VALUING THE VITAL: GRASSLAND ECOSYSTEM SERVICES IN THE UK

A Review of the Evidence and Analysis

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Valuing the Vital: Grassland Ecosystem Services in the UK

In the UK, species-rich grasslands provide a wide array of benefits for nature, climate, and people. As ecosystem services gain increasing attention in policy and funding decisions, this report offers a review of existing literature and evidence on the numerous advantages associated with species-rich grasslands. This report is intended to inform the understanding of these diverse habitats and inform decision-making around the restoration, management, and creation of species-rich grasslands.

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This report has been funded by Air Wick in partnership with WWF, with a pledge to restore 20 million square feet of UK wildflower habitats between 2021 and 2024.

'Working together to help restore UK wildflower habitats'

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1.0 OVERVIEW

1.1 Rationale

This report focusses on the ways in which UK grasslands can contribute to human wellbeing. In other words, it provides a review of the 'ecosystem services' (hereafter ES) delivered by grasslands in the UK, including how restoration of and reversion to semi-natural grasslands can be beneficial for people. The report complements one on the extent of UK grasslands that includes a discussion of grassland types across the UK and review of recent trends in their extent.

This report acknowledges the distinct characteristics of grasslands and their ES across England, Scotland, Wales, and Northern Ireland. Differences in climate, geography, and land-use practices contribute to variations in grassland types and the specific services they provide. This review will discuss these regional variations and their implications for grassland management and policy. Both reports focus on extensively managed permanent grassland, or "semi-natural" grassland – grasslands which require some form of management, but are key valuable habitats that support high biodiversity and the delivery of ES. The term "semi-natural" is discussed in Section 2 of the companion report, and a Glossary is provided in Appendix 02 of this report.

The concept of ES links ecosystems' biophysical structures and functions to socio-economic systems and human wellbeing. This is its virtue, and the reason why it resonates with decision-makers in government and business. Semi-natural grasslands contribute to a range of ES, enhancing our environment and supporting our wellbeing in various ways. They provide habitat for a diverse range of flora and fauna, contribute to climate regulation, help maintain clean water and air, and preserve our cultural heritage.

As the UK faces growing challenges from environmental degradation, habitat loss, and climate change, understanding and valuing the multifunctionality of semi-natural grasslands becomes more important than ever. The restoration and creation of semi-natural grasslands offer significant opportunities to enhance the delivery of ES, while also bolstering the resilience of our landscapes. Through this report, we invite you to explore the many facets of UK grasslands and their ES, delving into the scientific, social, and economic dimensions of these vital landscapes. As you read on, we hope that you will not only gain a deeper understanding of the crucial role that grasslands play in our lives but also feel inspired by the immense potential they hold for fostering a more resilient future.

1.2 Report Structure and Method

This report consists of three parts. Chapter Two introduces key concepts (ecosystem extent, ecosystem condition, ecosystem services), Chapter Three explores measurements of grassland condition and ES for the UK and Chapter Four raises strategic and policy issues around grassland management.

In conducting this report, we implemented a comprehensive evidence review process, encompassing a wide range of sources to ensure a robust understanding of grassland ES in the UK. Our research drew upon various types of literature, including peer-reviewed articles, governmental reports, and grey literature. Throughout the report, we provide citations to the relevant literature, highlighting the sources that have informed our analysis and conclusions. While our literature review was not conducted in a strictly systematic manner, we have tried to thoroughly investigate and synthesise the existing knowledge on the topic, presenting a well-rounded discussion of grassland ES in the UK.

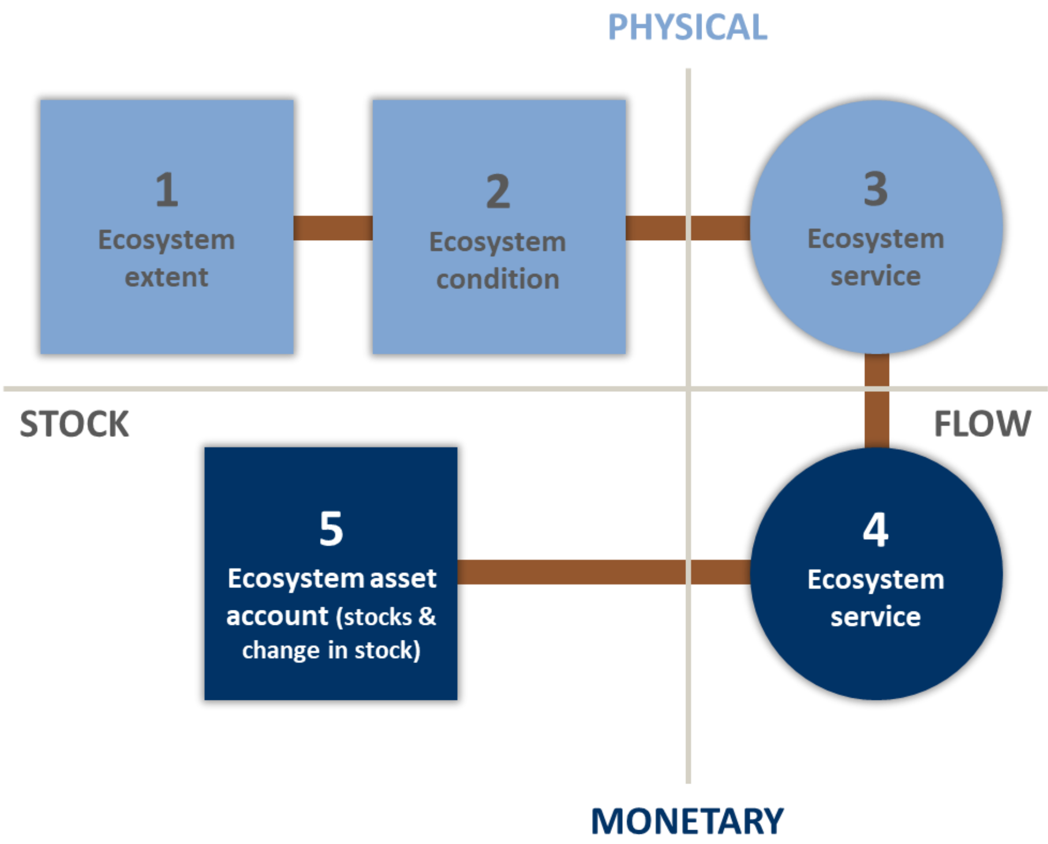
2.0 INTRODUCING GRASSLAND ECOSYSTEM SERVICES

2.1 What Are Ecosystem Services?

There are many different ES typologies. Some include a category of 'supporting services' including things like nutrient cycling, biodiversity, healthy soils and photosynthesis. This can lead to confusion, including double counting of benefits. The Common International Classification of Ecosystem Services (CICES), developed by the European Environment Agency, tries to avoid this problem by ensuring that each ES type is mutually exclusive from others. For this report we adopt a simplified version of the CICES typology[1], with 17 discrete ES (see Appendix 01 for full details): timber and other wood products; produce from the sea; plant-based energy; cultivated crops; plentiful water; reared animals; clean water; clean air; noise regulation; urban cooling; erosion control; flood protection; pollination; thriving plants and wildlife[2]; pest and disease control; climate regulation; and cultural services.

The ES concept is anthropocentric: the benefits of ecosystems for *people*. That is not to say that ecosystems are beneficial to humans only if they are used. Non-use benefits refer to the value people derive from ecosystems even if they don't directly use them. For instance, the knowledge that an ecosystem exists or that future generations can enjoy it are examples of non-use benefits.

Figure 2-1: The five ecosystem accounts



Source: adapted from United Nations, 2021

[1] This 'plain English' version of CICES is often used by the relevant agencies in the UK (e.g. Natural England, Defra, JNCC).
[2] This could be interpreted as being synonymous with 'biodiversity'. The double-counting problem is not entirely solved.

ES can be thought of as part of a 'cascade' from ecosystems' structures, processes and functions to the services they deliver that contribute to human wellbeing. Figure 2-1 formalises this with five distinct but interconnected ecosystem accounts, starting with the physical extent (1) and condition (2) of ecosystems, which together deliver physical ES flows (3). For example, carbon is *stored* in grasslands as a function of extent (1) and a variety of condition characteristics (2). The ecosystem service of carbon *sequestration* (3) is a flow, measured as an amount over a specified period of time. These three accounts are fundamental to the analysis across this report (referred to as 'extent', 'condition' and 'ES').

It is possible to put a monetary value on every ES flow (4) as well as the ecosystem assets themselves (5) and hence support decision-makers to take proper account of the value of nature. This is the theory, but although monetary valuation can help decision-makers appreciate nature's value, it can also contribute to its destruction by perpetuating a focus on a narrow set of market-driven values (IPBES, 2022). This report doesn't primarily focus on monetary valuation, except when it adds clarity.

Recent research by Zhu *et al*. (2023) of almost 28,000 global grassland studies from 2006 to 2021 found that biodiversity, vegetation and conservation were the three most common study areas. Each of these areas relate to ES in different ways:

- There is extensive literature about whether *biodiversity* is an ES, with Mace *et al*. (2012) providing some clarity that it can be considered an ES. However, its essential role is as a regulator of underpinning ecosystem processes. Living systems—biodiversity in its broadest sense—contribute to all ES;
- *Vegetation* characteristics partly determine grassland ES, such as climate regulation (e.g., biomass), erosion control (e.g., root systems), flood protection, and pollination; and
- *Conservation*, including restoration, appropriate management, and reversion, is sometimes essential for maintaining grassland ES delivery, as ES may not reliably flow from degraded ecosystems.

Biodiversity and vegetation characteristics would generally be included as part of the 'ecosystem condition' accounts as per Figure 2-1. Conservation is not explicitly included in any of the accounts, though can be important for fully realising grasslands' ES potential: by conserving ecosystems against common drivers of loss and degradation, both extent and condition as well as the ES that flow can be enhanced[3].

2.2 Grassland Extent

Permanent grasslands cover a greater proportion of the UK land surface than any other major habitat type, covering nearly 40% of the UK (Land Cover Map, 2020) and the question of definitions and trends is the subject of a report published alongside this one. Of course, the extent of grasslands is an essential factor in ES delivery (Figure 2-1). While 'temporary grassland' is used as an agricultural land management technique in the UK, with annual soil preparation and seeding (often as part of a crop rotation system), this report focuses on grasslands where the soil remains undisturbed for multiple years.

The spatial distribution of grasslands is critical for many regulating ES (e.g., flood protection, pollination) and most cultural services. Consequently, it is important to try and align the areas with potential supply of these services with the locations where the demand for them is concentrated. (This is less of an issue for many provisioning ES such as food which can be transported relatively easily.)

[3] See Eastwood et al., (2016) for a review of the ES benefits of conservation, based on nine case studies in the UK.

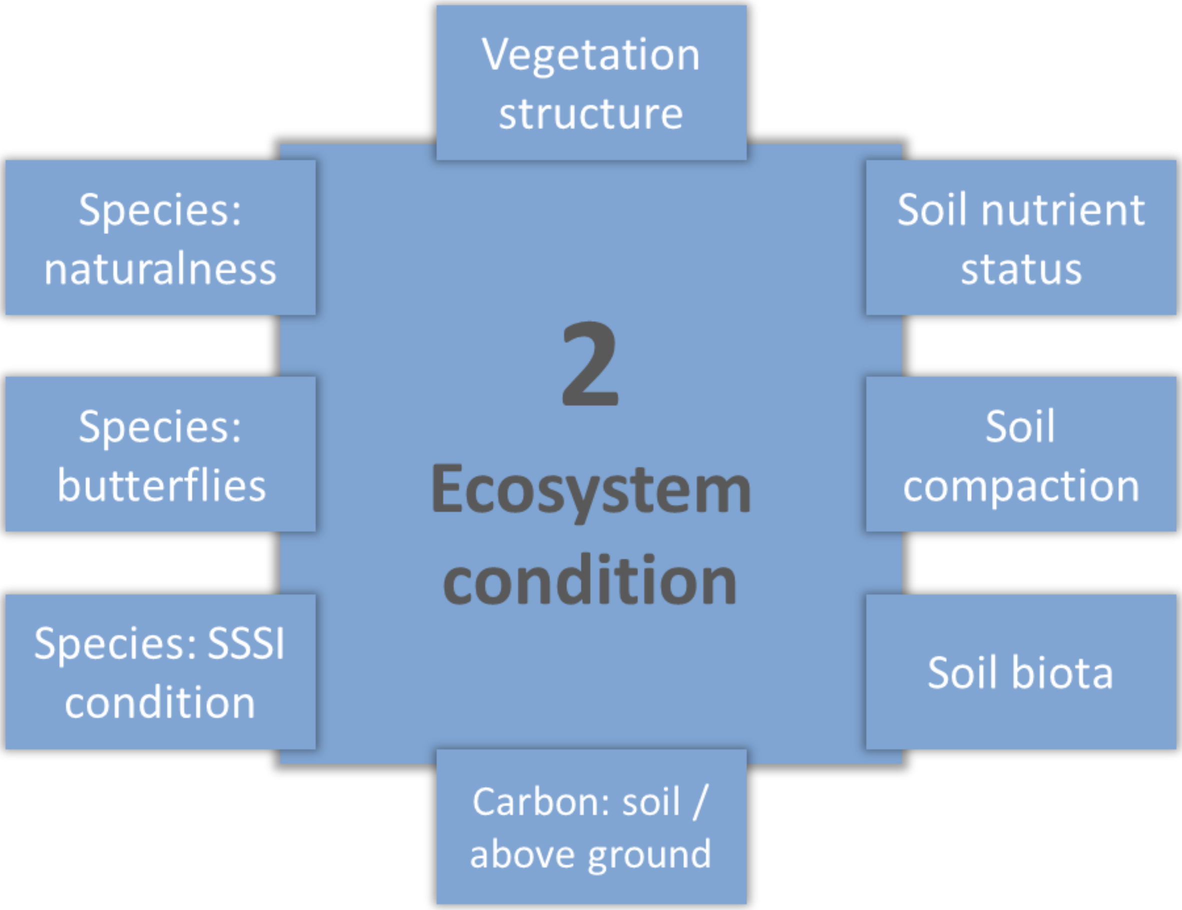
2.3 Grassland Condition

Our interest in condition (or state, or quality) pertains mainly to the delivery of ES. This includes variables such as grasslands':

- Physical condition including soil structure and water availability;
- Chemical condition including soil nutrient levels, water quality, air pollutant concentrations;
- Compositional condition including species diversity;
- Structure condition including vegetation, biomass and food chains;
- Functional condition including ecosystem processes and disturbances; and
- Landscape including diversity, connectivity, fragmentation.

In line with an unpublished report by Natural England and others, eight of the most important condition variable indicators for grasslands are shown in Figure 2-2. These indicators, though not exhaustive, can be excellent 'proxies' to understand the degree to which grasslands are able to deliver particular ES.

Figure 2-2: Non-exhaustive indicators of 'ecosystem condition' facilitating semi-natural grassland ES delivery in England



Source: adapted from Lusardi et al., 2022

2.4 Grassland Ecosystem Services

Grasslands deliver, in some way, each of the 17 ES types introduced above (apart from 'produce from the sea'[4]). For semi-natural grasslands, eight ES have been identified by Natural England and others as being particularly important. These are shown in Figure 2-3. The ability of grasslands to deliver these services now and into the future depends largely on their extent and condition.

Figure 2-3: Non-exhaustive ES delivered by semi-natural grasslands in England

Source: adapted from Lusardi et al., 2022

[4] Though this is arguable: machair ecosystems, for example, contribute to the health of nearby marine ecosystems.

2.5 Monetary Valuation of Grasslands

Five types of ecosystem account were set out in Figure 2-1, including monetary accounts for both ES flows and 'ecosystem assets'[5]. Monetary valuation techniques range from the simple (the market value of reared animals can be an indication of value), to somewhat challenging (restoration expenditures for grasslands demonstrate at least a minimum level for the value they provide; a house situated closer to grasslands will, all else being equal, be more expensive than one further away). There are also techniques that in theory allow for monetary valuation of all types of ES and ecosystem assets but that are prohibitively expensive to do well (asking people to state their willingness to pay for cultural ES; choice experiments where people are asked to make trade-offs between multiple ES and other goods in order to elicit willingness to pay).

Methodological issues include conflating welfare value, a subjective measure of satisfaction, with exchange value, the objective market price. While GDP relies on exchange values, most ES are not (and should never be) directly traded in markets and their importance is best understood in welfare value terms.

Any implication that the benefits of ES to humans must always be expressed in monetary terms is wrong. Indeed, there are a host of techniques to analyse human preferences in non-monetary terms, including preference assessment, photo-elicitation surveys, scenario planning, deliberative valuation and participatory GIS mapping. The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) in July 2022 published a 'Values Assessment' urging a move away from economic valuation of nature towards an approach including the multiple values of nature in policy decisions.

In summary, valuation of ES can be useful, and the 17 types of ES set out above are not assumed to be of equal importance[6]. If monetary values are cited for grasslands or related ES, it must be ensured that underpinning assumptions are explained to avoid unclear valuations.

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[5] In practice, monetary valuation of ecosystems ('ecosystem assets') is often an exercise in adding up the annual ES flow monetary values associated with that ecosystem, and then assuming these flows continue into the future to justify a 'net present value' calculation.

[6] Climate regulation is usually perceived to be amongst the most important, as are 'clean water', 'thriving plants and wildlife' and cultural services. It is beyond the scope of this report to assess relative importance in any detail, and this can be context-dependent and influenced by various factors.

3.0 MEASURING GRASSLAND ECOSYSTEM SERVICES

3.1 Introduction

In trying to understand the ES delivered by grasslands in the UK, we begin by investigating each of the eight indicators of 'ecosystem condition' shown in Figure 2-2. An advantage of this approach is that condition is an earlier part of the 'cascade', and so logically should be considered first. Another advantage is that trend indicators of condition are more available, compared with indicators of ES flows. Perhaps the most important reason is that indicators of *current* ES flows can be a poor indicator for *potential future* ES flows (think of overgrazed landscapes). The onus therefore is to demonstrate the connection between indicators of grassland condition and future ES delivery.

Extent is discussed in the companion paper. Using broad-scale estimates of grassland coverage from Land Cover Map data[7] revealed that improved grasslands managed for agricultural purposes dominate for all countries, covering almost 30% of the UK's total land surface. There is some 2.7 million hectares of semi-natural grassland (i.e., excluding improved grassland) across the UK, which constitutes 11% of the UK's total land surface. In comparison to the respective countries' land areas, semi-natural grassland is concentrated in Wales and Northern Ireland, with a slightly smaller proportion in Scotland and only 5% proportional cover in England. Land Cover Map 2020 data in relation to grasslands is summarised in Table 3-1.

Table 3-1:
Land Cover Map 2020 data relating to grassland extent in the UK

	Semi-natural grassland as a proportion of land cover	Improved grassland as a proportion of land cover	All grassland as a proportion of land cover
England	5%	32%	38%
Wales	23%	42%	65%
Scotland	16%	18%	34%
Northern Ireland	20%	39%	59%
United Kingdom	**11%**	**29%**	**40%**

3.2 Condition Indicators: Soils

Soils with balanced nutrient content sustain diverse plant communities[8]. Uncompacted soils promote healthy root growth and water infiltration, further supporting these communities. Soil biota help break down organic matter, cycle nutrients, and make them available for plant uptake. Thriving plant communities provide habitats and food sources for animals, including a wide range of insects, birds, and mammals.

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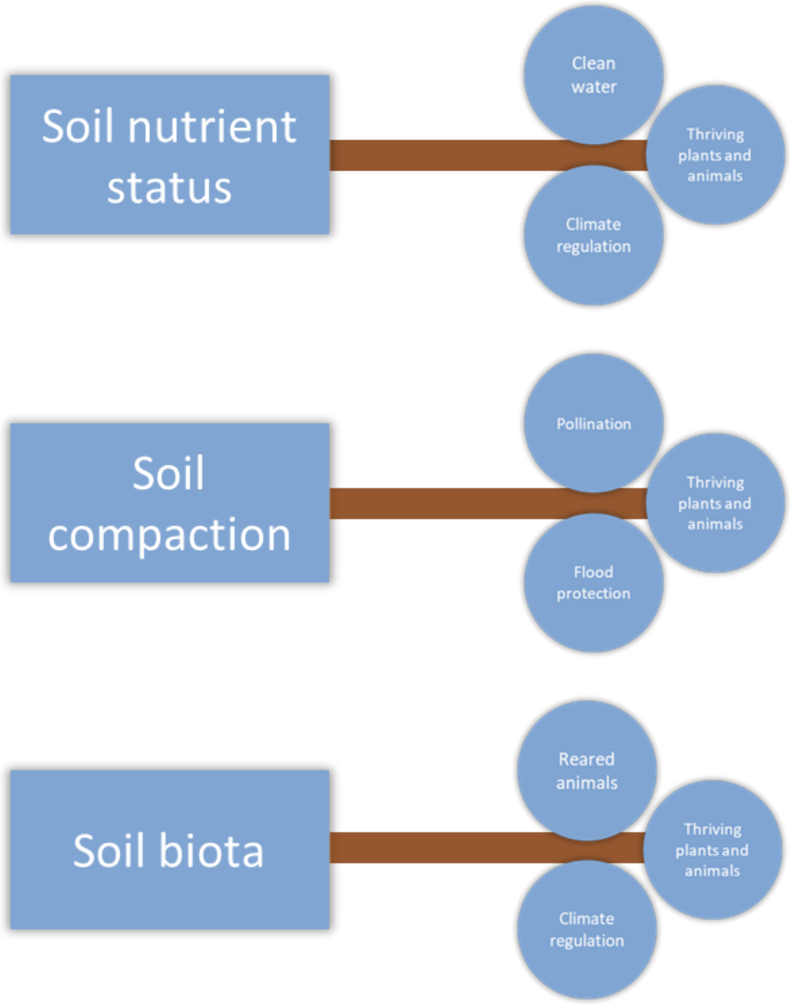
[7] This data was selected for use as the most recent, with UK coverage, and could be used in comparison with earlier data collected in 1990. However, methodological changes and the processing of satellite data mean that inconsistencies are present and data should not be over-interpreted, for example, within specific grassland types. Further detail is provided in the companion paper. Source: Land Cover Map 2020 (25m rasterised land parcels, GB): Marston, C.; Rowland, C.S.; O'Neil, A.W.; Morton, R.D. (2022). Land Cover Map 2020 (25m rasterised land parcels, GB). NERC EDS Environmental Information Data Centre.

[8] Though this depends. For example, diverse limestone and chalk grasslands are deficient in phosphorus. Calaminarian grasslands hosting specialised plant species often have high levels of lead or other metals. Diverse acid grasslands are low in available nutrients and acidic too. Low nutrient grasslands are also often better for fungi.

Other ES requiring high-quality soils are climate regulation, clean water (i.e. soils acting as a natural filter to break down pollutants and excess nutrients), pollination (e.g. uncompacted soils mean more diverse vegetation cover[9]), flood protection (e.g. uncompacted soils help with water infiltration and retention, root development, soil erosion control etc.) and reared animals. Healthy soils are vital, and the various aspects of soil condition including connections with ES delivery are illustrated in Figure 3-1.

Figure 3-1: How grasslands' soil characteristics link to specific ecosystem services



Source: adapted from Lusardi et al., 2022

The proposed England Ecosystem Survey, part of the Natural Capital & Ecosystem Assessment Programme, will include relevant information about these soil variables, but the first round of data collection is not due for completion until 2027. The National Soil Inventory (NSI) for England and Wales provides a baseline of soil properties, and The Scottish Soils Database does the same in Scotland, including for example risk maps for compaction. The Northern Ireland Countryside Survey is currently being carried out for the first time since 2007 and includes some relevant grassland soil data.

[9] The 'vegetation cover' condition indicator highlighted in Figure 2-2 is primarily linked to the same three ES as 'soil compaction': pollination; flood protection; and thriving plants and wildlife.

The UK Soil Observatory is perhaps the most useful source, as it brings together spatially explicit data from a range of sources and includes nutrient information (e.g. Olsen-P), physical data related to compaction as well as soil biota (e.g. topsoil microbes).

Unambiguous trend data is lacking, however. Reynolds et al., (2013) reported that the Countryside Surveys for Britain between 1978 and 2007 showed a general decrease in soil acidity, linked to a reduction in sulphur emissions, and an increase in total nitrogen concentration in topsoils, which could negatively impact sensitive grassland plant species. Further information about soil trends can be found on the ONS and UKCEH websites.

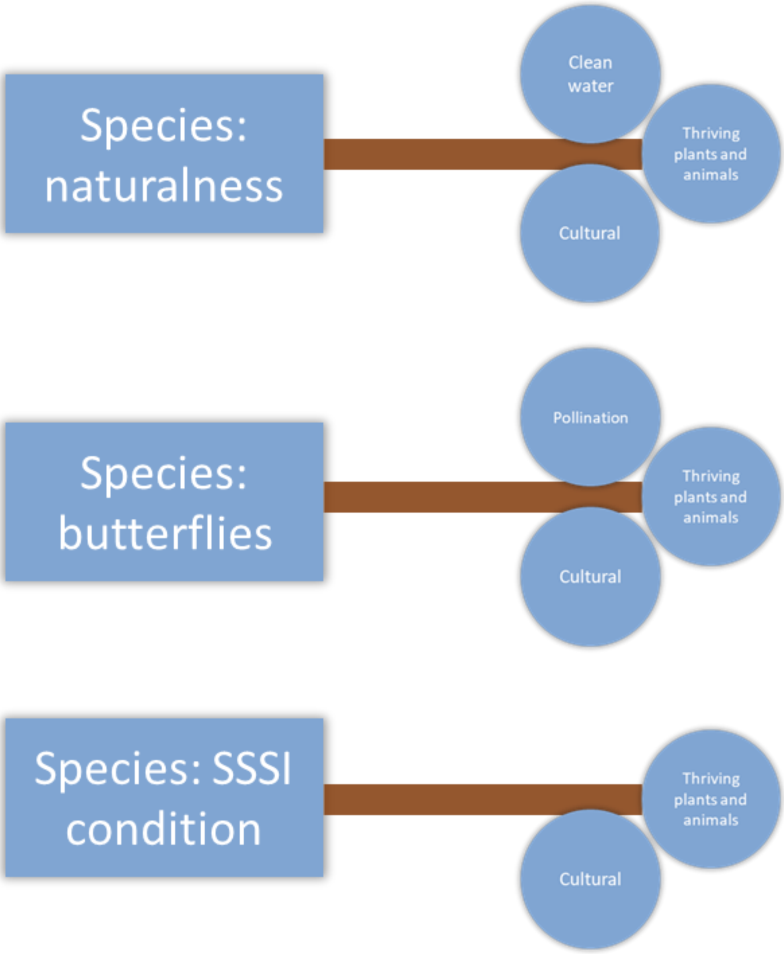
3.3 Condition Indicators: Species

Three possible species indicators for grassland condition are naturalness, grassland butterflies, and SSSI condition (Figure 3-2)[10] and clearly each link to the 'thriving plants and wildlife' ES. Each also tells a subtly different part of the story of grassland's importance for cultural ES, and when considered in combination can provide useful insights:

- Naturalness, measured by metrics such as the Biodiversity Intactness Index, covers a multitude of plant and animal species and as such can be useful for understanding the aesthetic value / visual appeal of grassland landscapes;
- A metric for grassland butterflies is more focussed, and can be useful with respect to recreational activities; and
- SSSI condition (for example percentage favourable), whilst applicable only for certain protected grasslands in the UK, is based on scientific theory that can be helpful for educational purposes.

[10] Six of the eight highlighted condition indicators are shown across Figure 3-1 and Figure 3-2. The 'carbon: soil / above ground' condition primarily links to the 'climate regulation' ES.

Figure 3-2: How grassland species indicators link to specific ecosystem services



Source: adapted from Lusardi et al., 2022

The UK Butterfly Monitoring Scheme's 2022 results for grassland butterflies are summarised in Table 3-2 and show a slight decline for more than half the species (17 out of 30) since records began, but a slight increase for more than half the species (again, 17 from 30) over the past ten years. In Table 3-2 where bold means statistically a very highly significant (P < 0.001) trend[11].

[11] The p-value is a measure used to determine the significance of a result. It represents the probability that the observed result occurred by chance alone. A smaller p-value indicates stronger evidence against there being no effect. The p < 0.001 means that the probability of observing the result by chance alone is less than 0.1%, or 1 in 1,000.

Table 3-2: Summary of butterfly abundance changes in the UK to 2022, for 30 species associated with UK grasslands[12]

Species	Change since 1976 (%)	Change since 2013 (%)	Species	Change since 1976 (%)	Change since 2013 (%)
Dingy Skipper	-1	15	Marbled White	**78**	10
Grizzled Skipper	**-45**	22	Pearl-bordered Fritillary	**-66**	12
Chequered Skipper	69	357	Small Pearl-bordered Fritillary	**-69**	-24
Small Skipper	**-71**	-37	Dark Green Fritillary	**300**	61
Lulworth Skipper	-71	-13	High Brown Fritillary	-63	13
Silver-spotted Skipper	**542**	-10	Marsh Fritillary	3	-9
Large Skipper	-27	-29	Duke of Burgundy	-35	20
Orange-tip	40	32	Small Copper	-41	6
Green-veined White	-20	-40	Green Hairstreak	-29	17
Wall Brown	**-85**	-8	Small Blue	26	93
Large Heath	**371**	43	Brown Argus	22	-2
Small Heath	-45	37	Northern Brown Argus	-58	0
Scotch Argus	37	-39	Common Blue	-20	-26
Ringlet	**318**	-27	Adonis Blue	100	-29
Meadow Brown	-1	4	Chalk Hill Blue	3	5

Source: UKBMS, 2023

The small skipper (found in open uncut grassland), wall brown (short open grassland with patches of bare ground) and small pearl-bordered fritillary (woodland clearings, damp grassland, heaths and dunes and other damp habitats) are in particular peril: all with highly significant declines since 1976, and all continuing that decline over the past ten years.

As well as wall brown butterflies some other grassland specialists with limited powers of dispersal, like small heath (-45%), and northern brown argus (-58%), have experienced significant declines. The small heath is found in open short grassland with fine grasses, and the northern brown argus inhabits calcareous grassland slopes with Rockrose. Despite these differences, habitat loss and fragmentation are likely common factors contributing to their declines.

Other specialist species like silver-spotted skipper (542%), large heath (371%), and dark green fritillary (300%) have seen substantial increases in their populations. The silver-spotted skipper inhabits chalk grasslands, the

[12] Data for some species not collected from 1976: chequered skipper (from 2003 only); lulworth skipper (1992); silver-spotted skipper (1979); large heath (1990); scotch argus (1979); high brown fritillary (1978); marsh fritillary (1981); duke of burgundy (1979); small blue (1978); northern brown argus (1979); and adonis blue (1979).

large heath is found in boggy habitats, and the dark green fritillary prefers bracken hillsides and flower-rich grasslands. Two factors that might contribute to their respective population increases are climate change and successful conservation efforts.

Figure 3-3: Common blue on cowslip: Common blue have seen a 26% decline in the UK since 2013. ©Lucia Chmurova

There are relevant trend data for many other pollinators and birds. For example, the Farmland Bird Index was 42% of its 1970 value in 2021[13], though this is relevant to arable land rather than semi-natural grassland. SSSI data suggest that more of Scotland's designated grasslands are in an unfavourable condition (26%) compared with England (14%)[14]. These estimates relate to very different types of grassland and are not calculated in the same way, so are compared with caution.

Plant species diversity is part of both the 'naturalness' and the 'SSSI condition' indicators. The UK's National Plant Monitoring Scheme (NPMS) which began in 2015 provides another useful source of information. As explained in Pescott *et al*., (2019) the NPMS's primary aim is monitoring the abundance of plants at small scales. The NPMS is based on botanical surveys carried out by volunteer citizen scientists throughout the UK and is therefore also a good indicator of cultural ES related to science and education. Significant efforts are made to train volunteers, with 34 separate training events taking place in 2021 and various video training materials available[15].

The Botanical Society of Britain and Ireland's Plant Atlas 2020 is the most in-depth survey of the British and Irish flora ever undertaken. The Atlas highlights the significant loss of species linked to arable lands and open habitats on infertile soils, such as species-rich grasslands, bogs, and heaths. Likewise, it notes an increased range of introduced species, generalists linked to nutrient-enriched soils, and southerly distributed species. The Atlas provides critical insights into the decline of iconic grassland species such as the devil's-bit scabious (foodplant for the marsh fritillary butterfly) and pasqueflower, primarily due to habitat changes.

Like pasqueflower, tubular water-dropwort and burnt orchid are signature species of chalk and limestone downland ecosystems, thriving on well-drained, nutrient-poor soils that support a rich diversity of plant species. However, alterations in land management, including the decline in grazing, have led to a decline in these species, mirroring the overall decrease in biodiversity in these habitats. Similarly, acid grasslands are characterised by hardy species such as sheep's sorrel and tormentil, which are adapted to low nutrient levels and support a range of insects and birds. Yet these species too have been declining due to pressures from agricultural intensification,

[13] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1141198/UK_Figure_1.3_2022.csv/preview

[14] 39 of 148 sites unfavourable in Scotland (2020); 18,557 hectares out of 136,724 unfavourable in England (2022). Wales and Northern have less available information. See Table 13 (Scotland), Table 14 (England) and Table 15 (Wales) of ONS website (2022): https://www.ons.gov.uk/economy/environmentalaccounts/bulletins/habitatextentandconditionnaturalcapitaluk/2022

[15] For example, see the NPMS YouTube Channel: https://www.youtube.com/@npmssupport9422/playlists

urban development, and reduced grazing. The trends in these key indicator species reflect broader shifts in our flora, emphasising the need for targeted conservation efforts

At the same time, the Atlas serves as a roadmap for conservation, emphasising a multi-faceted approach. This includes strengthening protections for plants, extending high-quality habitats, managing land more sustainably, and putting species recovery at the heart of conservation efforts. Moreover, it underscores the potential for grasslands restoration to contribute significantly to climate change mitigation. The Plant Atlas prompts us to apply our knowledge of these species trends and equips us with the tools to manage our valued natural landscapes more effectively.

3.4 Ecosystem Service Indicators

Having established some indicators of ecosystem condition, which are closely related to the capacity of the ecosystem to provide ES, let's return to the eight main ES introduced earlier. Relying solely on indicators of grassland condition as a proxy for ES has limitations, as they do not directly measure the actual magnitude of the services provided. Additionally, different grassland properties sometimes have contrasting influences on various ES, leading to trade-offs and challenges in managing grasslands for multiple services.

3.4.1 Plentiful Water

Grasslands, with their complex root systems, promote water infiltration into the soil to replenish groundwater. Grassland soils act as natural sponges, absorbing and storing water during periods of high precipitation. Souchere *et al*. (2003) found, using the STREAM model[16], that converting 17% of permanent grassland to arable land within a catchment basin resulted in a significant increase in both runoff volume (over 75%) and soil loss (over 85%).

Although not shown as linked in Figure 3-1, soil characteristics such as biota or (absence of) compaction are also decent proxy indicators of grasslands' ability to provide this service.

3.4.2 Reared Animals

Figure 3-4: White park cattle grazing on limestone grassland © Cath Shellswell

Grasslands serve as essential grazing habitats for cattle and sheep, as well as other livestock. The health and productivity of grasslands heavily rely on soil biota, while their nutritional qualities are primarily determined by dry matter content, digestibility, and protein content.

Agricultural statistics are gathered across the UK, and an indicator such as 'livestock units per hectare' provides a more direct measure of this ES flow. For a measure of *potential future* flows, for this ES in particular, condition indicators are more useful than indicators of *current* ES flows, as condition indicators are likely to predict the longer-term health and productivity of the grassland for potential future ES flows, such as grazing habitat.

[16] This was based on analysis for Upper Normandy in France. The STREAM model (Spatial Tools for River Basins and Environment and Analysis of Management Options) is a spatially distributed, process-based hydrological model. It is designed to simulate water balance, nutrient transport, and sediment dynamics in river basins. The model can be used to assess the impact of land-use changes, climate variability, and management practices on water resources and water quality.

3.4.3 Clean Water

Grasslands are also vital for the qualitative aspects of water supply. They help to filter and purify water as it percolates through the soil; they prevent soil erosion and sedimentation in water bodies; they reduce nutrient runoff and leaching; and they support species that remove pollutants or recycle nutrients.

There are many potential condition indicators beyond those shown in Figure 3-1 and Figure 3-2. More direct measurement of this ES is done by environment agencies across the UK, though the contribution of grasslands cannot always be separated from other ecosystems' contributions.

3.4.4 Flood Protection

Grasslands, both in natural floodplains and on slopes away from rivers and streams, play a significant role in flood protection. Their management practices, such as surface roughness, boundary features like hedges or walls, and drainage systems, can influence runoff speeds and, consequently, contribute to flood prevention or exacerbation.

Species-rich floodplain grasslands are more resilient to flooding compared to monoculture grasslands like rye grass. The diverse plant community found in species-rich grasslands can slow down water flow, enhance water infiltration, and help stabilise soil, reducing erosion and runoff. The Floodplain Meadows Partnership has collected data supporting the benefits of such grasslands in terms of flood management[17].

Grasslands also contribute to this ES via erosion control (i.e. preventing the clogging of rivers and streams). Vegetation structure can be an indicator for this, for example because vegetation intercepts rainfall including via root systems. Grasslands with minimal soil compaction, and hence a more porous structure, are better able to store water.

3.4.5 Pollination

Grasslands provide a range of flowering plant species and are also a vital habitat for pollinators. They also act as corridors enabling the movement of pollinators across habitats.

Indicators of soil compaction, vegetation structure and butterflies have been argued to be the most important condition indicators. However, this is not exhaustive and more direct measures can be used that are related to other pollinating insects such as bumblebees, or to crop outputs. Baude *et al*. (2016) for example found that calcareous grasslands (ahead of broadleaved woodland and neutral grassland) produce the greatest amount of nectar per unit area from the most diverse sources, with arable land being the poorest habitat[18]. For comparison, calcareous grassland productivity is well over 70 kg per hectare per year, and arable under 10 kg.

Figure 3-5: Leaf-cutter bee on knapweed © Lucia Chmurova

[17] See https://www.floodplainmeadows.org.uk/

[18] Habitat types included were: arable land; improved grassland; acid grassland; neutral grassland; calcareous grassland; conifer woodland; broadleaf woodland; bog; fen; bracken; and shrub heathland.

3.4.6 Thriving Plants and Wildlife

Each of the eight condition indicators is linked to the 'thriving plants and wildlife' ES, and the UK's grasslands are home to an abundance and diversity of species across different taxonomic groups.

3.4.7 Climate Regulation

A recent paper from Plantlife explores the role of grasslands in climate regulation. This includes much more detail about suggested indicators related to soil and above-ground carbon stored within and sequestered by grasslands in the UK. Research indicates positive correlations between the diversity of plants in grasslands and the amount of carbon that can be stored in their soils.

3.4.8 Cultural

'Cultural services' encompass a very wide range of things, from recreation[19] and tourism, to more abstract aspects such as a sense of place, to concepts that do not necessarily imply direct interactions with nature, such as spiritual and symbolic connections[20]. Grasslands deliver a wealth of cultural services and, as discussed, species information provides one proxy measure of flows. Other proxy measures include the Public Rights of Way densities or Scheduled Monuments at risk on grassland habitats. More direct measurement of ES flows is possible for tourism and recreation elements (e.g. the number of visits to and/or activities undertaken on grasslands) and also for education (e.g. number of NPMS volunteers).

In a recent literature review of cultural ES for European grasslands, Pellaton *et al*., (2022) discuss related threats (land-use and management change processes was by far the most important threat, followed by social attitudes, industrial developments and natural threats) and point out that tourism activities cause ecosystem disturbances. To protect future cultural ES flows, solutions such as frequentation management plans are recommended. Again, for understanding *potential future* flows, condition indicators can be more useful than indicators of *current* ES flows.

3.4.9 Others

Grasslands provide a multitude of ES, and the fact that the following are not central in this report's analysis is more of a reflection of this report's scope than any lack of importance:

- Timber and other wood products: Though not wood-based, grasslands deliver a range of products including hay, medicinal plants, wild food and fibers. French (2017) explores how species-rich grasslands offer more protein, phosphorus, potassium, and calcium than cereals and conventional hay, meeting livestock nutritional needs;
- Plant-based energy: grass cuttings can be transformed into biomethane, green hydrogen, solid biofuel, peat replacement products and bio-based building materials. There is significant potential, given technological advances, for grasslands to be central to a bio-based circular economy in the UK;
- Cultivated crops: livestock manure from grazing animals can be used as a natural fertiliser, and can act as buffer zones between agricultural fields. The pollination ES is important for crops such as oilseed rape, apples, strawberries, raspberries and broad beans;
- Clean air: grasslands help to reduce dust, particulate matter and volatile organic compounds. Lower grazing densities and reduced fertiliser inputs associated with semi-natural grassland management result in lower emissions of ammonia and other pollutants compared with improved grasslands;

[19] Each can be broken down further. Recreation, for example, includes walking, hiking, jogging, cycling, birdwatching, photography and painting. There is evidence about the importance of green space for relaxation purposes, including things like the health benefits of gardens near NHS hospitals.

[20] The examples towards the beginning of this report: "the knowledge that an ecosystem exists or that future generations can enjoy it…" are generally considered to be 'cultural' services, as well as examples of non-use benefits.

- Noise regulation: again, grasslands contribute in a variety of ways depending on vegetation densities, soil structure (e.g. absorbing sound waves especially where non-compacted) and topographies (e.g. hills are physical barriers to noise);
- Urban cooling: greenspaces are essential for reducing the urban heat island effect. This is only going to be more important into the future, and grasslands contribute due to a relatively high albedo and because of evapotranspiration processes;
- Erosion control: this has already been mentioned above in the context of clean water and flood protection ES[21], and clearly grasslands have a vital role in controlling erosion; and
- Pest and disease control: this is an intrinsic part of grasslands, from soil microorganisms controlling soil-borne pathogens, to birds and small mammals controlling insects.

3.5 Discussion

We have demonstrated the ways in which grassland condition, in particular its soils, species and vegetation, are connected to ecosystem services. Semi-natural grasslands best exemplify the full multitude of ES, more so than improved grasslands. We have not provided insights into the differences between acidic and calcareous grasslands, beyond noting the implications for plant diversity and pollination.

Other nuances are missing: hedgerows and copses within grassland habitats can enhance ES delivery in a number of ways, from carbon sequestration, pollination and flood protection to cultural aspects (e.g. contributing to the visual appeal of landscapes). Of course, the biodiversity benefits of hedgerows and copses are vital too, and they add to the heterogeneity of landscapes. Another example: the UK's 300,000-plus miles of road verges are vital in so many ways, and by definition are located where they need to be to mitigate vehicle noises and pollution, prevent flooding and provide vital habitats and corridors for many species.

There are some key differences in ES supply (and demand) between the UK countries. For example:

- England's green and pleasant (grass)lands inspired William Blake and countless others, and are an essential part of the idea and culture of England, going back for centuries;
- Grasslands are part of Wales' scenic beauty, and play an essential, practical role in the prevention of flooding following heavy rainfall;
- Heavy rainfall also affects the west side of Scotland in particular. But the machair found along parts of the coast is important mainly for its contributions to cultural ES; and
- Northern Ireland, like Scotland, has important machair habitats. Fermanagh's 'wet meadows' are another distinct habitat.

These examples provide just a flavour of the ways in which ES, and in particular cultural ES, are unique to a place. They also allow us to circle back to the question of monetary valuation. Monetary valuation is part of the UK Natural Capital Accounts and in 2022 'tourism and recreation', for example, was valued at £15.6 billion, with associated ecosystem asset values being well over £620 billion. All valuation is done from an 'exchange value' perspective, and this does not consider welfare considerations which includes subjective measures of satisfaction or 'value'. ES monetary values are included for types that are easy to calculate, and this is demonstrated by the fact that 'regulating' ES value (including clean water, flood protection, pollination, thriving plants & wildlife, and climate regulation) constitutes just 4% of that included in the accounts: it is very difficult to value these things in monetary terms.

We conclude this chapter, therefore, by reflecting on the incredible mix of ES delivered by grasslands in the UK and with a warning that, because so much of what grasslands deliver is invisible, they are often overlooked and, in every sense of the term, undervalued.

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[21] As with the 'thriving plants and wildlife' ES, this is another ES that could be interpreted to overlap somewhat with others, despite attempts to keep mutually exclusive.

4.0 GRASSLAND MANAGEMENT FOR ECOSYSTEM SERVICES

4.1 Introduction

Grassland restoration projects in the UK have seen success through collaboration between conservation organisations, local communities, farmers, and landowners. An example is Hope Farm in Cambridgeshire. The farm, owned and managed by the RSPB, was purchased in the year 2000 with the aim of demonstrating that wildlife-friendly farming practices could coexist with productive agriculture. Similarly, the Meadow Makers project, spearheaded by Plantlife, restored over 400 hectares of species-rich grassland across England and involved over 12,000 people in meadow making.

This final chapter is about land-use decisions in the UK, and in particular the management of grasslands. There are a multitude of actions that can increase grassland ES potential: an expansion of protected areas; large-scale restoration projects; educational efforts including citizen science; investment in research to better understand ES and for long-term monitoring; agri-environment schemes for grassland protection and enhancement; training for grassland management skills; urban grassland creation for recreation and cleaner air; support for community-led initiatives; financial support including blended finance; collaboration for integrated landscape management; policy integration especially around land-use, agriculture, climate change mitigation and biodiversity; protection of grasslands in local planning, including buffer zones where needed; the promotion and certification of meat from sustainably managed grasslands; knowledge sharing between farmers, conservationists, researchers and policymakers; and where appropriate, support conversion of croplands to grasslands.

Whilst acknowledging that actions for all of these are taking place to a greater or lesser degree throughout the UK, and that they are all interconnected, it is the final action that is our primary focus: why, when, where and how should croplands be converted or restored to permanent grasslands?

The farmer-led 'Farmer Guardians of the Upper Dove' project in Derbyshire exemplifies the potential of converting arable land to permanent grassland to benefit both biodiversity and agricultural productivity. In this initiative, farmers collaborate with conservation organisations and experts to ensure sustainable management practices. The Save Our Magnificent Meadows project, also led by Plantlife, focused on restoring and protecting wildflower meadows and grasslands across the UK, often involving the conversion of arable land. By partnering with farmers and landowners, this project highlights the importance of cooperation and learning exchange in achieving successful grassland restoration and conversion, whether from arable land or through the enhancement of existing grassland habitats.

There is an opportunity to support many other similar initiatives throughout the UK, and strategically improve ES delivery where it’s most needed.

4.2 Strategic Grassland Revival in the UK: Balancing Priorities and Trade-offs

It is essential to consider potential trade-offs when land-use decisions prioritise certain ES or habitats over others. In the UK, this balance is particularly crucial given the variations in grassland types and land uses across England, Wales, Scotland, and Northern Ireland. By taking a holistic approach that considers the unique context and priorities in each region, we can ensure that land-use decisions contribute to long-term prosperity, sustainability and the delivery of ES where they are most needed.

In an extensive systematic literature review of permanent grasslands[22] in Europe, Schils *et al*., (2022) compared ES delivery with that of croplands and forests. Of the eight main grassland ES that we have discussed, only

[22] The authors use the European Union’s definition of permanent grassland, as land used to grow grasses or other herbaceous forage that has not been included in the crop rotation of the holding for a duration of five years or longer. It should be noted that this is not necessarily species-rich semi-natural grassland.

'plentiful water' was not included, and a significant proportion of the 696 papers included were from UK studies. Table 4-1 compares permanent grassland ES delivery with those from either croplands or forests:

- Croplands provide better forage yield and energy, though grasslands provide more protein. Four out of the eleven included studies suggest grasslands deliver more ES for reared animals than croplands. There are no studies comparing grasslands and forests;
- Grasslands clearly deliver more 'clean water' than croplands (especially for nitrogen, and to a lesser extent phosphorous). The majority of studies (15 out of 21) suggest that forests deliver this ES more than grasslands, though the evidence is more balanced;
- Forests are clearly preferred for flood protection (high hydraulic conductivity means that water can easily infiltrate the soil), though grasslands tend to deliver this better than croplands;
- There is very limited evidence about the pollination ES, and of the six studies[23] comparing grasslands and croplands, half favour each. As cited above, Baude *et al*. (2016) found that calcareous grasslands in particular produce the most nectar per unit area, with arable the lowest;
- Schils *et al*., (2022) include studies of 'threatened species' and 'plant diversity' as proxies for biodiversity. In both cases (and in comparison with both croplands and forests) grasslands perform best;
- Grasslands are clearly (P<0.001) better for climate regulation than croplands. Of 22 studies comparing grasslands and forests, roughly a third were neutral and a slight majority of the others (eight compared with six) favoured forest over grasslands; and
- Most of the evidence for cultural ES was based on studies of aesthetics (the visual appeal, beauty, and overall sensory experience that people derive from natural landscapes) and though this is subjective grasslands are favoured over both croplands and forests. Other evidence related to recreational services, and again grasslands tend to be preferred over either alternative.

Table 4-1: Permanent grassland ES delivery compared with cropland and forest

Tables show number of studies that indicate grasslands deliver more, with comparison land-use shown in parentheses; dark green or dark grey means significance levels of at least P<0.01. Source: Adapted from Schils et al., 2022

Ecosystem Service	Cropland
Reared Animals	4 (7)
Clean Water	26 (11)
Flood Protection	7 (5)
Pollination	3 (3)
Thriving Plants & Wildlife	8 (4)
Climate Regulation	30 (3)
Cultural	15 (7)

Ecosystem Service	Forest
Reared Animals	0 (0)
Clean Water	6 (15)
Flood Protection	0 (8)
Pollination	0 (0)
Thriving Plants & Wildlife	13 (4)
Climate Regulation	6 (8)
Cultural	8 (3)

In general, the Schils *et al*., (2022) review suggests that permanent grasslands are vital for cultural ES and thriving plants and wildlife, and also for climate regulation. The paper also compared permanent grassland with temporary grassland and for every ES (with the possible exception of 'clean water') evidence suggested more favourable delivery from permanent grasslands. However, this was based on very limited number of studies. The paper concludes: "The outcomes of our review suggests that, in spite of apparent changes in dietary preferences,

[23] Not shown in Table 4-1are the studies which were neutral. There were nine relevant studies comparing pollination for grasslands and croplands, but three were neutral (one study compared grasslands with forests and that was also neutral).

the protection of permanent grasslands in Europe has to be prioritised to prevent further losses of the area and thus the provision of multiple ecosystem services. At the same time, in view of the need to reduce ruminant livestock's impact on climate change, the time seems ripe to increase support for low-intensity management on existing permanent grasslands."

In 2010, Natural England produced a Technical Information Note[24] advising on site selection and methods for arable reversion to species-rich grassland, based on soil type, pH and nutrient status. Sites with the highest potential were those with low soil-available phosphorous (i.e. greater potential for plant diversity) and with livestock available for low-intensity management. Guidance is also provided in the UK devolved administrations, for example NatureScot[25] provide advice relating to grazing, cutting and other management to encourage the maintenance and restoration of species-rich grasslands.

There are multiple policy challenges, and correlations between biodiversity and particular ES are not guaranteed: there may be trade-offs. For example, a recent study (Gimona *et al*. 2023) explored the spatial coincidence between species richness targeted by agri-environment schemes in Scotland and selected ES including pollination and climate regulation. They found some overlap between grassland target species richness and high ES delivery, particularly in East Lothian and coastal Angus. However, there are also mismatches, with the Tweed valley and upland areas of Perth and Kinross having only moderate densities of targeted species.

Context is crucial when considering the benefits of different habitats for specific ES. Deciding between grasslands and others (including a mosaic of habitats) depends on factors such as biodiversity targets, soil and geological conditions, land-use history and cultural values, landscape connectivity, and climate change adaptation. The timescale for ES associated with grasslands after reversion from arable land or restoration varies by ES and can also vary depending on factors like the type of grassland, initial site conditions and management practices.

4.3 Shaping the Future of Grasslands

As the UK navigates the post-CAP agri-environment policy landscape, supporting farmers and land managers to deliver a range of ES, including food production, becomes increasingly important. With different strategies being adopted across England, Scotland, Wales, and Northern Ireland, a systems-based approach (i.e. understanding interactions and interdependencies between agricultural practices, natural ecosystems, socio-economic incentives, and policy frameworks) is crucial to address regional variations in environmental and agricultural conditions.

Grasslands play a vital role in sustainable food production while providing a range of public goods. However, many farmers managing lowland grazing livestock systems and those in Less Favoured Areas face economic challenges, such as low incomes and rising input costs. This situation can lead to intensification of practices or abandonment of semi-natural and species-rich grasslands.

To strike a balance between environmental goals and farmers' livelihoods, it is essential to explore and develop potential income streams and economic benefits for those extensively managing their permanent grasslands. Diversification of income streams, such as product certification, biodiversity net gain credits, carbon market opportunities, and integration of silviculture or agroforestry practices, will play a crucial role in sustaining both habitats and incomes.

The development of new agri-environment schemes presents an opportunity for public money to be used to deliver public goods while ensuring that farmers and land managers can maintain economically viable operations. Farmers face several challenges if converting from arable to grassland, including financial constraints, loss of agricultural productivity, and a lack of knowledge and expertise in grassland management. They may also struggle with market access and demand for their products, need to adapt infrastructure and equipment, and face

[24] TIN066. The complementary TIN067 advised on establishing a sown sward and TIN068 on early management of the new sward.
[25] https://www.nature.scot/doc/species-rich-grasslands-guidance-leaflet

uncertainty and risks associated with long-term viability and policy inconsistencies. To overcome these challenges, farmers require support in the form of financial and technical assistance.

4.4 Concluding Remarks

Grasslands in the UK provide a multitude of essential ES that contribute significantly to our wellbeing. A robust understanding of ecosystem extent and ecosystem condition allows us to appreciate the true value of grasslands and the services they offer. By better understanding the size, distribution, and health of these habitats, we can make better-informed decisions to protect, restore, and manage them for optimal delivery of ES.

While forests have often been the focus of policy, our analysis demonstrates that grasslands deserve greater attention and recognition. The diverse ES provided by grasslands highlight their significance in addressing a range of environmental challenges, including climate change and biodiversity loss. It is crucial that policy and decision-making incorporates the full range of ES and benefits provided by grasslands, ensuring that they are not undervalued.

The vital role of grasslands in our daily lives, although often taken for granted, cannot be overstated. From the air we breathe to the food we eat, these habitats play a critical role in supporting our well-being and contributing to the richness and beauty of the landscapes we cherish. It is our collective responsibility to ensure that future generations can enjoy the same benefits that grasslands have delivered for centuries.

By elevating the importance of grasslands in policy, investing in research, supporting grassland restoration, and fostering collaboration among stakeholders, we can safeguard these habitats and enhance the multitude of ES they provide. In doing so, we will not only protect our environment but also help build a sustainable and prosperous future for the UK and its people, inspiring everyone to act as stewards of our precious habitats.

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APPENDIX 01

Ecosystem Service Typologies

Table A1 – Ecosystem services and CICES framework

Ecosystem service categories (plain English)	CICES categories (version 5.1)
Timber and other wood products	Fibres and other materials from cultivated plants, fungi, algae and bacteria for direct use or processing (excluding genetic material)
Produce from the sea	Wild animals (terrestrial and aquatic) used for nutritional purposes
Plant-based energy	Cultivated plants (including fungi, algae) grown as a source of energy
Cultivated crops	Cultivated terrestrial plants (including fungi, algae) grown for nutrition
Plentiful water	Surface water for drinking Surface water used as a material (non-drinking purposes) Ground (and subsurface) water for drinking Ground (and subsurface) water used as a material (non-drinking purposes)
Reared animals	Animals reared for nutritional purposes
Clean water	Regulation of the chemical condition of freshwaters by living processes Regulation of the chemical condition of salt waters by living processes Dilution by freshwater and marine ecosystem
Clean air	Filtration/sequestration/storage/accumulation by microorganisms, algae, plants, and animals
Noise regulation	Noise attenuation
Urban cooling	Regulation of temperature and humidity, including ventilation and transpiration
Erosion control	Buffering and attenuation of mass movement Control of erosion rates
Flood protection	Hydrological cycle and water flow regulation (Including flood control, and coastal protection)
Pollination	Pollination (or 'gamete' dispersal in a marine context)
Thriving plants and wildlife	Maintaining nursery populations and habitats (Including gene pool protection)
Pest control and disease control	Pest control (including invasive species) Disease Control
Climate regulation	Regulation of chemical composition of atmosphere and oceans
Cultural services	All services within the Cultural (Biotic) section of CICES v5.1

Source: Lusardi et al., 2022

APPENDIX 02

Glossary

Term	Definition	Source
Permanent	Grasslands established for more than 60 years	Fuller, 1987
Temporary	Land that has been in grass or other herbaceous forage for less than 5 years	Scottish Government (2018), Woodland Trust
Grassland	Areas with variable vegetation cover and not on waterlogged soils. Vegetation is at least 75% herbaceous (grasses, sedges, rushes, ferns, forbs) rather than woody, with salt-tolerant species absent or occasional.	UKHab, 2023
Calcareous grassland	Consists of vegetation on dry ground with scattered sedges and many calcicoles present. Found on basic soils (ie. pH>6.5).	Countryside survey (CSS), 2007
Acid Grassland	Grasslands occurring on acidic soil (ie. pH<5.5).	CSS, 2007
Purple moor grass and rush pastures	Grasslands occurring in lowland areas, on poorly drained, typically acidic soils in areas of high rainfall. The vegetation comprises types of fen meadow and rush pasture.	CSS, 2007
Neutral Grassland	Occurs on soils with a pH between 5.5 and 6.5 (ie. neither acidic or lime-rich). Includes all semi-improved and unimproved grassland on neutral soil, as well as enclosed and managed grassland such as pastures, a range of wet grasslands where the vegetation is dominated by grasses, sown grassland strips alongside arable fields, long-term set-aside or fallow land and tall unmanaged grasslands. It does not include improved species-poor grassland.	CSS, 2007
Semi-improved Grassland	Semi-improved grassland is a transition category made up of grasslands which have been modified by artificial fertilisers, slurry, intensive grazing, herbicides or drainage, and consequently have a range of species	JNCC, 2016

Term	Definition	Source
	which is less diverse and natural than unimproved grasslands.	
Improved Grassland	Species poor, grass dominated swards occurring on all soil types that have been either sown, or created by modification of unimproved grassland by fertilisers and selective herbicides, for agricultural or recreational purposes. It includes grassland that has been reseeded for more than one year. Improved grassland is synonymous with Modified Grassland (see below)	JNCC, 1999
Modified Grassland	Species poor (<9sp/m2) vegetation dominated by a few fast-growing grasses on fertile, neutral soils. It is frequently characterised by rye-grasses (Lolium spp.).	UKHab v2, 2023
Unimproved Grassland	Unimproved grasslands may be rank and neglected, mown or grazed. They may have been treated with low levels of farmyard manure, but should not have had sufficient applications of fertiliser or herbicide, or have been so intensively grazed or drained, as to alter the sward composition significantly. Species diversity is often high, with species characteristic of the area and the soils and with a very low percentage of agricultural species.	JNCC, 2016
Pasture	Land managed via grazing, typically but not exclusively referring to permanent pasture.	
Wildflower Meadow	Area of permanent grass where wildflowers grow. Wildflower meadows grow better on unproductive soil, where vigorous grasses don't out-compete the flowers.	
Semi-natural Grassland	Comprise acid, neutral, and calcareous grassland broad habitats, as well as purple moor-grass and rush pasture. Distinct from improved grassland by lack of recent cultivation, re-sowing or heavy fertilisation. A mixture of grasses and herbaceous plants, along with sedges, rushes, mosses and other low-growing species, often created	Bullock, et al., 2011 SoNaRR Welsh report 2016, taken from NEA

Term	Definition	Source
	by low-intensity, traditional farming or natural vegetation on poor soils or in exposed locations. They often contain a rich variety of grasses and herbs.	
Long-continuity habitat -grassland	Grassland that is likely to have been the same habitat since 1936 and subject to similar human management.	UKHab, 2023
Ancient Grassland	A semi-natural plant community maintained as grassland since 1840, on a site with no history of arable management or agricultural improvement since 1840 in any of the currently available land-use datasets	Inside Ecology, 2018 referencing Redhead et al. (2013)
Species-rich Grassland	Grasslands comprising rich variety of grasses and herbs. Species rich grasslands have a high diversity of native wildflowers and grasses, which have co-evolved with traditional farming techniques over the last 6000 years.	Bullock, et al., 2011 NatureScot, 2021
Amenity Grassland	Highly managed, species-poor grasslands	Bullock, et al., 2011
Hay Meadow	A type of neutral grassland; grasslands that are left to grow over the spring and summer and are cut for hay.	Plantlife
Leys	Temporary grass or legumes sown in rotation, with grain or other crops, usually as a soil conservation measure.	UKHab, 2023

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