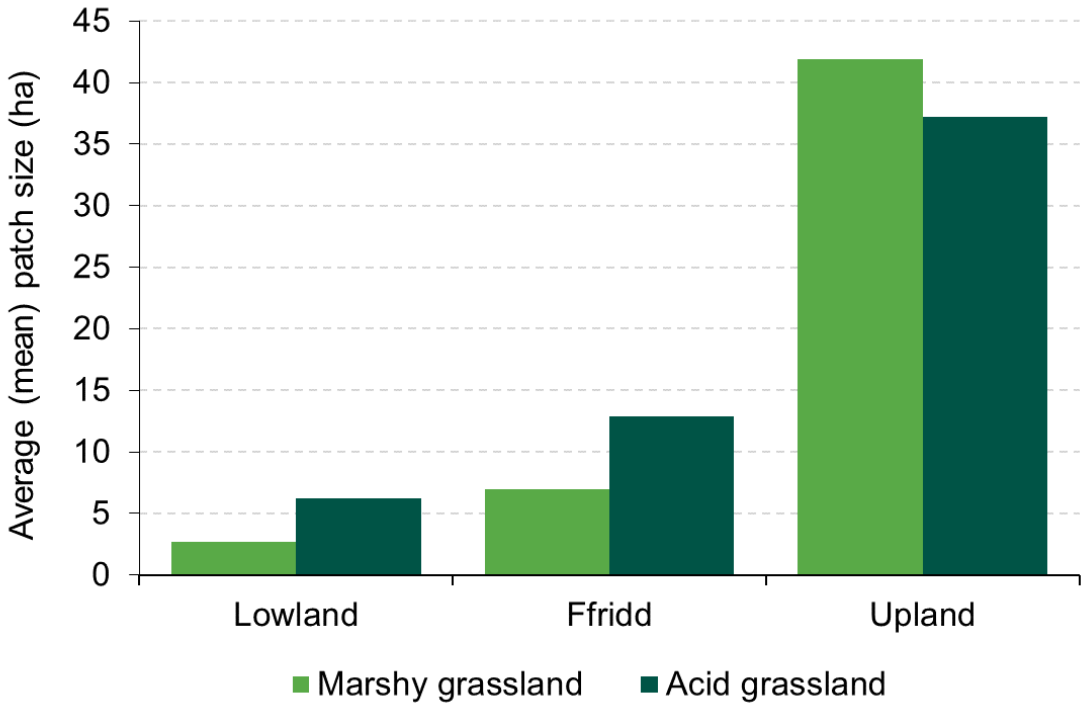

Figure 6 Comparison of average patch sizes, in hectares, of marshy and acid grassland in Wales in different landscape settings
Upland marshy grassland is included in the MMH chapter
Source: Blackstock et al., 2010

There is no evidence of any recent improvement in lowland semi-natural grassland connectivity in Wales. However, surveys in the latter part of the 20th century (Blackstock et al., 2010; Stevens et al., 2010a) revealed large differences in connectivity across the lowland landscape and highlighted that some better-connected lowland grassland landscapes remain at a local level (Figure 7).

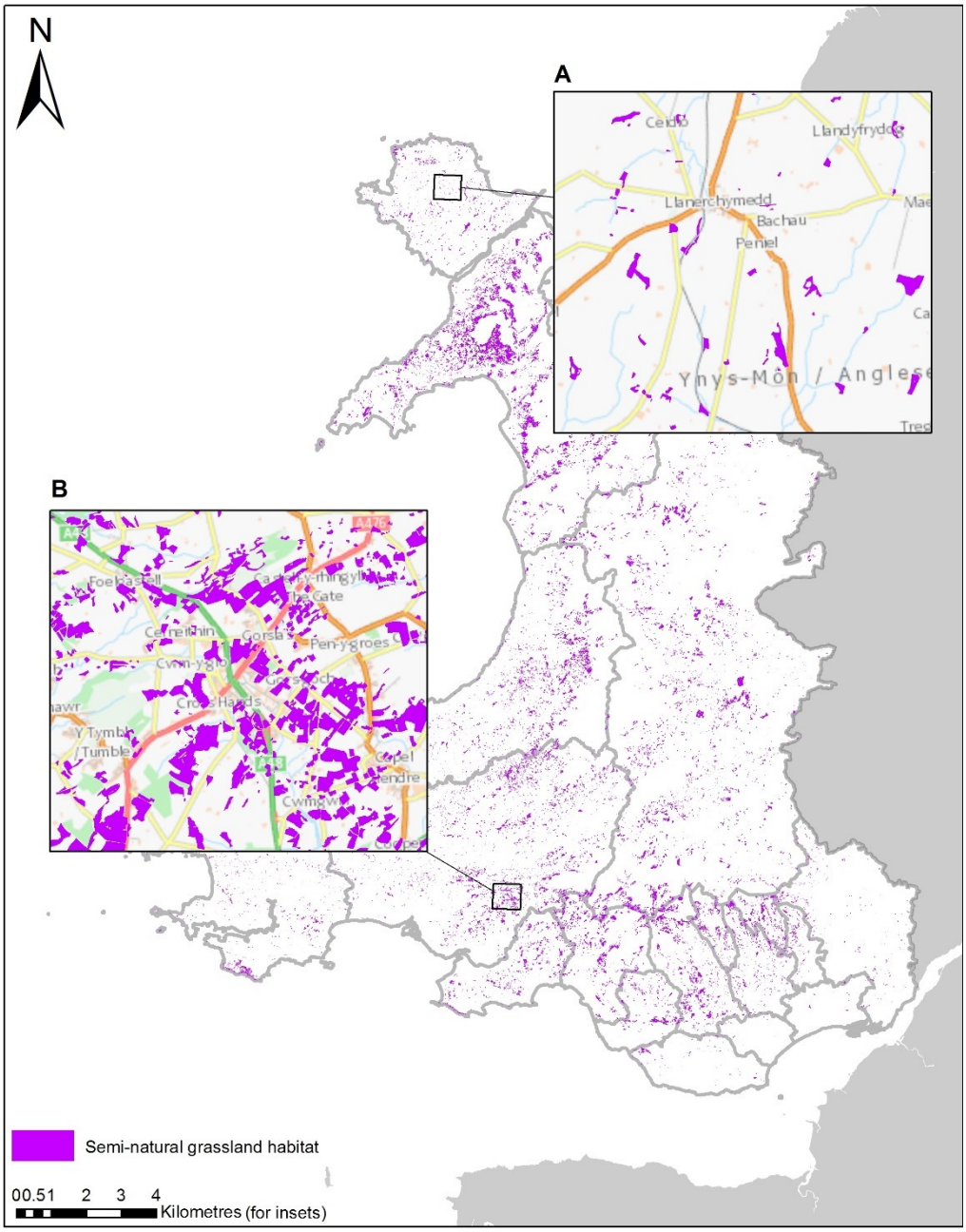

Figure 7 Examples of poorly connected (A: central Anglesey) and well-connected (B: south-east Carmarthenshire) semi-natural grassland landscapes
Grassland habitat is shown in purple; intervening land is mainly 'improved' grassland and built-up areas. Source (grassland habitat areas): NRW Priority Habitat database

Grassland connectivity is enhanced, to some extent, by road verges and other linear habitat features, which support occasional areas of species-rich semi-natural grassland along with more abundant, but less species-rich, semi-improved grasslands.

Semi-natural grasslands are generally better connected in the upland fringes, ffridd, and much better connected in the uplands, where patches of habitat are generally much larger (Figure 6) and more than 80% of the land is still semi-natural (Blackstock et al., 2010).

Current management

The vast majority of semi-natural grassland in Wales is managed for livestock-rearing, mostly by private land-owners. However, only a small proportion is covered by tailored management agreements. Completely unmanaged grassland is a small proportion of the total area, although a larger proportion is undermanaged. Grassland undermanagement and neglect is driven partly by economic factors, with semi-natural grasslands seen as providing lower financial returns due to lower productivity (Bullock et al., 2011).

Grasslands are a principal focus of agri-environment scheme delivery in Wales and several options are available in Glastir Advanced for maintenance, restoration or creation of semi-natural grassland habitat (Welsh Government, 2018a). However, only 19% of mapped grassland Priority Habitat has been covered by Glastir Advanced grassland options in recent years, 2012 to 2019.

27% of semi-natural grassland in Wales is on statutory protected sites (SSSIs/SACs). However, much of this is upland acid grassland, and only about 10% of grassland Priority Habitat is on protected sites (Figure 8); this is lower than the Convention on Biological Diversity (Aichi) target of 17% of terrestrial areas on protected sites. A total of 21% of the semi-natural grassland on protected sites is currently covered by specific SSSI management agreements mostly aimed at improving grassland condition.

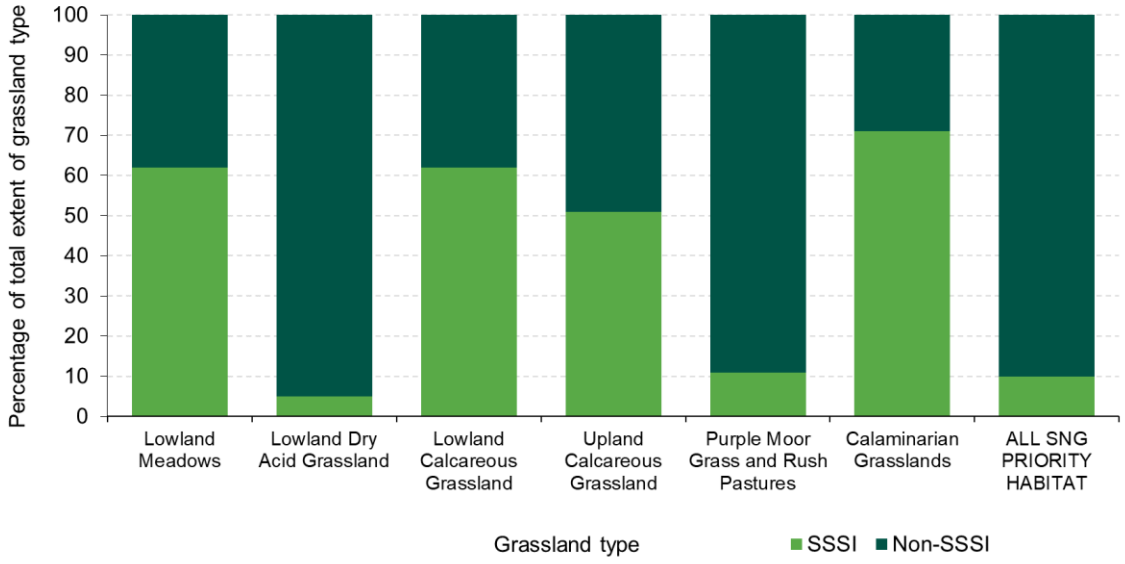

Figure 8 Percentage of the total extent of different grassland Priority Habitats within and outside SSSIs in Wales
Source: derived from digital geographic information system (GIS) overlay of grassland Priority Habitat areas and SSSI boundaries (2020)

All semi-natural grassland, including that outside statutory sites, is covered by EIA (Agriculture) (Wales) Regulations 2002. These do not determine specific management but have an important role in protecting semi-natural habitat from land intensification. The regulations have prevented significant damage to at least 89 high conservation value grassland sites since 2002 (Welsh Government, 2017b), but they are unlikely to guard against gradual changes, such as incremental increase in

fertiliser application (Stroh et al., 2019), and are not able to prevent management neglect or abandonment.

A small proportion of semi-natural grassland in Wales is owned by statutory bodies, including National Nature Reserves managed by Natural Resources Wales. A further proportion is managed by conservation non-governmental organisations (NGOs) such as the Wildlife Trusts, Plantlife, and the National Trust. Most of this land is managed primarily for nature conservation, although livestock production is usually a secondary function. The National Trust in Wales is aiming to achieve good floristic condition of all the habitats it manages as part of achieving 'high nature status' on all its land holdings; currently 27% of the land it owns in Wales is considered to achieve that status (Mike Howe, pers. comm., 2019). Management of some areas of grassland has improved through specific projects, such as Save Our Magnificent Meadows (Shellswell and Squire, 2019), Elan Valley Meadows (Hayes and Lowther, 2014) and Farming for the Future on the Llŷn Peninsula (Porter, 2019).

Pressures and threats

Pressures and threats are assessed on a six-yearly cycle for habitats listed in Annex 1 of the European Habitats Directive, the most recent report being 2019 (Article 17 report: JNCC, 2019). Annex 1 habitats account for 2% of total semi-natural grassland in Wales, but include land both within and outside statutory protected sites and are likely to be reasonably representative of the wider resource.

Pressures and threats relating to level of grazing were listed as 'high' for all grassland European Protected Habitats in Wales, from either under-grazing, including abandonment and succession to scrub/trees, or over-grazing or both. Air pollution was also listed as 'high' for all of the habitats; this includes atmospheric deposition of nitrogen oxides (NOx), from the burning of fossil fuels by traffic and industry, and local sources of ammonia (NH_3) deposition, arising mainly from intensive poultry and dairy enterprises. These pollutants are known to cause decreased species-richness of grassland through the effects of eutrophication and soil acidification (Stevens et al., 2004; Stevens et al., 2010b; Van den Berg et al., 2011). Intensive poultry units are particularly common in parts of mid Wales, Anglesey and Pembrokeshire (Laimann and Henderson, 2018).

Other recorded 'high' pressures or threats include agricultural intensification, for example artificial fertiliser application, and, for some grassland habitats, spread of invasive non-native species (Table 4). Many of these pressures and threats are compounded by lack of ecological connectivity, as small, fragmented habitat patches are inherently more vulnerable to harmful impacts.

Climate change was given a medium threat for some grassland habitats and considered likely to have an increasing impact in the future from direct effects such as increased summer droughting and alteration of the hydrology of wet grassland systems. However, the indirect effects of climate change, including changes to land management aimed at reducing the impact of climate change, are also likely to be very significant (Natural England and RSPB, 2020; Stroh et al., 2019).

Areas of semi-natural grassland outside the statutory site network are at greatly increased risk from agricultural intensification and, locally, land development, including new roads, quarrying and housing.

Table 4 Pressures and threats assessed as ‘high’ for grassland European Protected Habitats in Wales (JNCC, 2019) Those assessed as “high” are shown in dark grey

European Protected Habitat listed in Annex 1 of EU Habitats Directive, 1992 abbreviated titles – see JNCC 2019 for full names	Extent (Wales), in hectares	Tourism and leisure activities	Invasive non-native species	Atmospheric nitrogen pollution	Natural succession	Over-grazing	Under-grazing	Abandonment	Artificial fertilisers	Conversion to intensive agriculture
Calaminarian grasslands	74.5									
Siliceous alpine and boreal grasslands	84.0									
Alpine and subalpine calcareous grasslands	1.7									
Semi-natural dry grasslands	712.8									
Species-rich Nardus grasslands	136.8									
Molinia meadows	515.6									
Lowland hay meadows	10.7									

Future prospects

European Habitats Directive (Article 17) reporting also includes an assessment of the future prospects of each habitat. Most grassland habitats were considered to have negative prospects for area, including all the lowland types where it was known. All had negative or very negative prospects for condition (Table 5). This reflects the recent and ongoing pressures described above. However, this could change significantly should government policy and land-use priorities change, or should significantly more resources for site management become available.

Table 5 Future Prospects for grassland European Protected Habitats in Wales (from JNCC, 2019)

European Protected Habitat, abbreviated titles, and habitat code as listed in Annex 1 of EU Habitats Directive, 1992	Future prospects for extent	Future prospects for condition
Calaminarian grasslands H6130	Negative	Very negative
Siliceous alpine and boreal grasslands H6150	Stable	Negative
Alpine and subalpine calcareous grasslands H6170	Stable	Negative
Semi-natural dry grasslands H6210	Negative	Negative
Species-rich Nardus grassland H6230	Negative	Negative
Molinia meadows H6410	Negative	Very negative
Lowland hay meadows H6510	Unknown	Negative

4. Assessment of Resilience (Aim 2)

Table 6 Ecosystem Resilience Assessment for Semi-natural Grasslands

Practical habitat unit	Diversity	Extent	Condition	Connectivity
Lowland semi-natural grassland. Calcareous, neutral, acid, marshy, calaminarian	**Low** Naturally very high diversity and important for a wide range of flora and fauna. Loss of diversity due to huge decline in the habitat extent in the last half of the 20th century, as well as current poor condition and connectivity. Large number of grassland species under threat.	**Low** >90% losses in the last half of the 20th century. Losses continue. Main issues are agricultural intensification and undermanagement. Protected sites appear largely protected from loss, but 90% of grassland Priority Habitat not on protected sites.	**Low** Condition generally poor on both protected and unprotected sites, due largely to undermanagement, combined with factors such as atmospheric deposition. Some evidence suggests trend in condition has stabilised.	**Low** The least well connected of all main habitat groupings. Surveys in 1980s/90s revealed very high fragmentation which is highly likely to be still worsening due to continued losses in extent. Less mobile species severely affected. Several better-connected landscapes remain locally.
Upland semi-natural grassland. Calcareous, acid, calaminarian	**Medium** Diversity naturally lower than in lowlands, but with notable exceptions in calcareous and calaminarian grasslands. Fewer threatened flora and fauna than in lowlands.	**High** Extent of calcareous and calaminarian grasslands constrained by bedrock and probably little changed in recent history. Upland acid grassland increased at the expense of heathland in the past.	**Medium** Poor condition often caused by inappropriate grazing levels: overgrazing and, to a lesser extent, undergrazing. Atmospheric deposition the other main cause of poor condition. Recreation damage is locally significant.	**High** Connectivity relatively good and probably little changed in recent decades.

Diversity

Temperate semi-natural grasslands are some of the most biologically diverse of all of the world's ecosystems (Wilson et al., 2012; Habel et al., 2013). Welsh semi-natural grasslands are of particular importance for their diversity of higher plants, grassland fungi and invertebrates. They also support a range of birds, mammals and other fauna. They have a particularly high diversity of soil animals, including earthworms (Tsiafouli et al., 2014; George et al., 2019).

However, the huge losses in lowland grassland habitat over the latter part of the 20th century, worsened by recent and ongoing losses, often poor condition, and low ecological connectivity, have had a huge impact on the biological diversity of semi-natural grasslands in Wales; the result has been major declines in the flora and fauna associated with the ecosystem:

- A wide range of, mainly lowland, grassland plant species have suffered significant decline or local extinctions in Wales. Among them are green-winged orchid *Anacamptis morio*, frog orchid *Coeloglossum viride*, petty whin *Genista anglica*, field gentian *Gentianella campestris* and lesser butterfly orchid *Platanthera bifolia* (Stroh et al., 2019).
- Declines in bumblebee species in recent decades have been directly attributed to the loss of semi-natural grassland and grassland species (Goulson et al., 2005; Carvell et al., 2006). These include shrill carder bee *Bombus sylvarum*, which has been lost from most of Wales and is now restricted to just three sites in the south (Bumblebee Conservation Trust, 2017).
- Corncrake *Crex crex* was once found in species-rich meadows in every county (State of Nature: Hayhow et al., 2019), but has declined by 98% as a breeding bird in Wales since around 1970 (Bladwell et al., 2018).
- Loss of lowland wet grasslands is considered to be the main cause of the decrease in lapwing *Vanellus vanellus* (State of Nature: Hayhow et al., 2019), which suffered an estimated 46% decline in its breeding distribution in Wales between 1970 and 2010 (Bladwell et al., 2018).
- Curlew *Numenius arquata* was widespread in lowland wet grasslands and upland habitats in Wales, but more than three-quarters of its Welsh population has been lost in the last 25 years and it is now considered the most pressing bird conservation priority in Wales (Bladwell et al., 2018; Patrick Lindley, pers. comm., 2020; see also Mountains, Moorlands and Heath chapter).

Biodiversity in grassland is severely negatively impacted by cultivation, such as ploughing, and high levels of nutrient enrichment, such as from agricultural intensification and atmospheric pollution. Inappropriate management, such as overgrazing and undergrazing, also have a detrimental effect on plant and animal diversity.

The positive relationship between grassland species diversity and delivery of ecosystem services is outlined in sections 5 and 6; see also Hooper et al., 2005; Isbell et al., 2011; Weisser et al., 2017; Bengtsson et al., 2019.

Extent

Many of the declines in grassland flora and fauna mentioned above are largely due to loss of species-rich grassland habitat, for example decline in traditionally managed hay meadows, affecting corncrake and green-winged orchid, and loss of lowland wet pastures, affecting curlew and lapwing. Patch size of semi-natural grassland is critical for the survival of many invertebrate species, especially butterflies and moths (Botham et al., 2015; Alison et al., 2017).

Ecological resilience is significantly enhanced where semi-natural grassland occurs in mixtures with other habitats to form more substantial habitat patches. Grasslands are frequently found intermixed with, for example, heathland, wetland and woodland or scrub habitats. Such mixtures, and the transitions between habitats, are important for a range of species and can contribute greatly to landscape heterogeneity.

Condition

The level of management, especially grazing, is critical to maintaining grassland condition. Undermanagement or abandonment leads to over-dominance by coarse grasses and often invasion of grassland by scrub, trees or bracken. It typically causes significant decrease in plant species-richness (Moog et al., 2002; Bohner et al., 2019; Kimberly et al., 2019) and is seen as the greatest current threat to uncommon plant species of semi-natural grasslands (Stroh et al., 2019; Walker et al., 2017). Marsh fritillary butterfly *Euphydryas aurinia*, a species mostly associated with lowland wet grassland, declined by 71% between 1990 and 2017 in Wales, mainly due to under-management, although recovery on some sites has been noted since 2007 (JNCC, 2019; Tordoff and Williams, 2018). [see Biodiversity Assessment]. Overgrazing also typically leads to a decline in plant species richness over time, for example by preventing or restricting flowering and seed setting.

Undermanagement of grassland can also lead to an increase in certain invasive non-native species such as Himalayan balsam *Impatiens glandulifera*. However, the greatest invasive non-native species threat to grassland condition is cotoneaster species, which are a significant issue on a number of calcareous grassland sites across Wales (Stroh et al., 2019). [see INNS chapter]

Upland grasslands are more likely to be subjected to high levels of atmospheric nitrogen deposition, due to generally higher rainfall levels. However, even low nitrogen deposition levels can detrimentally affect more sensitive species, in both upland and lowland situations, notably lichens (Stevens et al., 2012). [see Air quality chapter]

Poor grassland condition impacts the delivery of some ecosystem services (see sections 5 and6). For example, undermanagement and overgrazing are both likely to deplete pollinator resources (Hudewenz et al., 2012; Jerrentrup et al., 2014; Vanbergen et al., 2014; Lázaro et al., 2015), as well as reducing overall species diversity. Undermanagement means lower livestock production and an increased fuel loading, meaning increased fire risk (Leonard et al., 2010). Overgrazing is likely to increase soil compaction levels, which can reduce the soil's capacity to hold water and, therefore, potentially increase flood risk. (See section 5).

Connectivity

Habitat fragmentation can have a huge effect on less mobile flora and fauna, leaving populations isolated from one another and therefore much more prone to extinction if local conditions become unfavourable for a time, and with little chance thereafter of them being restored by natural means. It is also likely to prevent movement of species when local conditions become less favourable as a result of climate change (see Climate Change chapter).

Connected landscapes are highly important for many butterfly species which persist as metapopulations and are at significantly increased risk of extinction in fragmented landscapes (Butterfly Conservation, 2015).

Habitat connectivity does vary locally across Wales, and a few well-connected, and therefore more resilient, grassland landscapes still remain in the lowlands, for example, in south-east Carmarthenshire (Figure 7), on the Castlemartin Peninsula in Pembrokeshire, and on the Creuddyn Peninsula in Conwy County. These areas support populations of scarce or threatened grassland species which have been lost from many other areas, such as marsh fritillary butterfly in SE Carmarthenshire (see Biodiversity chapter), shrill carder bee in Castlemartin, and a range of uncommon higher plant species, including spiked speedwell *Veronica spicata* in Creuddyn. These areas could provide templates for programs aimed at improving grassland resilience elsewhere.

Better ecological connectivity in upland landscapes, together with larger habitat patch sizes (see section 3), is part of the reason for the much smaller proportion of scarce and threatened species in upland compared to lowland grassland habitats. For example, more than three quarters of grassland Priority Species are exclusively or very largely lowland in distribution. However, in some areas, upland acid grassland does provide short-turf feeding areas for chough *Pyrrhocorax pyrrhocorax*.

Summary

Semi-natural grasslands in the lowlands are generally far from being resilient and are poor for all four attributes. However, some better-connected landscapes with comparatively frequent patches of semi-natural grassland intermixed with other habitats, remain locally. Upland grasslands are currently much more resilient, but include only a very small proportion of the grassland Priority Habitat and harbour fewer threatened species.

Land use and management have a major effect on this ecosystem, and are likely to be greatly impacted by future changes in land priorities and policies. Climate change exacerbates the effects of fragmentation on less mobile species. Targeting of grassland restoration and creation is likely to be required to tackle issues around fragmentation of lowland habitats and improve ecosystem service delivery (see sections 5 and 6).

5. Healthy places for people (Aim 3)

The Regulating and Cultural ecosystem services for well-being provided by semi-natural grassland ecosystems are outlined in Table 7 and Table 8 below. They are developed from the set of services and definitions of the UK NEA Conceptual Framework (Mace et al., 2011). The Wales assessment is our current interpretation based on expert opinion. Values for Wales are informed by UK values in the UK NEA Key Findings report (UK NEA, 2011) but are amended to take into account new evidence and recent environmental changes affecting ecosystem service delivery in Wales

Table 7 Relative importance of regulating ecosystem services provided by Semi-natural Grasslands in Wales

Regulating Services	**Importance of service**
Climate (greenhouse gas balance)	Medium -High
Hazard (wildfire and flooding)	Medium
Disease and Pests	Medium
Pollination	High
Noise	Low
Water Quality	Medium -High
Soil Quality	High
Air Quality	Medium -High

Table 8 Relative importance of cultural ecosystem services provided by Semi-natural Grasslands in Wales

Cultural services	**Importance of service**
Sense of place; landscape and aesthetic value	High
Leisure, recreation, tourism, physical and mental health	Medium
Cultural heritage	High
Education and learning	Medium
Employment	High

Pollination

Insect pollination contributes an estimated £400m per year to the UK economy (POST, 2010). The importance of wild pollinators is now being more widely recognised (Garibaldi et al., 2014; IPBES, 2016; Rader et al., 2016; Lucas et al., 2018; Walton et al., 2020) but both managed bees (Potts et al., 2010) and many wild pollinator groups (Biesmeijer et al., 2006; Fox et al., 2013; Baude, 2016; Powney et al., 2019) have endured huge declines in recent decades. **Semi-natural grasslands are of particularly high importance for pollinating invertebrates**, with calcareous and neutral grasslands having among the highest nectar levels of all habitats (Baude, 2016). Marshy grasslands had the highest density of bumblebees and butterflies of ten broad habitats assessed during Glastir Monitoring and Evaluation Programme (Alison et al., 2020).

Pollination services are greatly enhanced by closeness of a habitat to the crop: Rickets et al. (2008) found that, on average, in crop fields 1.5 km away from habitat patches, pollinator diversity was reduced to 50% of that in fields closest to areas of habitat.

Climate

Soils in the UK are estimated to contain 94% of all carbon in the environment and vegetation the remaining 6% (ONS, 2016; see Land Use and Soils chapter). **Semi-natural grasslands are an important store of soil carbon** (Lal 2004, Soussana et al., 2010, Bullock et al., 2011, Lemaire et al., 2011, Smith, 2014; Bengtsson et al., 2019), storing much more than equivalent areas of cultivated land (arable or ploughed grasslands). Soil carbon levels under semi-natural grassland appear to be

similar or slightly more compared to levels seen under woodland (Chamberlain et al., 2010; Alonso et al., 2017; Bengtsson et al., 2019). There is evidence that restored grasslands contain a significantly greater level of soil carbon than restored woodland when whole soil profiles are considered (Wei et al., 2012).

Soil carbon levels increase with plant species diversity (Weisser et al., 2017; Chen et al., 2018; Chen et al., 2020), particularly where there is an abundance of legume species such as red clover *Trifolium pratense* (De Deyn, 2011). Restoration of species-rich grassland from abandoned grassland has been shown to greatly increase carbon sequestration, with an important role for perennial species with extensive root systems (Yang et al., 2019). Soil carbon levels can be particularly high for grasslands on alluvial soils where the introduction of riverine material from periodic flood events leads to deepened soil profiles (D'Elia et al., 2017).

Livestock grazing of grasslands contributes to greenhouse gas emissions through the release of methane, but **methane levels are lower for grasslands managed at low intensity due to lower stock numbers** (Bullock et al., 2011; Bengtsson et al., 2019). Nitrous oxide (N_2O) release is also much lower under semi-natural grassland management due to low or zero use of nitrogen-based fertilisers.

Hazard - flood

Semi-natural grasslands can have an important role in the maintenance of water flows, having a greater capacity to store water than intensively managed grassland, and therefore playing a role in Natural Flood Management across whole catchments (see Freshwater chapter). Compacted soils increase flooding risk due to increased surface run-off (Alaoui et al., 2018). Soils under semi-natural grassland are generally much less compacted than those under intensive agricultural management due to lower livestock numbers and lower use of farm machinery (Weatherhead and Howden, 2009; Bengtsson et al., 2019; Hargreaves et al., 2019). Semi-natural grassland, especially wet grassland, generally has more water-retentive soils, a more varied sward structure (Figure 11), and a wider range of plant species rooting depths, all of which help to retain or regulate water flows. They can therefore play an important role in flood prevention during wet weather, especially in upper river catchments with abundant wet grassland (Figure 12). However, intensive agriculture currently dominates most lowland flood plains in Wales (Rothero et al., 2018).

Hazard - fire

Management is key to reducing fire hazard in semi-natural grasslands. Suitable levels of either livestock grazing or cutting or both reduces fuel loading and are also likely to have other ecosystem benefits, such as increased plant species-richness and increased agricultural productivity. Grassfires, together with a much smaller number of forest fires, have been estimated to cost South Wales Fire Service £7 million annually (Jollands et al., 2011).

Water, Soil and Air quality

European livestock production provides most of agriculture's contribution to air and water pollution and most nitrogen water pollution impact is caused by agriculture (Leip et al., 2015; see Freshwater Ecosystem chapter and Air Quality chapter). However, **low input semi-natural grassland management produces much less air and water pollution than intensive agriculture** due to minimal use of soil enrichers such as artificial fertilisers and farm slurry, lower livestock densities, and less use of machinery (Jarvie et al., 2008, 2010; Bullock et al., 2011).

Soil quality is similarly benefited by low intensity agricultural production. Grasslands which are not ploughed can also, if not mismanaged, contribute greatly to soil erosion prevention (Bengtsson et al., 2019), in contrast to cultivated grasslands or arable land (Souchere et al., 2003; Bengtsson et al., 2019; Evans et al., 2019; see Land use and Soils chapter). Intensive grassland management reduces soil animal biodiversity, including earthworms, and may therefore threaten soil functioning in agricultural systems (Tsiafouli et al., 2014).

Cultural services

Semi-natural grasslands form some of Wales's most iconic and valued landscapes. Among them are Great Orme's Head in north Wales (Figure 9), the Elan Valley meadows in mid-Wales, and the Gower limestone coast in south Wales. They also dominate many of Wales's upland landscapes.

Figure 9 Great Orme's Head, an iconic calcareous grassland landscape in north Wales. Photo: Stuart Smith/NRW

Over half of Wales, 57% or 12,200 km^2, is associated with the LANDMAP Grassland and Marsh category (Cottrell and Medcalf, 2019), which takes a wider definition of grassland than the semi-natural grassland definition, but excludes the most 'improved' grasslands. Tranquillity, wildness, naturalness and aesthetic appreciation are associated valued cultural services and benefits of this category. **Semi-natural grassland is associated with a number of traditional management practices with high cultural and heritage value**, such as hay making and grazing with rare livestock breeds.

A total of 3,900 km^2 of the Grassland and Marsh landscapes is evaluated as outstanding, and is recognised as of national and regional importance in Wales. A further 7500 km^2 are recognised as being of county or local importance. However, monitoring of the LANDMAP Landscape Habitat dataset revealed that Grassland and Marsh dominated landscapes accounted for the majority of real landscape habitat change in Wales, 1900 km^2 or 9% of Wales.

Surveys show that people prefer areas with structural variation and an abundance of flowers over monotonous landscapes (Lindemann-Matthies et al., 2010; Junge et al., 2015). Flower-rich meadows are particularly valued for their aesthetic appeal and as inspiration for artists. At a local level, varied landscapes and aesthetic value help to provide a sense of place and link to traditional, cultural and heritage practices. A lack of intensive farming may also benefit well-preserved buried archaeology and earthworks.

Grasslands are widespread in Wales and generally easy to access for recreation and leisure purposes. A few grassland sites are of particular importance for tourism, notably Great Orme's Head, which receives more than 600,000 visitors per year (Sally Pidcock, pers. comm., 2020) (Figure 9).

Semi-natural grasslands help to support a significant amount of local employment in Wales, especially that associated with small beef and sheep farming businesses. A significant amount of seed is sourced from semi-natural grasslands for use in creating species-rich grasslands under agri-environment schemes and other conservation initiatives (Bullock et al., 2011).

Many schools and other educational establishments make occasional use of grassland sites for learning purposes; the amount of use often depends on proximity to an appropriate site. For example, Great Orme's Head receives around 200 school groups per annum, not including unofficial visits, many of which engage in environmental activities on the site (Sally Pidcock, pers. comm., 2020). Flower-rich meadows make a good subject for school study, as moderately diverse meadows can be created in school grounds over a relatively short timescale and encourage the study of, for example, meadow management and pollinator-flower relationships.

6. Regenerative economy (Aim 4)

Semi-natural grasslands require low intensity management, meaning low or zero inputs of fertiliser and farm chemicals, and no deep ploughing or cultivation; **this favours delivery of almost all ecosystem services**, although food production levels are reduced compared to intensively managed grassland (Bullock et al., 2011; Frei et al., 2018; Bengtsson et al., 2019; Le Clec'h et al., 2019).

The provisioning ecosystem services for well-being provided by semi-natural grassland habitats are outlined in Table 9 below, and were developed from the set of services and definitions of the UK NEA Conceptual Framework (Mace et al., 2011). The Wales assessment is our current interpretation based on expert opinion.

Table 9 Provisioning Ecosystem services provided by Semi-natural Grasslands

Provisioning Services	**Importance of service**
Crops (food and medicinal – Crop Wild Relatives)	Medium -Low
Livestock (forage and fodder)	Medium
Standing Vegetation (biofuel) and Trees	Low
Water Supply	Medium
Wild Species Diversity	High

Wild species diversity

Temperate semi-natural grasslands are some of the most biologically diverse of all ecosystems (Wilson et al., 2012; Habel et al., 2013) and Welsh examples are important for a wide range of flora and fauna, for example:

- One third of higher plant Priority Species, 27 out of 82 taxa, occur predominantly or wholly in semi-natural grasslands (Julian Woodman, pers. comm., 2020).
- Welsh semi-natural grasslands support about 60% of the British population of wood bitter-vetch *Vicia orobus*, a species endemic to western Europe (Stroh et al., 2019; Fig 9).
- 11 of the top 20 richest British sites for grassland fungi are in Wales (Griffith et al., 2006).
- Semi-natural grasslands are highly important for many butterfly species, including the threatened marsh fritillary butterfly.
- Semi-natural grasslands and their associated flora are of key importance for many bumblebee species (Goulson et al., 2005; Carvell et al., 2006; Bullock et al., 2011).

- Semi-natural grasslands are important for a range of plant feeding arthropods, due to the great variety of host plants.

Figure 10 Wood bitter-vetch *Vicia orobus*, a grassland Priority Species; Wales supports some 60% of the British population. Photo: Stuart Smith/NRW

Species diversity is positively related to delivery and stable supply of other ecosystem services (Hooper et al., 2005; Isbell et al., 2011; Weisser et al., 2017). The level of management, especially grazing, is critical in maintaining species-richness in grasslands (Divinsky et al., 2017; Weisser et al., 2017). Under-management or abandonment causes significant decrease in plant species-richness (Moog et al., 2002; Bohner et al., 2019; Kimberly et al., 2019), which in turn negatively affects delivery of several ecosystem services. **High species diversity also increases resistance to colonisation of grassland by invasive non-natives** (Kennedy et al., 2002).

Livestock production

Semi-natural grasslands provide grazing forage for livestock and fodder in the form of cut hay or haylage. They typically have reduced yields, but lower capital costs and various other production benefits, such as higher meat nutritional content, compared to intensively managed grassland.

The production levels of semi-natural grassland are typically about 30% that of the most intensively managed grassland but can be as high as 80%, depending

on, for example, type of grassland, situation, and form of management (Tallowin and Jefferson, 1999; Bullock et al., 2011; Rothero et al., 2016). **Semi-natural grasslands generally deliver higher livestock production levels than other semi-natural habitats**, including heathland, fen, bog and woodland.

Where grassland soil fertility is low to moderate, higher plant species diversity promotes higher productivity (Hector et al., 1999; Bullock et al., 2007; Weigelt et al., 2009; Bullock et al., 2011; Weisser et al., 2017; Bengtsson et al., 2019). Soil compaction and erosion, which are more prevalent in intensive agricultural systems, generally lead to reduced yields (Luten and Roozeboom 1976; DEFRA, 2007).

Semi-natural grasslands can help support sustainable agricultural systems and contribute to a circular economy through the minimal use of artificial fertilisers and farm chemicals in their management. The production of the artificial fertilisers used in intensive agricultural production have a large environmental cost, including a huge energy requirement for the production of ammonia, estimated to be more than 1% of the world's energy supply, as well as extraction, processing and transportation costs associated with mining of phosphate, a finite mineral resource (Cordell et al., 2009).

The capital costs of farming semi-natural grassland are markedly lower than for intensive grassland management, largely due to much lower spending on fertilisers and farm chemicals, and also less use of farm machinery.

Semi-natural grasslands show a higher resistance to drought and extreme wet conditions, potentially brought on by climate change, compared to intensively managed grasslands. They can therefore provide forage and fodder when intensively managed grassland swards have stopped growing or died back (Tilman and Downing 1994; Isbell et al., 2015; De Keersmaecker et al., 2016).

Meat produced from semi-natural grasslands has higher nutrient content and lower fat levels than that produced from agriculturally improved grasslands, although levels of protein and energy are generally lower (Wood et al., 2007; Fraser et al., 2009; Bullock et al., 2011; Shellswell, 2017; McAuliffe et al., 2018). Meat and other food products from semi-natural grassland have been shown to perform better in consumer smell and taste tests (Coulon et al., 2004; Shellswell, 2017).

There is evidence that **certain species from diverse grassland swards have medicinal qualities or are deliberately selected by livestock to self-medicate**. In the past, and to a lesser extent currently, farmers frequently retained a field of semi-natural grassland, often named 'Cae Ysbyty', or 'hospital field', to aid recovery of sick animals (Shellswell, 2017).

Vegetation (biofuel)

The Committee on Climate Change's Net Zero report (CCC, 2019) suggests 10% of the UK's primary energy consumption could potentially be provided by bio-resources by 2050. Although this would probably be largely supplied by bioenergy crops, **stands of semi-natural grassland have the potential to provide biofuel without the large greenhouse gas emissions associated with planted energy crops**,

from, for example, fertilisers, irrigation and labour. (Tilman et al., 2006a; Burrascano et al., 2016).

Water Supply

In grassland, regulation of water flows is affected by a number of factors, such as soil porosity, sward texture (roughness), and the varying capacity of different plant species to absorb water. **Semi-natural grasslands generally have a much greater capacity to regulate water flows than more intensively managed grasslands** as their soils are usually less compacted, due to lower livestock numbers and less use of farm machinery (Alaoui et al., 2018; Hargreaves et al., 2019). They have more heterogeneous, and often tussocky, sward structures, and contain a more diverse range of species with a wider range of rooting depths. Semi-natural grassland has notably higher capacity than intensively managed grassland to hold water in dry conditions (Macleod and Ferrier 2011, Volaire et al., 2014).

Wet grasslands have a particularly varied and typically tussocky structure (Figure 11). They are formed over naturally water-retentive soils, due to the presence of shallow or irregular peat deposits or the gleying of clay-rich deposits (Stevens et al., 2010a). They form a significant component of a number of Welsh upper river catchments, for example, in several of the south Wales valleys (Figure 12).

Further research is required to look at water storage in soils at the sub-habitat type level (Rothero et al., 2018).

Figure 11 Marshy grassland showing tussocky sward structure

Photo: Stuart Smith/NRW

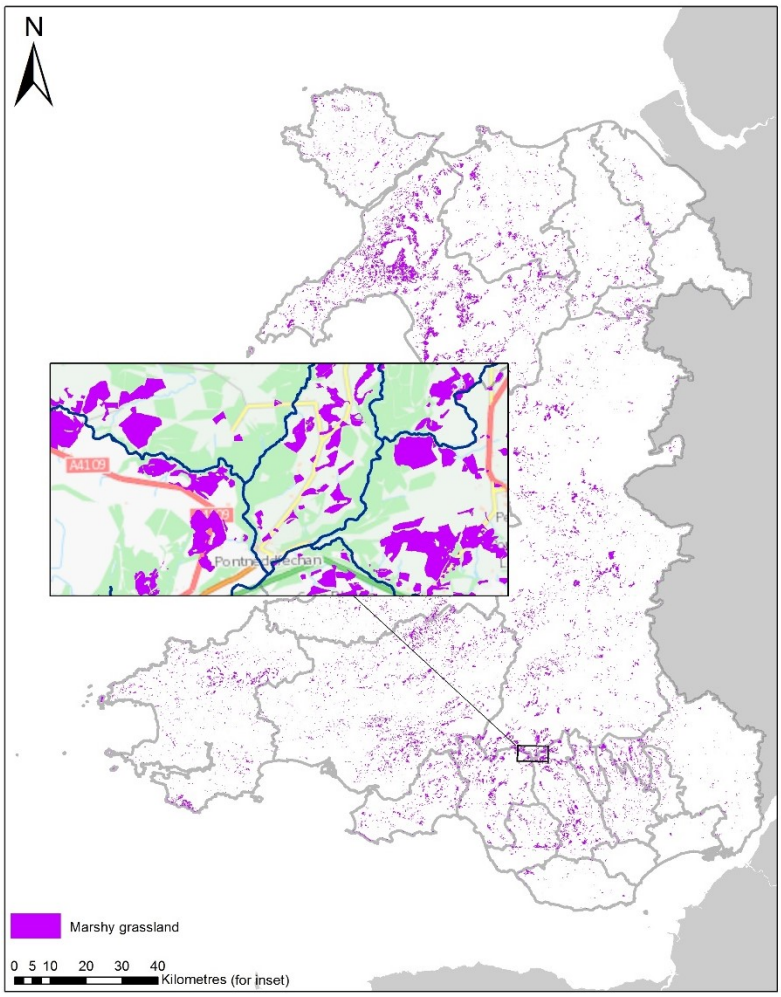

Figure 12 Marshy grassland (shown in purple) is a major component of land within the upper Neath catchment, helping to regulate water flows and reduce flooding downstream

Source (marshy grassland areas): NRW Priority Habitat database

Crops

Welsh semi-natural grasslands contain Crop Wild Relatives (CWRs) of important human foods, such as carrot, parsnip, brassicas and strawberry, as well as the key forage crops rye-grass and white clover. Grasslands are of high importance in the conservation of CWRs (Hopkins & Maxford, 2011; Jarvis et al., 2015), which are an important genetic resources for crop breeding used, for example, to improve pest and disease resistance, increase tolerance to environmental stress, and improve yield. Such species have increased importance as climate change increases the need for crops to be resilient to extreme environmental conditions such as drought (Volaire et al., 2014).

7. Synergies and Trade-offs

The principal trade-off in semi-natural grassland, compared with intensively-managed grassland, is between agricultural productivity and most other ecosystem services, as described in section 6. Production levels are typically significantly lower in semi-natural grassland, but vary between different grassland types, and can more closely approach those of intensively managed grassland where soil fertility is either naturally high, such as on flood plains, or is enhanced by controlled manure application (Tallowin and Jefferson, 1999). Where soil fertility is low to moderate, higher plant diversity promotes higher productivity (see section 6).

A focus only on production ignores other factors such as the quality and nutritional value of meat, which are enhanced in semi-natural grasslands (see section 6). Given that a reduction in consumption of red meat is currently being recommended, driven both by current healthy eating guidelines and climate change adaptation policy (UKCCC, 2020), this may be compatible with less production-led stock-rearing and favour more sustainable grassland management in the future.

Semi-natural grasslands are more resilient to the extremes of weather likely to be increasingly encountered due to climate change. Their greater natural resilience and resistance to drought and extreme wet conditions than intensively-managed or lower-diversity grasslands can provide more reliable yields (Tilman and Downing, 1994; Tilman et al., 2006b; Isbell et al, 2015).

As the climate changes, land-use pressures are highly likely to intensify, with calls for increased woodland planting (Welsh Government, 2018b) and growing of more biofuel crops (UKCCC, 2020), along with possible increase in the area covered by solar farms. Such needs should be viewed alongside the need for sustainable, low-carbon food production, as well as enhancing and restoring habitats and reversing the decline of biodiversity (UKCCC, 2020).

Most woodland planting in Wales currently takes place through the Glastir Woodland Creation scheme, which includes guidance designed to protect Priority Habitat and certain species groups from being planted on, including marsh fritillary butterfly and grassland fungi (NRW, 2018a; NRW, 2018b).

Table 10 is a comparison of the likely impact on regulating and provisioning ecosystem service delivery of four different land uses. It gives an indication of the ecosystem service trade-offs between them and, therefore, the potential effects of a change in land use. For example, a change from intensive agriculture to semi-natural grassland would be expected to result in decreased food provision but increased provision of most other ecosystem services. On the other hand, a change from semi-natural grassland to woodland would be expected to increase provision of timber, if commercial forestry, but a decrease in pollinator provision (Bartual et al., 2019). Tree planting leads to sequestration of carbon in vegetation (see Woodlands chapter), but conversion of grassland to plantation forest can result in a rapid decrease in soil carbon levels (Ostle et al., 2009), and there could potentially be a long-term negative impact on carbon budgets in carbon-rich soils (Friggens et al., 2020; Hong et al., 2020).

Table 10 A comparison of the current 'provisioning' and 'regulating' ecosystem service delivery of four different land-use types, taking into account their overall impact on each Ecosystem Service compared to the other land-use types

Ecosystem service	Semi-natural grasslands	Intensive agriculture	Commercial woodland	Miscanthus biofuel
Food	Medium	High	Low	Low
Energy	Low	Low	Medium	High
Timber	Low	Low	High	Low
Pollination	High	Low	Low-Medium	Low
Water, air, soil quality	Medium-High	Low	Medium-High	Medium
Water supply	Medium	Low	Medium	Low
Wild Diversity	High	Low	Medium	Low
Climate	Medium-High	Low	High	High
Flood prevention	Medium	Low	Medium	Low

High means a high positive impact, Low a negative or zero impact.
Information on woodland and intensive agriculture is taken from SoNaRR2020 Woodland and Enclosed Farmland chapters respectively

Conversion of semi-natural grassland to woodland would cause biodiversity loss of the grassland. The biodiversity value of the new woodland would depend on its form, for example native or non-native species, and would require long timescales to be fully realised. Planting new woodland on agricultural land might therefore be a better option for enhanced ecosystem service benefit, although this could take more productive land out of food production.

Growing of bioenergy crops, such as *Miscanthus* species and short rotation forestry/coppice, results in similar trade-offs in comparison with semi-natural grassland. The Committee on Climate Change recognise that "bioenergy crops could have negative impacts on biodiversity, soil health, water quality and invasive species, particularly if planted on grasslands" (UKCCC, 2020). Although there is currently very little *Miscanthus* production in Wales, the plant is considered to be

suitable for growing on poor soils (Radley, 2019) with some fertiliser addition (McCalmont et al., 2017), and, therefore, could compete for land space with some forms of semi-natural grassland.

Some stands of semi-natural grassland could be suitable for cropping as biofuel and, as long as this is conducted without increased intensification, most semi-natural grassland ecosystem services would be maintained (Bullock et al., 2011), the obvious exception being agricultural production. Cropping of semi-natural grassland might have negative effects on biodiversity, for example inappropriate timing of cuts. However, grassland biodiversity could benefit if currently neglected or abandoned grassland were utilised.

It is important to note that conversion of an ecosystem to another land-use type is not generally reversable. Once lost, semi-natural grassland ecosystems take decades and often more than 150 years to be fully re-created (Fagan et al., 2008; Waesch and Becker 2009; Woodcock et al., 2011; Redhead et al., 2013), and some forms are particularly difficult to create, such as calcareous and acid grasslands (Pywell et al., 2002).

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

Opportunities for sustainable management of semi-natural grasslands focus around improving resilience of the ecosystem by:

1. **Maintaining and enhancing grassland habitat on protected sites**, allowing these sites to 'function as core areas of a resilient ecological network' (NRW, 2018c);
2. **Maintaining and enhancing grassland habitat outside protected sites, particularly grassland Priority Habitat**;
3. **Restoring degraded grassland habitat**, including abandoned/neglected and slightly modified (semi-improved) grasslands;
4. **Creation of new grasslands**, targeted to improve semi-natural grassland resilience, reverse habitat fragmentation, and enhance ecosystem service delivery.

Maintaining and enhancing grassland habitat on protected sites

Protected sites have proved to be an effective means of preventing loss of semi-natural grassland habitat and conserving remaining populations of rare and threatened grassland species, such as shrill carder bee, marsh fritillary butterfly and spiked speedwell (see section 3). Nevertheless, many sites are currently in poor condition (see section 4). NRW has a duty to designate SSSIs and a key role in ensuring management and monitoring of statutory protected sites. Most sites are owned by private landowners or various NGOs and statutory organisations, making collaboration with site owners and managers of key importance. Options include:

- Designate more grassland habitat.
    - 10% of grassland Priority Habitat is currently on protected sites, which is much lower than the Convention on Biological Diversity (Aichi) target of 17% of terrestrial areas on protected sites. A number of unprotected grassland sites of high conservation interest (candidate SSSIs) have been identified.
- Have annual targets for achieving good grassland condition on protected sites.
    - Currently an estimated 70% of grassland habitat on SSSIs is in poor condition, with undermanagement being the principal cause (see section 3).
- Target and tailor management to conserve particularly rare or threatened forms of grassland and species.
- Ensure semi-natural grassland on NRW's own land, especially National Nature Reserves, is in good ecological condition.

- Purchase additional land which supports particularly good habitat examples.
- Make full use of grassland habitat on NRW's land as exemplar grasslands for demonstrating management practice and achieving good condition.
- Ensure all exemplar sites have access to agri-environment schemes.
- Better integrate agri-environment scheme delivery with achieving good grassland condition on protected sites.
- Increase coverage and efficacy of SSSI management agreements.
- Closer working between NRW and protected site owners and farmers to achieve good grassland condition.
- Improved collaboration between NRW and NGOs and other organisations that own or are responsible for management of grassland on protected sites.
- Tackle, at a national and local level, sources of air pollution which harm grassland habitat.

Maintaining and enhancing grassland habitat outside protected sites, particularly grassland Priority Habitat

Continuing losses of extent, widespread poor condition, and very poor connectivity of lowland semi-natural grassland, including Priority Habitat, outside protected sites (see section 3) illustrate that enhanced measures are required for the ecosystem to be resilient. Options include:

- Improve capture of recent spatial habitat data across Wales, utilising both remote sensing and ground survey methods, and provide regular updates.
- Ensure databases containing lists and maps of known areas of grassland Priority Habitat are up-to-date and made available.
- Target agri-environment scheme delivery to maintain and enhance grassland habitat, especially Priority Habitat.
- Ensure that agri-environment schemes are sufficiently resourced and incentives sufficient to encourage high uptake of grassland habitat and to prevent landowners undertaking detrimental land use and land management changes.
- Consider use of results-based payment schemes, which are considered particularly suitable for maintenance of grassland habitat (Allen et al., 2014).
- Target action to maintain and enhance grassland habitat in Area Statement delivery, through improved local action and collaboration.
- Ensure appropriate guidance is in place within the regulatory framework to prevent damage to grassland Priority Habitat.
- Review effectiveness of delivery of existing regulation, especially EIA Agriculture and Forestry Regulations.
- Consider introduction of conservation covenants in Wales.
- Consider higher protection levels for grassland Priority Habitat outside protected sites, as in Denmark (Danish Government, 2014).
- Consider changes to agricultural policy and management incentives to shift focus towards multiple ecosystem benefits rather than predominantly on agricultural production.
- Encourage sustainable agricultural farming systems that produce high-quality food or animal products with associated environmental and economic benefits.

- Improve management of road verges to increase area of semi-natural grassland and improve ecological connectivity.

Restoring degraded grassland habitat

- Target agri-environment delivery for grassland restoration, providing sufficient incentives to initiate restoration management and bring currently unmanaged sites back into sustainable agricultural production.
- Increase species-richness of semi-improved grasslands, particularly in places close to statutory protected sites or which help to improve ecological connectivity (see also Enclosed Farmland chapter).
- Target action to maintain and enhance grassland habitat in Area Statement delivery, through improved local action and collaboration.
- Target restoration management for specific grassland species which rely on optimal sward conditions, such as marsh fritillary butterfly (see biodiversity chapter).
- Consider use of some grassland habitat for sustainably-produced biofuel, for example, currently abandoned sites or sites where grazing is problematic.

Creation of new grasslands

Semi-natural grassland ecosystems, with the full range of different species groups, take many decades to fully develop from scratch (see section 4). However, replications of several existing forms of grassland can be created in a much shorter time. While these lack many features of more ancient grasslands, they can help to deliver ecosystem resilience, such as by helping to reconnect existing habitat, and provide a number of important ecosystem services related to less intensive agricultural practise. Methods for the creation of such new grasslands are well established and tested (Tallowin and Smith 2001; Pywell et al., 2002; Walker et al., 2004; Smith et al., 2008). Most methods involve the introduction of seed, although natural regeneration might be successful where wild seed sources persist locally, for example, in field edges or linear habitat features (Smart et al., 2006).

Up to now, creation of new grassland sites in Wales has mainly been conducted through agri-environment schemes, along with country-wide projects such as Coronation Meadows and, currently, Plantlife's Magnificent Meadows Cymru. Other projects are regionally focused, for example, the Elan Valley Meadows project in mid-Wales (Hayes and Lowther, 2014) and Farming for the Future on the Llŷn Peninsula.

Targeted grassland creation can be informed by use of spatial GIS datasets. In a recent project looking at Welsh flood plains, this has assisted in identifying where, within a catchment, grassland restoration or creation would be best targeted to improve biodiversity and ecosystem service delivery (Rothero et al., 2018).

These projects could provide templates for new landscape-scale projects across Wales, for example through Area Statement delivery, informed by Wales grassland connectivity mapping (Latham et al., 2013).

Targeting of grassland creation, as well as restoration of existing sites, can further enhance ecosystem resilience and service benefits in certain situations; examples are listed below, showing the main enhanced ecosystem benefits:

- Where forming part of important ecological networks: ecosystem resilience
- On flood plains and within key river catchments: controlling water pollution and supply; natural flood management; carbon sequestration
- On steep slopes: erosion control
- Close to insect-pollinated crops: pollination; pest control
- On soils or localities vulnerable to drought: continued productivity in dry conditions
- Close to nature conservation sites: biodiversity; ecosystem resilience
- Close to human habitation, for example meadows in the grounds of hospitals or schools: aesthetic, cultural, education and health benefits.

Summary

It is clear that semi-natural grasslands in Wales are not currently sustainably managed. However, agricultural land management and use is going to enter a period of significant change, as Britain moves out of the European Union and due to the pressing need to adapt to, and mitigate the effects of, climate change. Up until now, semi-natural grasslands have been a principal focus for agri-environment delivery in Wales, although scheme uptake has often been too low (see section 3) and the effectiveness of delivery often unclear (National Assembly for Wales, 2008). However, a shift towards more outcome-based support is now being proposed, along with more emphasis on linking farm support to the environment, rather than food production (Welsh Government 2019). The importance of landowner commitment (Hewins et al., 2013) and advisor support at the beginning of and during the life of the scheme (Boatman et al., 2014), have been emphasised in the delivery of grassland options in agri-environment schemes.

Having been, until relatively recently, the prevalent ecosystem in the Welsh lowland landscape, semi-natural grasslands could be a key part of delivering a more resilient Welsh landscape, which can provide a wider range of ecosystem benefits to the Welsh people.

9. Evidence needs summary

There are fundamental gaps in the evidence required to ensure high levels of confidence in the assessment of SMNR for semi-natural grasslands.

Basic data and information on extent, condition, connectivity and biodiversity is largely either out of date or incomplete or both, causing difficulties with evaluating stocks of natural resources and assessing trends. For example, although it is clear that there have been significant losses of lowland grassland habitat in recent years (see Section 3), a thorough appraisal of those losses outside statutory protected sites is lacking. Similarly, there is limited data on possible gains in grassland habitat through, for example, agri-environment measures or habitat restoration projects. Fit for purpose evidence relating to stocks of natural resources is fundamental, as it

allows ecosystem resilience to be assessed, enables prioritisation of sustainable management and informs focus areas for other evidence needs.

It is clear that semi-natural grasslands can play an important role in the provision of healthy places and progress towards a more regenerative economy. Many of the ecosystem service benefits of the ecosystem are already well understood, but more evidence is required for some aspects, for example:

- The role of plant diversity on carbon sequestration and storage;
- The role of management and sward heterogeneity on water regulation; and
- The quality and health benefits of meat from different forms of grassland.

The long-term effects of climate change on the different forms of semi-natural grassland and on uncommon or threatened grassland species are not yet fully understood, nor are the effects of climate change on grassland ecosystem service delivery, for example carbon sequestration and storage. More evidence is needed to fully evaluate the effects of atmospheric pollution on semi-natural grasslands, including general levels of atmospheric nitrogen and local sources of ammonia, for example to confirm which grassland species are most vulnerable to elevated nitrogen/ammonia levels.

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