Office for National Statistics

UK natural capital: developing semi-natural grassland ecosystem accounts

A discussion of semi-natural grassland ecosystem accounts, including available data sources, and recommended approaches to developing an initial account.

Contact:
Matthew Bezzano
environment.accounts@ons.gov.uk
+44(0)1329447199

Release date:
19 April 2018

Next release:
To be announced

Table of contents

1 . Summary

This article scopes the development of ecosystem accounts for semi-natural grassland and discusses several methodological challenges arising from the unique characteristics of this habitat. To help the development of initial accounts, recommendations are given where possible.

Feedback from experts from all disciplines will be essential for the successful development of ecosystem accounts. All feedback is welcome and can be sent via email to Environment.Accounts@ons.gov.uk.

2 . Collaboration

This publication is produced in partnership with the Department for Environment, Food and Rural Affairs (Defra).

The contributions and time given from colleagues at Natural England have been greatly appreciated in the development of this article.

3 . Introduction

This work is part of the Office for National Statistics and Department for Environment, Food and Rural Affairs (ONS-Defra) Natural Capital Accounting Project. In 2015 a revised Natural Capital Accounting 2020 Roadmap was published, which discussed progress, challenges and objectives of the project. Among the objectives is the development of eight habitat-based ecosystem accounts, one of which is semi-natural grassland.

Natural capital accounts (also called ecosystem accounts) offer a consistent way of monitoring our natural assets and can help identify drivers of ecosystem change. Development of monetary valuation in particular, aids integration with other economic statistics, as economic and environmental data are presented in a consistent unit. The purpose of national level ecosystem accounts is to provide evidence to inform and improve decision-making by integrating environmental and economic information. The accounts can then be a tool to help decision-makers understand the trade-off between different ecosystem services and alternative land uses.

By providing a link between the ecosystems and the benefits they provide to humans, the accounts help us understand the contribution made by the environment to economic activity and human well-being. Additionally, by valuing the stocks of these natural assets and the flows of benefits, the accounts facilitate comparison with other economic and social information and help to emphasise the importance of maintaining and improving the stock of natural capital.

The UK National Ecosystem Assessment (UK NEA) highlights the important role that semi-natural grasslands have as a habitat, as it can be seen as an “intermediate stage” in development over time, since some areas (such as cultivated soils) will develop into grassland, before eventually acquiring tree cover if undisturbed. This intermediate stage can be maintained by processes that prevent growth of scrub and trees, for example, grazing, cutting and light burning. Not only is it a crucial ecosystem for a wide array of important species, but it also provides us with many essential services, which are discussed in the following sections. The features described justify a stand-alone semi-natural grassland account.

More information on our programme of work in this area can be found on the Natural Capital Accounts webpage.

4 . Structure of an ecosystem account

The national level UK ecosystem accounts have been developed on the basis of the eight broad habitats set out in the UK National Ecosystem Assessment (UK NEA). These include:

- semi-natural grassland
- woodland
- farmland
- freshwater
- coastal margins
- marine
- urban
- mountain, moorland and heath

An ecosystem account has five main components:

- an extent account (the size of the asset, for example, thousands of hectares of land)
- a condition account (containing indicators of the capacity to deliver services, for example, quality of soil)
- physical ecosystem service flow accounts (annual supply and use of benefits we receive in physical terms, for example, tonnes of pollution removed)
- monetary ecosystem service flow accounts (annual supply and use of benefits in monetary terms)
- monetary ecosystem service stock accounts (net present value of ecosystem services over the life of the asset)

After defining the asset, this study will work through each component in turn, providing recommendations where possible for developing a semi-natural grassland ecosystem account.

5 . Defining semi-natural grassland

A primary obstacle when producing an account for semi-natural grassland (SNG) is the wide spectrum of definitions available. These exist because there are difficulties in characterising the limits of SNG, but also because of the degree of overlap with other habitats, such as enclosed farmland. In this section, the most appropriate method of classifying SNG will be derived.

An ecological area-based definition of SNG can be based on the characteristics of habitats, land cover or land use, as displayed in Table 1.

Table 1: Habitat, land cover and land use definitions, UK National Ecosystem Assessment

UK	
Habitat	An ecological or environmental area that is inhabited by particular animal or plant species.
Land cover	The physical coverage of land, usually expressed in terms of vegetation cover or lack of it. Related to, but not synonymous with, land use.
Land use	The human use of a piece of land for a certain purpose (such as irrigated agriculture or recreation). Influenced by, but not synonymous with, land cover.

Source: UK National Ecosystem Assessment (UK NEA)

According to the UK National Ecosystem Assessment (UK NEA), the vegetation of SNG comprises a mixture of grasses and herbaceous plants, along with sedges, rushes, mosses and other low-growing species. This definition could be problematic, since many of the grasses, grass-like herbs (for example, sedges or rushes) and forbs (non-grass herbs) can be found in other terrestrial ecosystems too.

The Countryside Survey defined four types of SNG, determined by factors such as geographic location, geology and soil type. These are:

- acid grassland
- neutral grassland
- calcareous grassland
- purple moor grass and rush pasture

and are defined in Table 2.

Table 2: Definitions of each semi-natural grassland habitat

UK	
Broad habitat	**Definition**
Acid grassland	Occurs on acid soils (potential of hydrogen (pH less than 5.5). Fine grasses predominate generally in dry situations and usually on brown podzolic soils [1] or rankers, e.g. Bentgrass, Fescues and Tormentil. Acid indicators are present, e.g. Heath Bedstraw, Red-stemmed Feather-moss and Sheep's Sorrel.
Neutral grassland	Occurs on soils that are neither strongly acid nor lime-rich (pH 5.5 to 6.5). 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.
Calcareous grassland	Consists of vegetation on dry ground with scattered sedges and many calcicoles present. It can be relatively species poor if inappropriately managed, but is often species rich with greater than 50% forb cover. It is found on calcareous soils (pH greater than 6.5), usually rendzinas on chalk or limestone. Examples include Birdsfoot Trefoil, Horseshoe Vetch, Purging Flax, Salad Burnet, Carline Thistle, Blue Moor-Grass and Dwarf Thistle.
Purple moor grass and rush pastures	Occurs on poorly drained, usually acidic soils in lowland areas of high rainfall. Their vegetation, which has a distinct character, consists of various species-rich types of fen meadow and rush pasture. Purple moor grass and rushes, especially sharp-flowered rush, are usually abundant. Key species associated with purple moor grass and rush pastures include: wavy St. Johns-wort, Meadow Thistle, Marsh Hawk's Beard, Greater Butterfly Orchid, Lesser Butterfly Orchid, Marsh Fritillary Butterfly, Curlew, and Barn Owl.

Source: Countryside Survey (2007)

Notes:

1. Podzolic soils are infertile acidic soils which have an ash-like subsurface layer. They are generally physically limiting soils for productive use, and lack in most plant nutrients. They are also used for rough grazing and for forestry and recreation (The James Hutton Institute).

2. Rendzina is a dark, greyish-brown, humus-rich soil. Rendzinas are calcareous soils over chalk limestone, or extremely calcareous unconsolidated material (Soils Worldwide, 2009).

The UK NEA advise the four SNG types included in Table 2 should be included within the SNG habitat definition. However, practically it will be difficult to include purple moor grass and rush pastures, as known data sources, such as the Land Cover Map, do not identify this separately. Additionally, the Countryside Survey includes purple moor grass and rush pastures within the fen, marsh and swamp broad habitat. In the UK natural capital accounts, fen, marsh and swamp is included in the freshwater habitat (ONS, 2014, 2017). Due to these difficulties and potential for overlap, purple moor grass and rush pastures should not be included within this account.

To avoid double-counting, some assessment of the habitats' most prominent features is needed to ensure types are recorded in appropriate accounts. Table 3 identifies overlaps that could occur.

Table 3: Potential overlaps between semi-natural grassland and other broad habitats

UK							
Semi-natural grassland	**Mountains, moorlands and heathlands**	**Coastal margin**	**Enclosed farmland**	**Woodland**	**Freshwater**	**Urban**	**Marine**
Acid grassland	Bracken, dune heath, montane grassland, inland rock, dwarf-shrub heath	Sand dune grassland		Wood pastures, afforested dunes		Highly managed species-poor grassland	
Neutral grassland		Maritime grass - land	Silage, hay, pasture, improved and amenity grassland	Wood pastures	Water meadows, grazing marshland		
Calcareous grassland	Dwarf-shrub heath, montane grassland, inland rock	Machair grass - land	Cultivated machair	Wood pastures	Machair lochs		

Source: Office for National Statistics

Some of the most notable overlaps to note are the following.

Bracken and heathlands

Bracken is most extensive on deep well-drained fertile soil and therefore can be found across a variety of habitats, including heathland. However, since it is more commonly found within SNG (specifically acid grassland), it should be included within the SNG account instead of mountains, moorlands and heathlands (MMH).

Improved and amenity grassland and enclosed farmland

Improved and amenity grasslands (PDF, 1.15MB) are typically managed as pasture or mown regularly for silage production or in non-agricultural contexts for recreation and amenity purposes (Centre for Ecology and Hydrology, 2017). There are lots of similarities between improved grassland and enclosed farmland. The UK NEA differentiates SNG from improved and amenity grassland and so these should not be included within the SNG account and included in the enclosed farmland account.

Maritime grassland and coastal cliffs

Scottish Natural Heritage suggests neutral grassland on coastal cliffs (PDF, 101KB) belongs in the maritime cliff habitat. However, it is advocated in the UK NEA that coastal grasslands are more suited to the SNG habitat. Therefore, coastal grasslands such as dune grassland, machair grassland and maritime grassland should be included within the SNG account.

Dwarf-shrub heath and heathlands

As suggested in the MMH scoping study, some characteristics of acid grassland can be found within lowland heaths. Heathland grasslands should not be included within this account, but instead be placed in the MMH account.

Upland and lowland grasslands have not been distinguished, but further breakdown by upland and lowland could help to alleviate the overlaps. Upland and lowland semi-natural grasslands have been defined in Annex A.

Recommendation

The UK NEA provides an appropriate definition to classify semi-natural grassland, with the exception that purple moor grass and rush pastures should be excluded and included in the freshwater habitat. Therefore, acid grassland, neutral grassland and calcareous grassland should be included within this account.

Within these sub-habitats to minimalise these overlaps, it is advised that bracken is included within SNG, however, dwarf-shrub heath, improved and amenity grassland should not.

This recommendation principally aims to retain consistency and clarity. This broad habitat definition is also consistent with most data sources, which should enable easier account compilation.

SNGs are often found in intricate mosaics so care must be taken when measuring the extent of this habitat. Once initial ecosystem accounts have been developed for the full range of broad habitats, it will be necessary to review the coverage of each account to ensure that they are comprehensive and there is no double-counting.

6 . Developing the extent account

Between 1960 and 2013, 47% of semi-natural grasslands (SNGs) were lost and the decline continues in some areas. This decline has been largely attributed to intensification of agriculture, conversion to improved grasslands and abandonment of remaining SNG areas, resulting in significant and extensive fragmentation.

Open areas such as cultivated soil and burnt woodland will usually develop into grasslands of various types over time – this process is known as succession. This intermediate grassland stage may be maintained through grazing, cutting and other processes, but if undisturbed, such grassland will eventually acquire tree cover. Therefore, it is important to construct a robust extent account to monitor changes.

This section gives an overview of the data sources currently available and their suitability for ecosystem accounting. Some initial estimates of the extent are also presented.

Data sources

Three available datasets that could be used for a UK semi-natural grassland extent account are the Centre for Ecology and Hydrology (CEH) Land Cover Map 2015 (LCM2015), CORINE Land Cover data (CLC2012) and Countryside Survey data (CS2007). These sources have been used in different reports and studies to define the extent of grassland, including the UK Land Cover Account and the UK National Ecosystem Assessment (UK NEA).

Natural England and the Environment Agency also provide various geographic information systems including digital boundary shape files to map the extent of particular areas. The general concept how each data source collects its data are found in Table 4.

Table 4: A brief description of data collection methods by different sources

UK	
LCM2015	Derived from satellite images and digital cartography, provides detailed land cover information for the entire UK, with a minimum mappable unit of 0.5 hectares.
CLC2012	A map of European land cover based on interpretation of satellite images. It provides comparable digital maps of land cover for each country for much of Europe, with a minimum mappable unit of 25 hectares.
CS2007	A study of the natural resources of the UK countryside conducted by the CEH. This field survey has been carried out at regular intervals since 1978.

Source: Centre for Ecology and Hydrology (2017), Copernicus, Office for National Statistics

The potential dataset sources were reviewed (Table 5) in the UK Natural Capital Land Cover Accounts to establish which would be most suitable for land cover accounting purposes.

Table 5: A comparison between LCM, CORINE and Countryside Survey for use in an extent account

UK			
	Land Cover Map (LCM)	**Corine Land Cover (CLC)**	**Countryside Survey (CS)**
Coverage	UK	EU	Great Britain and Northern Ireland (NI Countryside Survey)
Releases	1999, 2007 and 2015	2006 and 2012	1978, 1990, 1998 and 2007
Type of data	Vector data – satellite imagery	Remotely sensed imagery and visual interpretation	Field Survey
Strengths	Small minimum mappable unit of 0.5ha (parcels based on detailed national cartography), providing comprehensive coverage of the UK	Changes are identified by computer-aided visual interpretation of satellite imagery	Land cover is measured consistently over time and great care is taken by field surveyors when assessing whether land cover has changed
	New classification algorithm, and a more consistent spatial framework	Likely to be updated in 2018	Sample squares mapped in great detail – minimal mappable unit
	Rich set of metadata for each polygon	Comprehensive coverage of the UK	Longitudinal dimensions allow changes in habitats to be recorded accurately
Weaknesses	Measurement error; lack of consistency between 2007 and 2015	Large minimum mappable unit (25 hectares)	Stocks and changes are statistical estimates (imprecise estimates; low statistical power for some habitats)
			Unlikely to be updated in the future
			As it is a survey, relatively small changes cannot be detected

Source: Centre for Ecology and Hydrology (2017), Office for National Statistics

SNG can be very fragmented and scattered within a landscape as small habitat patches. Considering this, Corine Land Cover (CLC) may not be an appropriate data source as CLC2012 used a minimum mappable unit of 25 hectares. Polygons are assigned to the class occupying the greatest percentage of their surface and it is likely that small fragmented areas of SNG would not dominate polygons of this size, so such areas of SNG would not be accounted for.

The Countryside Survey (CS) is the most comprehensive and reliable data source, however, is not expected to be updated in the future and the most recent data is from 2007. SNG is a fluid habitat and can be readily converted to arable land and improved grassland through cultivation, re-sowing and fertiliser application. It can also be restored and recreated from arable or improved grassland precursors. A data source consistently and regularly updated to monitor change over time is important to monitor the changing extent of SNG, meaning CS is not appropriate.

LCM2015 does not have the extended time-series available with CS and has a higher measurement error, but has comprehensive coverage of the UK and a much smaller minimum mappable unit than CLC. It has also been recently updated and there are plans to keep this source updated so has improved consistency, making it a useful data source.

One potential weakness of LCM is that it does not distinguish between upland and lowland SNGs. For example, according to the UK NEA, upland acidic grassland is a major component of UK SNG, but it is not considered a priority habitat since it is a result of overgrazing, thus is species-poor and lacks biodiversity. This is discussed further in Section 7.

Choosing the most suitable data source is important, since this can have a notable impact on the extent account, as shown in Table 6.

Table 6: A comparison of the extent of semi-natural grassland in the UK when using different data sources, UK, thousand hectares

UK				
	Land Cover Map		**Countryside Survey**	**CORINE Land Cover Map**
	LCM2007	**LCM2015**	**CS2007**	**CLC2012**
Semi-natural grassland	3274	2331	4328	2145
As a % of total UK land cover	13.30%	9.53%	18.39%	7.64%

Sources: Office for National Statistics and Centre for Ecology and Hydrology (2017)

Notes:

1. ‘Semi-natural Grassland’ includes the habitats neutral grassland, calcareous grassland, acid grassland and bracken for LCM2007 and CS2007. CLC2012 includes 'natural grassland'.

A comparison between LCM2007 and LCM2015 suggests that the extent of SNG has decreased rapidly; by almost one-third between these years – however, CEH advise against a comparison between the two, so some of this disparity could be measurement improvement.

The CS estimated the extent of SNG to be 4,328,000 hectares in 2007, which is relatively higher than the figures reported from other sources. LCM2015 and CLC2012 are more consistent, estimating that SNG covered 7.64% and 9.53% of total UK land cover (excluding sea) respectively.

Differing methodology, definitions or data collection methods could account for large variations between the data sources, rather than inaccuracies. For example, the CLC2012 has a large minimal mappable unit, as explained previously, which could underestimate the land cover.

In previous studies (for example, the Coastal Margins Scoping Study and the Land Cover Accounts for 2015), it was advised that the CS should be used on the basis that there was a lack of comparability between LCM2000 and LCM2007. In the Office for National Statistics and Department for Environment, Food and Rural Affairs (ONS-Defra) Principles of Natural Capital Accounting, LCM2015 is recommended to form the foundation of the habitat accounts and from the previous discussion it should adequately provide SNG extent information.

It is expected that future releases will be published at a fast pace and it should capture the fragmented and changing nature of SNG.

LCM2015 is determined to be the most suitable data source, but it is worth noting some important factors to consider when using this data source for monitoring SNG.

Firstly bracken is included within acid grassland. According to LCM2015, bracken “often fails to offer stands sufficiently extensive for classification and training”, so for consistency it is assigned to “acid grassland”. This prevents bracken from being separately distinguished, but this is not an issue since bracken is included within the SNG account.

Secondly, the rough grassland class has been removed from LCM2015 for several reasons including absence of consistent soil data across the UK and instead been assigned to “neutral grassland”, “acid grassland” or “calcareous grassland".

A report by the Centre for Ecology and Hydrology (CEH) advised against a comparison between LCM2007 and LCM2015. Due to the slight changes in the data format and the complex nature of detecting change, a straightforward comparison between the two will not provide accurate results, although there should be a more systematic comparison between them in due course. CEH’s new techniques have been designed with change detection in mind, so improvements are anticipated in the future.

A full discussion of the differences between LCM2007 and LCM2015 can be found in the CEH Land Cover Map 2015 dataset documentation (PDF, 1.15MB).

LCM2015 provides the following estimates of extent for each sub-habitat of SNG. In Table 7, the UK Land Cover Accounts show over half of all SNG is found in Scotland and a clear majority of this is acid grassland. The vast majority of all neutral and calcareous grassland (almost 93%) is found in England and Northern Ireland.

Table 7: The amount and proportion of each semi-natural grassland sub-habitat in the UK, from Land Cover Map 2015 (LCM2015)

UK

Land Cover Map (LCM2015)	UK	England	Scotland	Wales	Northern Ireland
Neutral grassland	115	61	2	10	42
as a % of UK neutral grassland		53%	2%	8%	36%
Calcareous grassland	83	81	0	1	0.3
as a % of UK calcareous grassland		98%	0%	2%	0%
Acid grassland	2134	469	1210	415	39
as a % of UK acid grassland		22%	57%	19%	2%
Total semi-natural grassland	2331	611	1213	426	81
Proportion of all SNG		26%	52%	18%	3%

Source: Centre for Ecology and Hydrology (2017)

Notes:

1. Figures expressed in thousands of hectares.

2. Figures rounded to nearest whole number.

Recommendation

Considering all available data sources, the Land Cover Map (LCM2015) is recommended as the data source for the extent account. LCM2015 provides the detail needed, is eventually expected to have improved consistency between years and will have more frequent releases in the future.

7 . Developing the condition account

The condition account is intended to give an insight into changes in the state of the ecosystem and its capacity to provide ecosystem services in the future. Natural England suggests potential condition indicators that could be used for semi-natural grassland (SNG) and other broad habitats. Some of these are explored in this section and include soil nutrient status, plant species diversity and soil carbon content.

Indicators selected for the condition account are based on main services provided. Before potential indicators are discussed, it is worthwhile highlighting factors that lead to a deterioration in condition of SNG to ensure indicators are selected that ably reflect these. Table 8 presents hectares of sites of special scientific interest (SSSIs) classified as SNG in unfavourable condition in England and the principal reason why they are in this condition.

Table 8: The number of hectares of semi-natural grassland SSSIs in England that are in unfavourable condition, and the principal reason for this

England

Habitat	Under-grazing	Over-grazing	Drainage/ ditch control	Agriculture	Inappropriate scrub control	Inappropriate cutting/mowing	Total
Lowland acid grassland	277	53	86	3	31	8	458
Upland acid grassland	10	710	66	137	13	0	936
Lowland calcareous grassland	767	48	0	15	662	488	1980
Upland calcareous grassland	72	184	0	1	32	0	289
Neutral grassland	1327	342	165	228	735	348	3145
Total	2453	1337	317	384	1473	844	6808

Source: Natural England (2010)

Note:

1. Figures as of November 2010.

From Table 8, it is evident that the main reasons for a decline in condition of SSSIs is inappropriate grazing as well as inappropriate cutting or mowing. Under-grazing is a big contributor to unfavourable condition on neutral grassland (since 1,327 hectares are in unfavourable condition), since the relaxation of human interventions causes change; halting management techniques such as cutting, grazing or burning leads to colonisation by shrubs and trees that develop into scrub and woodland – a process which, over the last few decades, has occurred on various abandoned SNGs.

It is worth noting that Table 8 only reflects condition on designated sites (that is, those that have statutory protection). Consequently, these sites will be better protected from agricultural intensification than those outside of SSSIs.

This habitat needs to be closely monitored and a range of condition indicators are needed to do this. As set out in the Office for National Statistics and Department for Environment, Food and Rural Affairs (ONS-Defra) Principles paper, the condition account can be extended to include indicators of management practices, access facilities and protected status. The dimensions of quality for which condition can be indicated, as suggested in Principles of Natural Capital Accounting are explored in this section.

Soil indicators

The state of soil in SNG areas is an important indicator for many things such as quality of biodiversity, water regulation and carbon storage. Factors such as available phosphorus, soil moisture, carbon content, ammonia and nitrogen levels are good indicators of soil condition.

Carbon content

Soil and vegetation can sequester or emit carbon depending on how the ecosystem is managed. A high amount of carbon in the soil is a good indicator of healthy soils. Soil organic carbon levels are directly related to the amount of organic matter found in soils, since soil organic matter is made of organic compounds that are highly enriched in carbon. Soil organic matter (SOM) can improve the quality of soil through increased retention of water and nutrients, resulting in greater productivity of plants. SOM is also able to improve soil structure and reduce erosion, leading to improved water quality in groundwater and surface waters.

SNG is important in terms of carbon storage, since soils are less disturbed (that is, they are not as intensively managed and have more vegetative cover) than improved grasslands. According to the UK National Ecosystem Assessment (UK NEA), grassland soils have the highest carbon stock of any NEA broad habitat (within the top 15 centimetres of soil).

ONS has published estimates for UK total carbon stock in soil. In 2007, there were approximately 324.1 million tonnes carbon (MtC) stored in semi-natural grasslands, which accounted for roughly 8% of the UK's total. This could be compared against relative changes in other habitats to ensure it continues to have a high carbon stock, as if it is falling this could indicate degrading grassland soil quality. Care should be taken when using these indicators, since high levels of organic matter and carbon does not mean that all soils with high organic matter are diverse – they may have been treated with herbicides, for example.

Lack of up-to-date soil carbon data could be a limitation in developing this indicator.

Water content

SNG soils store water more effectively if in good condition. Plant growth, soil temperature, chemical transport and groundwater recharge are all dependent on the state of water in the soil. Soil moisture content can therefore be an indicator of these things.

Compaction

Winter grazing and heavy machinery can cause soil compaction. A lower soil compaction would generally imply better condition of the soil and compaction can adversely affect provision of a wide range of ecosystem services within the habitat. Lower soil compaction would increase water infiltration, which decreases surface runoff, reducing the risk of flooding and increasing the recharging of aquifers (Weatherhead and Howden, 2009).

Other impacts include increased emissions of nitrous oxide and ammonia (due to decreased filtration in compacted soils) and decreased plant growth, which leads to limited availability of food for wildlife.

Bulk density of topsoil provides an indicator of soil compaction. Great Britain estimates of bulk density are provided in the Countryside Survey, although as already discussed it is not expected that the Countryside Survey will be updated. Lack of current and consistent soil data will be an issue when developing this indicator.

Ratio of vegetation to bare soil

Leaving fields with a vegetation cover during the winter reduces water pollution, as it restricts pollutant flowing towards rivers. Vegetation also provides various species cover from adverse weather and enhances infiltration of water. Therefore, the ratio of vegetation to bare soil could be used to indicate the ability to provide water quality regulation and storm, flood and erosion protection.

Complete vegetative cover may not be optimal as bare soil is important to some species and so it is important to have a mixture.

The Soil-adjusted Vegetation Index (SAVI) produces an output between negative 1 and 1 that shows the cover of green vegetation on soil. This would be the recommended data source.

The bare soils to vegetation ratio can be monitored at a coarse spatial resolution with SPOT VEGETATION and also at a higher spatial resolution with SPOT HRVIR. The Spot program consists of a series of optical remote-sensing satellites and provides imagery for land use and vegetation cover. Their vegetation program provides global coverage on an almost daily basis at a resolution of 1 kilometres, enabling the observation of long-term environmental changes on a regional and worldwide scale.

Biodiversity indicators

UK-wide biodiversity loss will lead to lower resilience of ecosystem functions such as pollination. Monitoring biodiversity is important as it is desirable to have a variety of plant and animal species in every ecosystem. According to the Biodiversity Information System for Europe (2017), 235 species covered by the EU Habitats Directive are linked to grassland ecosystems. Of this, 28% of amphibians, 12% of reptiles and 16% of mammals are threatened with extinction at the EU level.

Both species that are widespread, but in decline and those that are on red lists or identified as UK Biodiversity Action Plan (BAP) priority species will be important to monitor. These sources both aim to address threatened species and are designed to protect and restore ecosystems. Changes in these species indicate changes in the condition of the ecosystem and its ability to provide a suitable habitat for these species to exist in.

There are many species within SNG that are considered to be restricted to this habitat, as displayed in Table 9.

Table 9: Taxonomic groups and restriction class of UK Biodiversity Action Plan species associated with lowland grassland

UK			
Species	**Widespread**	**Localised**	**Restricted/Very Restricted**
Birds	15	5	3
Mammals	4	3	0
Amphibians /Reptiles	6	0	0
Vascular Plants	6	20	25
Lower Plants/Fungi	2	3	28
Invertebrates	13	24	42

Source: Webb et al. (2010)

Plant richness score

A plant richness score is calculated as the average count of plant species per 10 metres by 1 metre plot. SNGs are often rich in flowering plants, typically with at least 15 species per square metre and in excess of 40 species per square metre (PDF, 5.07MB) for some calcareous grassland.

A high plant richness score indicates a higher ability to provide ecosystem services, such as soil carbon, herbage production, forage quality and insect richness and abundance. High plant species richness is also linked to increased pollinator species richness (Carvell, 2002).

Grazing pressures, along with increasing fertility and habitat fragmentation have contributed to falling species richness. A large proportion of grassland has also been the subject of agricultural “improvement” through the re-sowing of plants, high inputs of inorganic fertilisers and intensive cutting or grazing. This has led to grassland being dominated by a few species, thus lacking diversity and richness.

Maintaining a high plant richness score is important, since herb-rich, unimproved grassland is the principal habitat for 38% of UK BAP species (PDF, 2.2MB). Therefore, in general, a higher score indicates higher ecosystem condition. However, plant richness will vary between different types of SNG and some grasslands have naturally low diversity (for example, certain types of acid grassland) but can still be in good condition.

Additionally, an increase in score could be due to nutrient enrichment, disturbance or an increase in generalist rather than specialist species, which would not indicate improving condition.

Estimated species richness was calculated by the Centre for Ecology and Hydrology for 2000 to 2013. This includes species occurrence for bryophytes and vascular plants.

Characteristic species

Further to general plant species richness, the occurrence of plant and other species that are characteristic of habitats in good condition could also be monitored. By using species that are agreed positive indicators, or “characteristic species”, some of the limitations identified previously are mitigated and a better understanding is gained of habitat condition.

Positive habitat indicators (CSV, 56KB) were compiled by Natural England and Centre for Ecology and Hydrology, based on the Common Standards Monitoring guidance in association with the Botanical Society of the British Isles, so these should be used when compiling characteristic species of SNG. For SNG, some positive indicators could include early hair-grass (acid grassland), dwarf thistle (calcareous grassland) and saw-wort (neutral grassland). These, and many others, could be used when compiling characteristic species of SNG.

This could be used alongside the CEH species richness estimates, which are based on the occurrence records of 11 taxonomic groups for 2000 to 2013: bees, birds, bryophytes, butterflies, carabidae, hoverflies, isopoda, ladybirds, moths, orthoptera and vascular plants.

Reptiles and amphibians

SNG is an important habitat for this group, as it is used for all aspects of their life history. Species of reptile found in SNG in Britain include: adders, grass snakes, slow worms and common lizards.

Reptiles are ectothermic, meaning they require the warmth of the sun to raise their body temperature. This has a strong influence on their behaviour and hence their habitat requirements. As a result, reptiles prefer habitats with well-drained soils, with good opportunities for basking on south-facing slopes. Conversely, they must also avoid overheating, so taller vegetation provides humid areas to cool down in on hotter days. Over-management of grassland areas can be very damaging to reptile populations (Blakesley and others, 2016). Therefore, reptiles could be used to indicate condition, as falling populations could indicate over-management, or just generally diminishing grassland.

However, since reptiles are also found more commonly in other habitats (for example, the grass snake is found more commonly near water), they should not be included within the SNG account.

Invertebrates

Thousands of species of invertebrates are found within SNG, all of which play an essential role in ecological processes underpinning the provision of ecosystem services, for example, nutrient cycling and soil formation. Pollination and other wildlife such as birds and bats are dependent on a healthy supply of invertebrates for food. Many SNGs, especially calcareous grassland, have high invertebrate abundance and diversity, and provide services such as pollination and pest control by the spread of insects to agricultural areas. Invertebrate species outlined in Table 10 can be monitored to indicate changing condition of SNG.

Table 10: Potential invertebrates to indicate condition of semi-natural grassland

UK		
Species	**Discussion**	**Recommended data source**
Butterfly	Specialist butterfly species are generally restricted to high quality habitats, therefore their abundance indicates condition. SNGs are a particularly important habitat for butterflies, especially calcareous grasslands, as they provide breeding grounds for 48 species, which is approximately 85% of the British total. In particular, the Duke of Burgundy butterfly and Adonis Blue are found primarily within SNG so could be good indicators. Butterfly conservation are currently working on a breakdown of butterfly population abundance indicators by habitat account.	- The UK Butterfly Monitoring Scheme. - UK Butterflies.
Moth	Moth populations are impacted from scrub encroachment, agricultural improvement and overgrazing. Straw Belle Moth and Black-Veined Moth population estimates in particular could provide useful indicators. The Straw Belle Moth is found exclusively in SNGs, and its population has rapidly declined with fewer than 20 colonies remaining. The Black-Veined Moth is sensitive to overgrazing and a decline in population could indicate mismanagement.	- UK Biodiversity Action Plan (UK BAP) Invertebrates. - National Biodiversity Network (NBN) Atlas.
Bumblebee	Since 1960, three of Britain's twenty-five native species of bumblebees have become extinct, and a further nine suffered serious declines. This is partly attributable to the loss of SNG over the 20th century. Worsening condition of SNG leads to pollen and nectar sources depleting and a reduction in bumblebee population. Fewer bumblebees indicate whether the habitat is declining in condition. Brown-Banded Carder Bee population has declined due to agricultural intensification and the loss of field margins. Pollinators are very important to the condition of the habitat and this resulted in a reduction in flower rich grassland. These bumblebees are found predominantly in SNG as they need large areas of fairly tall, open, flower-rich grassland with a variety of plant species. Brown-Banded Carder Bee population would provide a useful condition indicator for SNG. Joint Nature Conservation Committee suggest that the condition of pollinator indicators can be measured using the occupancy index. The occupancy index measures annual change in the number of pollinators "occupying" 1 kilometre grid squares across the UK. As species become more (or less) widespread, individual grid squares will have richer (or poorer) pollinator communities. Generally, species with greater occupancy are likely to be more abundant, although as a species with one individual would receive the same occupancy score as species with 100 individuals in the same grid square it is not a measure of abundance.	- UK Biodiversity Action Plan (UK BAP) Invertebrates. - National Biodiversity Network (NBN) Atlas. - Bumblebee Conservation Trust (Bee transects).
Beetle	Beetle populations are impacted by loss of wildflower-rich habitats, habitat fragmentation, changes to land management and a decline in host bee species (Buglife, 2012). Fewer beetles would imply a decline in condition.	- UK Biodiversity Action Plan (UK BAP) Invertebrates.

	Long-term maintenance of wildflower-rich SNG is important for oil beetles. Oil beetles like management by grazing, although there is a balance as over-grazing can result in reduced wildflowers and physical damage to bee burrows, which can be detrimental to beetle populations. Generally, if the number of beetles are rising this would indicate satisfactory levels of grazing and better SNG condition.	
Earthworms	Earthworms facilitate decomposition by fragmenting and incorporating litter into the soil stimulating microbial activity. Earthworms have a crucial influence on soil structure through burrowing, soil ingestion and mixing, and increasing plant growth (J. P. Curry, 1987). Ants are also considered 'ecosystem engineers', since they are important in below ground processes through the modification of the physical and chemical environment, and their effects on plants, microorganisms and other soil organisms (Folgarait, 1998). Earthworm and ant populations should also be included as important condition indicators.	- UK Biodiversity Action Plan (UK BAP) Invertebrates.

Source: Office for National Statistics

Several condition indicators could be provided with each individual species listed in Table 10, or they could be combined into a single indicator, possibly with other indicators of taxa abundance such as specific wild bird breeding populations.

Care must be taken not to include an invasive species, which have adverse effects on the condition of SNG. For example, wireworms feed on germinating seeds, roots, bulbs and tubers, destroying and killing them and aphids (sap-sucking tree bugs) weaken plants by stunting growth and distorting leaves. Many aphids also excrete sticky honeydew, which allows the growth of black sooty moulds damaging foliage (Royal Horticultural Society, 2018). Other invasive invertebrate species include leather-jackets, slugs and snails.

Although butterfly and bumblebee surveys are often done by volunteers, generally it is expensive and time-consuming to monitor most invertebrate species. Natural England has recognised this, so an alternative to this is to identify habitats with high invertebrate biodiversity value. Natural England's HLS Farm Environment Plan (FEP) Manual (PDF, 2.35MB) states if four or more microhabitat features are present then the site is likely to have a high potential for invertebrates; seven or more indicate that it is a high biodiversity grassland habitat for invertebrates. If it is not possible to monitor biodiversity directly, these features, which include coverage of grass, rush or sedge tussocks and flowering heads of wildflowers, could be monitored as a proxy.

Fungi

Fungi is important for some processes, such as disease control. Many fungi found in SNG are considered specialist to grassland, since most (that is, wax-caps, pink-gills and earth-tongues) are intolerant of modern agricultural practices. A decrease in fungi may point to factors leading to harmful change in the grassland ecosystem.

Club and coral fungi are major macro-fungal species of grassland. Some puffballs such as the meadow puffball occur predominantly in SNG and are dependent on soil characteristics, such as pH level and mineral content (Blakesley and others, 2016). A drastic change in the physical number of puffballs would suggest a change in soil pH level.

Care needs to be taken in interpreting declines in fungi as they are highly influenced by seasonal weather conditions. However, most data sources record yield rather than occurrence, limiting the impact of weather on estimates.

Birds

Several species are associated with SNGs as they provide important feeding and breeding areas, for example, the Stone Curlew, Twite and Yellow Wagtail. The presence or absence of these birds may inform on the condition of the habitat.

The Breeding Bird Survey (BBS) provides national population trends for over 100 species and is the most suitable indicator for bird data, as it is spatially explicit and available annually. For this to be a reliable indicator of change in SNG species abundance, a substantial subset of species will be needed.

Management practice indicators

It is not only diversity and the presence of main species of vascular plants that can inform assessment of condition, but also vegetation management as referred to previously. Potential management practices include the following.

Cutting and grazing

Grazing is often chosen as the best management option for SNG, as it can help to maintain diversity in the sward, prevent scrub encroachment and provide bare ground for regeneration.

Under-grazing can lead to bracken encroachment and abundance of invasive species which overcome several less competitive associated species. Over-grazing leads to a loss of plants species and associated fauna, and in extreme cases, very heavy grazing and trampling can lead to exposure of bare soil and erosion. Historically this has been a particular issue on upland acidic grassland, due to the overstocking of sheep (UK NEA, 2011).

Changes in the cover of scrub, bare ground and invasive species (such as coarse tall grasses and herbaceous species) may all provide good indication of the appropriateness of grazing level, since these can inform on biodiversity, and other ecosystem services.

Sites of special scientific interest (SSSI) and areas of special scientific interest (ASSI) condition status

SSSI and ASSI provide statutory mechanism for protecting sites of ecological and geological interest in the UK. From Table 11, it is evident that a fairly high proportion of lowland calcareous grassland is within SSSIs. Since non-SSSI grasslands tend to be at greater risk than SSSIs, these can be tracked over time to see fluctuations, indicating how the sites are being managed and their status. There are no area measurements of grassland features within Scottish SSSIs, so no figures for Scotland can be used. However, in Northern Ireland, approximately 15% of the SNG resource is within ASSIs (PDF, 2.69MB) .

Table 11: The areas and proportion of semi-natural grassland that fall within Sites of special scientific interest in England and Wales

England and Wales						
	Area of habitat within SSSIs (ha)		Total area of habitat (ha)		% of habitat within SSSIs	
	England	Wales	England	Wales	England	Wales
Lowland calcareous grassland	41,015	446	65,567	1,200	63%	37%
Lowland dry acid grassland	7,960	1,315	15,453	39,500	52%	3%
Lowland meadow	13,406	532	36,129	1,600	37%	33%
Upland hay meadow	842		3,525		24%	

Source: Joint Nature Conservation Committee Protected Areas Designations Directory (2010)

According to the UK NEA, only 21% of English non-SSSI SNGs were in favourable condition (PDF, 2.2MB). Management of Scottish SSSI lowland grasslands increased the number of sites in favourable or recovering condition from 45% in the early 2000s to 71% in 2010.

Data is available from the respective administrations through the Joint Nature Conservation Committee (JNCC) Protected Areas Designations Directory and protected area spatial maps are available from the UN Environment World Conservation Monitoring Centre (Unep-WCMC).

Wildfires

Fires in areas of combustable vegetation can destroy or disrupt many services within the ecosystem. According to the University of Manchester, the Fire and Rescue service deals with an estimated 70,000 grassland fires a year in the UK, with the Peak District National Park experiencing at least one potentially serious wildfire every year. However, their potential to cause serious damage has rarely been studied in detail.

Fires can damage the aesthetic of the landscape and worsen air pollution by destroying pollution-removing vegetation and emitting pollution to the local atmosphere. Risk of soil erosion is intensified after a fire, especially if organic layers are burnt off, this can compromise the quality of water within the ecosystem.

Wildfires are considered more of a concern for woodland and saltwater habitats, however, it is still important to monitor fires in SNG habitats as they can have devastating effects. The Home Office collects detailed information on various fire-related statistics, including area burnt, duration of fire and number of fire-related emergencies attended to by the Fire and Rescue Services.

Grazing intensity

As well as indirectly monitoring grazing through scrub encroachment, vegetation height and structure, it may also be possible to observe through more direct measures – for example, through volume of animals grazing on the land.

The Scottish Agricultural College (SAC) provides guideline stocking rates for grazing, which measure the number of animals on pastures for a specified time period (Table 12).

Table 12: Guideline for grazing stocking rates, provided by The Scottish Agricultural College

UK	
Grassland	**Guideline annual average stocking rate (LU/ha /year)**
Unimproved lowland grassland	0.30-0.40
Unimproved upland grassland	0.15-0.25

Source: The Scottish Agricultural College (2007)

Note:

1. These stocking rates can vary by 20-40% depending on soil fertility and rainfall.

Defra provide livestock estimates in England and the UK, however, data are not spatially disaggregated so it is not possible to disaggregate grazing on SNG and grazing on enclosed farmland.

Ecological condition indicators

This section refers to the state of the ecological system as well as the processes and interactions that connect them. Understanding these indicators is crucial, because humans depend on healthy ecological condition for many services and benefits, such as flood control. So, potential indicators could include the following.

Air quality

Air pollution is considered a significant pressure to the structure and function of most lowland SNG habitats. Atmospheric nitrogen deposition is a particular concern for all ecosystems. The observable effects include species loss, changes in soil chemistry and habitat degradation (PDF, 953KB) resulting from nutrient enrichment (eutrophication), acidification (lower pH), or direct damage (toxicity) (Plantlife, 2011).

Increased ground-level ozone also cause damage to cell membrane on plants, hindering important processes required for their growth.

Generally, less air pollution results in less pressure on the habitat and its general capacity to function, so unfavourable air quality would indicate a pressure on the condition of the habitat. There are over 1,500 sites in the UK that monitor air quality, however, work will be needed to distinguish which ones belong to SNG.

Naturalness of water levels

The characteristics of many SNGs (particularly lowland meadows) are influenced by the availability of water and the seasonal variation in the water table. The water table regime is an important factor determining species composition and even small hydrological changes can result in relatively rapid changes in the floristic composition.

SNG is sensitive to changes in the seasonal weather patterns and the effects of increased summer temperature on water usage. For example, reductions in summer rainfall and increased summer evaporation puts stress on wet meadow communities, since the water table may drop.

The British Geology Survey publish measurements of the depth below the ground surface of the water table, however SNG is not distinguished.

Spatial configuration

This describes the spatial pattern of the ecosystem. Most traditional spatial configuration measurements consider aspects of patches within the landscape, including patch size, shape, density and connectivity.

Proximity to insect pollinated crops

The proximity of SNG to insect pollinated crops is important and the abundance and species richness of pollinators in arable fields is related to the distance of the field to natural habitats. It was reported that there was 50% less pollination when crops where more than 1.4 kilometres away from “natural habitats”. The visitation rate by pollinators to flowers fell by the same amount after 900 metres.

An indicator of SNG condition would be the number of pollinator visits to pollinated crops, data is available from the Centre for Ecology and Hydrology, although much of this data are on trial sites and so are limited.

Proximity to infrastructure and settlements to protect against flooding

It is not only the amount of infiltration that can measure SNGs’ ability to provide flood protection. The proximity of SNG flood-mitigating land to infrastructure and settlements is an important factor when considering the value of flood protection; the closer it is to these areas, the more impact and valuable the service.

Proximity to water sources to regulate water quality

SNG habitats intercept water pollution, therefore, the location of the habitat in relation to the water source, pathways and receptors is important. Proximity of SNG in relation to pollutants to water sources is also important, such as agricultural pesticides and fertilisers and effluent from deficient septic tanks and sub-surface leaching fields can seep into groundwater.

Fragmentation

A process whereby a continuous expanse of habitat is broken up into many separate smaller patches, isolated from each other by a matrix of habitat unlike the original. A large proportion of SNG habitats have existed in a fragmented state for centuries, but ultimately fragmentation reduces the resilience of SNG to harmful impacts. Whilst small or disconnected sites can maintain their ecological condition under appropriate management regimes, they tend to be more vulnerable to edge effects.

Where fragmentation is extreme, small quantities of species living in isolated pockets of the habitat may become locally extinct during unfavourable conditions and fail to recolonise because there are no populations within dispersal range (Bullock and others, 2002). It also reduces the potential for a species to colonise (migrate) from distant sites, therefore lessening the ability of species to respond to climatic changes (PDF, 532KB) (European Commission, 2009).

A high proportion of UK Biodiversity Action Plan (BAP) priority grassland sites are less than five hectares in extent and very few are over 20 hectares, see Table 13. Only lowland acid grassland sites tend to have a bigger extent.

Natural England have attempted to measure habitat fragmentation (PDF, 2.46MB) based on National Character Areas (NCAs) and also provide site sizes in England.

Table 13: Percentage of UK Biodiversity Action Plan priority grassland sites within a certain size bracket

England				
UK BAP Priority Grassland	**less than 5 ha**	**5 to 9.99 ha**	**10 to 19.99 ha**	**more than 20 ha**
Lowland Calcareous	73%	13%	7%	7%
Lowland Meadows	80%	11%	5%	4%
Lowland Acid Grassland	71%	9%	6%	14%
Upland Hay Meadow	86%	8%	5%	1%

Source: UK National Ecosystem Assessment (2011)

Access and proximity to human habitation

Access to SNG affects its capacity to provide cultural services, such as recreation. Proximity to human habitation is important as 71 to 74% of outdoor visits to public spaces occur within five miles of home (PDF, 4.41MB). People are prepared to travel further to a place they value provided it is accessible and those travelling the longest distance tend to expend the most energy (Elliot and others, 2015).

The length of national trails can be used as an indicator for access. According to AECOM (2015) (PDF, 9.59MB), “the extent of paths and trails can act as a proxy indicator for cultural ecosystem services associated with access and interaction with nature”. Scotland’s Great Trails, The National Trails for England and Wales and WalkNI for Northern Ireland could all provide trail-length information.

Recommendation

Outlined in Table 14 are some of the main recommended indicators to use within the condition account. Some of these condition metrics have the capacity to provide services and the main services are included where appropriate.

Table 14: Summary of key condition indicators to include within the condition account

Condition indicator	Potential Data Sources	Key services
Soil indicators		
Carbon content	No up to date data	Biomass production
Soil compaction	No up to date data	Flood protection
Ratio of vegetation to bare soil	Potentially available form 'SPOT'	Water quality
		Storm, flood and erosion protection
Biodiversity indicators		
Plant species richness	Centre for Ecology and Hydrology	-
Characteristic species	Positive habitat indicators and species richness estimates	-
Invertebrate abundancy	Data available from various sources, could be combined into single indicator	Pollination, soil fertility
Management Indicators		
Cutting and grazing	Not currently available	Flood protection
		Grass fodder
Sites of Special Scientific Interest and Areas of Special Scientific Interest	Data available from the respective administrations through the JNCC Protected Areas Designations Directory,	-
	UN Environment World Conservation Monitoring centre	
Grazing intensity	Not currently available	-
Ecological Condition Indicators		
Air quality	No up to date data	
Naturalness of water levels	British Geological Survey, although work will be needed to extract SNG	-
Spatial Configuration Indicators		
Proximity to insect pollinated crops	Limited data availability	Pollination
Fragmentation	Limited data availability	Recreation
Access	To be developed	Recreation

Source: Office for National Statistics

Many extent and condition indicators are for SNG are unlikely to change much in the short-term, and may not warrant annual reporting.

8 . Physical and monetary accounts for ecosystem services

The System of Environmental-Economic Accounting Experimental Ecosystem Accounting (SEEA-EEA) (PDF, 2.84MB) guidance recommends to “initially select a limited rather than a comprehensive set of ecosystem services for inclusion in ecosystem accounting”. Environmental policy priorities, economic importance and the availability of data should be considered in the selection, as well as the assessments of state and significance set out in the UK National Ecosystem Assessment (UK NEA). This section gives an overview of the different ecosystem services and their importance for semi-natural grassland (SNG) habitats. The services covered in this section do not represent every ecosystem service provided by the SNG habitat. The assessment of services is summarised using the following structure:

- “service” identifies the individual, specific good or service that benefits the economy or society, for example, the provision of grass fodder
- “flow” identifies the annual flow of the service we want to measure and in what metric
- “data” assesses available data sources and their robustness
- “valuation” assesses whether monetary valuation is possible and if so, whether it can be consistent with accounting principles

Ecosystem service accounts can be in both physical and monetary terms. Physical accounts will have a range of physical metrics and are not readily aggregated. Monetary accounts provide valuations of these physical flows to enable comparison, there are two types of monetary accounts:

- annual flow accounts – the value of ecosystem service provided each year
- asset accounts – value the expected future flow of services (up to 100 years) discounted to a “net present value”

These are explained in more detail in the Office for National Statistics and Department for Environment, Food and Rural Affairs (ONS-Defra) Principles of Natural Capital Accounting. According to these principles, ecosystem services are classified using the Common International Classification of Ecosystem Services (CICES) as a checklist, distinguishing between provisioning, regulating and cultural services.

For accounting purposes, it is useful to identify the beneficiaries of these services and the extent to which changes in the number of beneficiaries affects the value of the service.

SNGs provide some disservices, but these should not be included in the accounts as “the natural capital accounts should not take into account the disservices or negative externalities arising from ecosystem functioning” (see Principle 5.5 of the Principles of Natural Capital Accounting).

9 . Provisioning services

Following the System of Environmental-Economic Accounting Experimental Ecosystem Accounting (SEEA-EEA) definition, provisioning services are defined as “contributions to the benefits produced by or in the ecosystem, for example, a fish, or a plant with pharmaceutical properties”.

According to the UK National Ecosystem Assessment (UK NEA), semi-natural grasslands (SNGs) present opportunities for delivering multiple services, while requiring relatively low energy inputs.

Table 5.1 in the Principles of Natural Capital Accounting publication outlines a list of natural capital provisioning services to be considered in the UK accounts, which will be followed when considering services. Provisioning services that could potentially be included are the following.

Biomass and water supply

SNG provides important provisioning ecosystem services in crops to eat, water and grass for grazing. Livestock is excluded as a provisioning service, but grass fodder consumed by the livestock is included as advised in Principles of Natural Capital Accounting.

Grass fodder

SNG is still used for animal production, even if only for conservation management, but it is grazed at a lower intensity than improved grassland. For example, roughly 95,000 hectares of land (PDF, 240KB) in lowland England used for grazing livestock production are classified as SNG. Grass fodder is grass mowed and cured into a feed for domesticated livestock, including hay, straw and silage, and grass used for general grazing.

Even though the yields are not as substantial as those from improved grassland, fodder from herb-rich meadows can contain a greater variety of essential minerals from animal production than that from improved pastures. The production of dry matter cut hay could be a straightforward measure of this if it can be extracted for SNG.

Statistics on grass fodder for UK countries are produced by the respective administrations, and data for the UK as a whole is published by Office for National Statistics (ONS) and Department for Environment, Food and Rural Affairs (Defra). Fodder data is broken down by type, but further work will be needed to disaggregate by fodder produced by SNG habitats and enclosed farmland.

Fodder could be valued using the cost of reseeding, or the feed value. The feed value is a measure of the fodder's main nutritional components. The worth of any fodder depends mainly on the concentration of energy and protein in the dry matter of that feed, which could be used to estimate how much the producer would be willing to pay for alternative feeds of comparable nutrient status (PDF, 664KB) (Bell and others, 2012). Relative feed values are provided by Defra.

Wild produce

There is a variety of wild produce found within this habitat, in particular mushrooms. Picking of mushrooms for private consumption has been a tradition for centuries in the UK, but commercial harvesting and trade is becoming more popular, which concerns some mycologists and nature conservationists who query whether it is sustainable. There has been protection put in place in some areas, for instance, picking wild mushrooms is now prohibited in national parks and other strict nature reserves.

Commonly eaten field mushrooms are considered “grassland specialist” since relatively few of these species occur in other habitats.

The Fungal Records Database of Britain and Ireland, which is updated regularly, provides yield of wild produce. Further work would be needed to determine how much of the yield is consumed and how this service can be valued.

Water supply

Upland grasslands are particularly important for water supply. SNG contributes to water supply predominantly through groundwater (particularly on chalk grasslands), for example, it supplies 30% of public water supply in England.

SNGs are important for water quality (as explored in regulating services) and this water is most commonly used for drinking, irrigation and recharge for lakes, rivers and wetlands. Defra provides statistics on water abstraction (2000 to 2016) and the British Geological Survey (BGS) provides data on current UK groundwater use.

A resource rent approach could be used to value water supply (as explained in Annex B). Alternatively, a replacement cost approach could be taken whereby the value is based on the cost of taking water from another source if the groundwater wasn't available.

Materials

There are also some services within SNG that provide materials of great interest to an array of consumer groups. These include the following.

Medicinal and genetic resources

For some organisms, including medicinal plants, only SNG ecosystems are suitable habitats for them to flourish (Bastian and others, 2015). Traditionally, SNGs have been a healthy source of medicinal plants and resources, for example, Common St. John's Wort, Meadow Clary and Ribwort Plantain. These are valuable for traditional medicines or for commercial utilisation in the production of teas, oils and other medicines.

The Plants For A Future database provides data on medicinal plants and their use, however, there is not currently data available for medicinal plants harvested in SNG habitats.

Ornamental resources

This ecosystem provides several resources that humans use for ornamental purposes. This includes various plants and flowers used in gardens and for indoor decoration, such as the meadow or alpine flower. Many orchids found in this habitat can be categorised as ornamental resources, as well as animal skins, bodies and horns, which are used as throws, wall mountings and taxidermy.

Unfortunately, there is very limited data on the use and production of ornamental resources in the UK and so it may be difficult to include this within the account.

Energy

Due to the vulnerability of this habitat, the installation of physical infrastructure would be an issue, so there are limited options regarding energy production. Although when considering the favourable topography of the land and wind exposure, it may be possible to harvest energy through renewable sources such as wind farms (an abiotic, rather than ecosystem, service) but it is generally advised against as it would have an adverse effect on the grassland. Some potential sources of energy include the following.

Bio-energy

This is considered one of the major sources of future energy supply systems. While plant biomass for fuel is generally considered in terms of planted crops, hay from SNG could produce another fuel source that does not monopolise cropland. Grassland biomass can either be combusted, converted into bio-fuel or digested into bio-gas. This can be used as an alternative use of biomass no longer needed for forage production. However, this could result in pressures for SNG to produce more biomass and therefore to convert them to improved grassland.

Herbaceous biomass of similar properties, such as cereal straw or perennial energy grasses, are already used extensively as fuel. In the past, the potential for harvesting biomass was rarely considered in the UK, so there is very little data on this.

However, there is increasing interest in the use of SNG (including roadside verges) for bio-energy production and there are a number of pilot and feasibility studies up and running (for example, the “Prograss” idea). In the future, it may be possible to use these studies to include bio-energy within the account, but for now it should not be included within the account.

10 . Regulating services

The System of Environmental-Economic Accounting Experimental Ecosystem Accounting (SEEA-EEA) defines regulating services as those that “result from the capacity of ecosystems to regulate climate, hydrological and biochemical cycles, Earth surface processes and a variety of biological processes”.

The Common International Classification of Ecosystem Services (CICES) separates this into:

- mediations of waste, toxins and other nuisances (for example, removal of air pollution absorption)
- mediation of flows (for example, water flows or flood protection)
- maintenance of physical, chemical, and biological conditions (for example, local climate regulation)

This is supported by Table 5.1b in Principles of Natural Capital Accounting, which follows the same breakdown as CICES. Semi-natural grassland (SNG) provides many regulating services, some of which are explored in this section.

Mediation of waste, toxins and other nuisances

SNG can provide many services that are crucial for regulating global warming, reducing negative externalities and aiding the alleviation of climate stress.

Carbon sequestration

Carbon sequestration is an ongoing process by which plants, soils and geologic formations remove CO2 from the atmosphere and retain it as stored carbon.

In 2015, there were approximately 25,500,000 tonnes of CO2 sequestered in the UK, with an annual value of £1.55 billion. More detailed carbon sequestration data can be found in the UK Natural Capital Ecosystem Services Accounts.

The recommended data source for carbon sequestration is the UK Greenhouse Gas Inventory. This can be valued using the carbon price, as explained in the methodology of the Office for National Statistics's (ONS's) Ecosystem Service Accounts.

Table 15: Carbon sequestration by grassland, UK, 2015

UK

	Physical Flow (million tonnes CO_2 eq)	**Annual Value of Flow £m 2016 prices**
Grassland remaining grassland	5.04	312
Cropland converted to grassland	4.57	283
Settlements converted to grassland	0.89	55
Total	10.49	650

Source: Department for Business, Energy, and Industrial Strategy (2017)

Air pollution removal

Vegetation and soils are able to remove pollution emissions from the atmosphere. Pollution removal can result in the deterioration of ecosystems, particularly through nutrient enrichment. By absorbing compounds containing nutrients and phosphorus, this will encourage processes such as eutrophication, which may encourage harmful effects to ecosystems including nuisance or toxic algae blooms and reduced water quality.

Vegetation removes pollution from the atmosphere, through either uptake via leaf stomata, or by intercepting airborne particles. Pollution removal valuations for SNG are presented in Table 16.

Table 16: Physical and annual flow of UK pollution removal by pollutant type, for grasslands for 2015

UK		
Pollutant	**Physical Value (ktonnes per year)**	**Annual Flow (£, 2012 prices)**
PM_{10}	1.5	-
$PM_{2.5}$	1.0	£39,859,000
SO_2	7.7	£122,000
NH_3	5.8	-
NO_2	6.5	£5,541,000
O_3	141.4	£5,969,000
Total	164.0	£51,491,000

Source: Centre for Ecology & Hydrology (2017)

Notes:

1. Physical values expressed in thousand tonnes.

2. Pollution removed by SNG vegetation, in particular grasses, trees and shrubs.

Pollution absorption figures have been recently released by ONS, including time series data and asset values, although the latter are not currently disaggregated by all habitat types.

Valuations are based on the reduction of exposure of the population to pollution and the associated health benefits. Where vegetation has greater potential to prevent illness (for example, in areas with greater population density), avoidance of health threats, hospital admissions and premature deaths are likely to be more frequent, increasing the value of pollution removal.

Water quality

Unlike intensive grassland and arable land where artificial fertilisers can pollute drinking water, SNG can help to purify it (PDF, 7.77MB) (The Grassland Trust, 2011). In many grasslands, water moves slowly through the underlying geology (groundwater), filtering many contaminants, including bacteria and viruses. Vegetation can also slow down surface run-off, enabling the water to infiltrate into the soils at a faster rate.

This is an area for further research and a greater understanding of this service, data and methods of valuation is needed.

Mediation of flows

SNGs have the capacity to moderate extreme events like floods or landslides, even though rates of geomorphic change in the UK's landscape are typically relatively modest and the integrity of landforms is rarely threatened. Some services include the following.

Flood protection

SNGs protect UK landscapes from flooding, as they allow high water infiltration rates and enhanced storage, some grassland meadows also serve as wash-lands for floods.

Water infiltration can depend on many factors such as soil (type, texture, water content and structure), earthworm burrow numbers and volume of vegetation – all of which are favourable in SNG habitats. For example, vegetation will intercept and slow surface run-off from rainfall and provide space for water to be stored during flood events. Grasslands can reduce water run-off by 20% and 50% compared with cropland and urban areas respectively. This is important for flood protection, as a slowdown in run-off allows for more infiltration, minimising the potential for flooding.

SNGs complement wetlands and woodlands with regard to buffering water flows and relieving water stress by increasing landscape water holding capacity. This area is a research priority and a greater understanding of this service, data and methods of valuation need to be understood.

Storm and erosion protection

SNGs provide soil with storm protection, most importantly through vegetation cover. By reducing wind speed, top-soil is protected from wind erosion, thus providing protection during storms.

Soil erosion is a large concern when considering degradation of SNGs and erosion can damage the most fertile top-soil, leading to reduced soil productivity. Further, deposition of soil particles in water systems can reduce the ability to provide clean water, waste treatment and flood control. By providing a dense rooting system and a permanent soil cover, grassland can bind soil particles together, thus aid the prevention of soil loss due to water and air erosion.

Storm and erosion protection is also an area for future research.

Biophysical maintenance

"The biosphere regulates climate by controlling the flow of greenhouse gases (principally carbon dioxide, but also methane and nitrous oxide), sources of aerosols and the transfer of heat, moisture and momentum" (PDF, 3.1 MB) (UK National Ecosystem Assessment (UK NEA), 2011). Ecosystems also regulate microclimate, dampening temperature extremes and providing shade and shelter.

Local climate regulation

This service focuses on the role SNGs play in modifying temperature and climate. This is an important service as good local climate regulation (that is, no extreme rain or temperate events) have a positive correlation with better air and water quality (Pilgrim and others, 2010). Under poor climate regulation, in particular higher temperatures, there are elevated quantities of GHGs, which can have further warming effects.

There is some evidence of local climate regulation in SNG habitats, since studies show vegetated sites are cooler than non-vegetated locations. This could be because vegetated habitats can influence albedo, which is the proportion of incoming solar radiation that is reflected from the Earth's surface. A change in vegetation cover will enforce a change in albedo, which can have a cooling or heating effect on the surface climate – therefore making the ecosystem warmer or cooler than its surrounding ecosystems, in turn affecting precipitation.

Shade is also provided by tall vegetation on SNG, which can have a similar cooling effect on local climate. This tall sward is also important as, according to Natural England, some seed species (for example, buttercups) will only germinate underneath it. Equally, this shade is used as shelter for many species (for example, invertebrates, birds and small mammals), which in turn attracts birds of prey.

Similarly, soils and plants can control the amount of water vapour entering the atmosphere , regulating cloud formation and the radiative properties of the atmosphere through evapotranspiration (Yin and others, 2015).

However, the valuation of this service is likely to be very small, since it is based on benefits to people and the economy. This valuation, usually measured in terms of avoided productivity loss and air conditioning costs (PDF, 2.84MB), may be minimal in the countryside.

Pollination

Pollination can take place either abiotically (primarily by wind), or biotically (predominantly by bees and other insects). Many species, such as bumblebees, hoverflies and feral bees, are reliant upon SNG to provide biotic services for pollination and particularly benefit from the floristic diversity in this habitat.

Several plants, trees and crops are dependent on pollination by wild pollinator species, for example, wildflowers, however, according to the UK NEA the value of pollinators and pollination service to wildflowers and for recreational and other cultural services is unknown, but it is expected to be significant.

There is currently no suitable data source for this and further research is needed to establish how this service could be included. If a data source for physical service flow were available, it may be possible to value pollination services using a dependence ratio (DR) (PDF, 5.68KB). DR studies estimate the proportion of yields that would be lost without pollination services and multiply this with the production value to get the pollination value. Limitations of this method are the ratios neglect changes in crop quality and only consider quantity. A replacement cost approach could be taken, which would measure the cost of replacing these services artificially.

Pest control

Grasslands mediate the biological control of pests and pathogens through the removal of invasive species, improving diversity. For example, arthropod predators and parasitoids suppress populations of herbivorous crop pests, providing bio-control services (Gardiner and others, 2009).

However, similarly to pollination, the relative role of biotic, abiotic and socio-economic factors in regulating specific pest and pathogen systems is largely unknown, making it difficult to evaluate the importance of UK ecosystems in regulation.

11 . Cultural services

Following the UK National Ecosystem Assessment (UK NEA) definition, cultural services are derived from “the environmental settings that give rise to the cultural goods and benefits that people obtain from ecosystems”. They are produced by the interaction between people and nature and are an essential part of everyday human life.

The Common International Classification of Ecosystem Services (CICES) breaks this down into:

- physical and intellectual interactions with biota, ecosystems and landscapes, for example, recreation
- spiritual, symbolic and other interactions with biota, ecosystems and landscapes, for example, symbolic use

This structure is in line with United Nations Statistical Division (UNSD) best practice guidance and is again supported by Table 5.1b in the Principles of Natural Capital Accounting, which follows the same breakdown as CICES.

Semi-natural grasslands (SNGs) are part of the cultural landscape of the UK. Most are remnants of traditional farming practices and are the product of thousands of years of human interaction with landscape and its wildlife. “Although the use of cultural services has continued to grow, the capability of ecosystems to provide cultural benefits has been significantly diminished in the past century” (Wild and others, 2008).

Physical and intellectual interactions

Humans can interact with natural ecosystems in many ways and SNGs provide places where people can rest and relax. Cultural ecosystem services provided by SNG include recreational, educational and scientific interactions.

Recreation

Generally, the capacity of ecosystems to provide recreational services depends on their uniqueness, the culture that generated them, the possibility for outdoor activity and access (such as proximity to areas of population and alternative site availability). SNG can provide a source of recreation through activities, including hiking, fishing and dog walking, as well as visiting barrows and hill forts, which can also have cultural and spiritual importance.

Calcareous lowland grassland is a major habitat of the new South Downs National Park. A visitor survey of the South Downs took place in 2003 and of the 7,342 people interviewed, roughly 90% visited the area to indulge in relaxation or recreation (PDF, 2.29MB).

SNG is vital to many wild bird species making it popular for bird-watching. For example, many birds of prey, such as the Honey Buzzard use this habitat as hunting ground during the breeding season.

Recreation data for England is available from the MENE (Monitor of Engagement with the Natural Environment) survey, which provides information on how frequently people visit places in nature and the duration and reason for their visit. It also provides data on fuel spending and admission fees, which prove useful for valuation. MENE is not designed to capture habitat-specific visits, but it does capture some location information and asks self-reported questions about the type of natural space they visited, for example, woodland, farmland and so on. It is not currently detailed enough to provide information about semi-natural grassland only.

The method currently used to value recreation is to use travel expenditure and admission fees as a proxy for the value placed on the visit. This is an underestimate and does not capture recreational activities close to home, such as dog walking. Therefore, as suggested by Ricardo, these values should be presented alongside visitor data to demonstrate gaps in the valuation (PDF, 1.22MB).

Valuing recreational services for the purpose of ecosystem accounting are currently being reviewed by Office for National Statistics (ONS) and Department for Environment, Food and Rural Affairs (Defra), so these estimates should be taken as experimental pending further development.

Tourism

SNG landscapes provide the backdrop for some of the most popular tourist destinations in the UK including the Lake District, South Downs and the Yorkshire Dales. In large parts of rural England, tourism contributes more to the national economy than agriculture (PDF, 3.16KB) (Bojnec and others, 2010), so is likely to be an important service contributed to by SNG.

Overnight and overseas visitors not currently captured in recreational estimates would be captured in the tourism estimates. Regional tourism estimates are provided by ONS, although further research is needed to decide what would constitute a visit to a natural environment and to SNG habitats using the ONS tourism statistics.

A resource rent approach to valuation would be taken, whereby the value attributed to the natural environment would be the revenue generated minus the cost of all other inputs.

Military use

Large areas of SNG are owned, leased and used for training by the Ministry of Defence (MoD). A submission to the UK NEA by the Defence Estates reports that the Salisbury Plain Training Estate is the largest (38,000 hectares) and most important training area in the UK, since the favourable nature of the terrain (that is, resilient, chalk soils) enables extensive armoured manoeuvre training to be undertaken. Salisbury Plain is the largest area of chalk grassland in north-west Europe, containing 40% of the remaining areas of this habitat in the UK.

During the financial year ending 2010, there were 740,560 personnel training days spent on the estate (PDF, 2.69 MB). With further research it may be possible to use this data source to derive a value attributable to SNG for supplying an area suitable to train. This value could be estimated using a replacement cost approach, that is, estimating how much the MoD would be willing to pay for similar land if this ecosystem did not exist, or the condition deteriorated.

Educational

An environmental setting, such as the one provided by SNG, is a potential location for outdoor learning, as engaging with the outside world can enhance connection to nature and increase ecological knowledge; this is known as green education. Many national parks provide field trip opportunities for young students to attend and learn more about the environment.

Also, the abundance of rich plants and bio-diversity within SNGs can aid in educating individuals on the importance of the environment for a sustainable future and many charities (such as the Green Education Foundation) are trying to promote this. This could be valued using the number of educational hours spent within this habitat, alongside a financial expenditure approach.

No collated data sources with educational visits to SNG are currently available, further research is also needed to value these interactions.

Scientific

SNG's have possibly contributed more than any other ecosystem to the development of the UK's ecological knowledge (PDF, 2.29MB) (UK NEA, 2011). For years, SNGs have been the testing ground for important ecological concepts in the UK, such as ecological stability, the productivity-diversity relationship and population biology.

Due to the high local diversity of plants and animals found within this habitat and its highly dynamic and fluid nature, SNG is ideal for experimental work. Thus, research on grasslands has been critical to the UK's ecological research reputation (PDF, 2.29MB), an area in which the UK excels (UK NEA, 2011). However, this is difficult to value and further work is needed to incorporate this service into the accounts.

Mental health benefits

It is widely known that exposure to natural places, whether a view from a window, or being within a natural place can lead to positive mental health outcomes (PDF, 2.47MB) (Pretty and others, 2009). These psychological benefits range from reduced anxiety and mental fatigue, to improved moods and faster healing. For example, patients with views of nature in hospital recover from illness and surgery quicker, spend less time in hospitals and need fewer painkillers than those who don't.

These psychological benefits are difficult to quantify and attribute to SNG specifically, so it is not possible to include this service in the accounts presently.

Aesthetic

The abundance of flowers and naturalness of SNG makes this habitat very pleasing to look at, and many national parks and areas of outstanding natural beauty are included within this habitat. Humans can benefit from the outstanding scenery services offered and the beauty around us can bring joy, solace, inspiration and is life-enhancing.

Ecosystems of extreme beauty still have a value even if they are not easily accessible, through inactive appreciation; for example, television documentaries, amenity values and so on. As a result, it may be possible to use the number of pictures takes from a particular area as a proxy for identifying areas of relative aesthetic value – this was attempted by AECOM (2015), albeit experimentally. This is an area in need of further research.

Assigning a monetary value to this is practically and conceptually problematic, as there may be overlap with recreational services and adjoining habitats. It may be possible to use a hedonic price method (explained in Annex B) to derive the value of a home with a scenic view, as this could indicate the aesthetic benefit an ecosystem provides. For this, Zoopla house price data could be used. This is currently being explored by ONS in the development of a UK urban ecosystem account.

Spiritual, symbolic and other interactions

Nature and wildlife have always had a part in ancient cultures and SNGs are littered with spiritual and symbolic services, as well as many important historical events that occurred on English battlefields. For example, this ecosystem can provide a rich source of inspiration for art, folklore, national symbols and advertising. It has also been an area of inspiration for many writers across the centuries, including William Shakespeare – who describes grassland in many of his plays.

Spiritual services and heritage

Over the centuries, heritage artefacts have been found, constituting material objects, recording of landscapes in visual form and written memoires, for example, Salisbury Plain contains 2,300 ancient monuments. SNG is perhaps the most suitable environment for the preservation of these objects, although mismanagement of grassland can damage important features.

The role of ecosystem services in the generation of heritage goods in the UK is complex and the experience of heritage will vary between different groups of people in different parts of the country, making it difficult to value.

SNGs can also provide spaces for meditation, as well as providing people with spiritual sustenance. Many churchyards and cemeteries comprise SNG, which is important spiritually and religiously to many people. Reverend Nigel Cooper of Anglia Ruskin University strongly emphasises the importance of churchyards to spiritual interactions and can also provide important areas for recreation and access to nature (PDF, 2.29MB) (UK NEA, 2011).

The MENE Survey does not currently distinguish visits with a religious or spiritual motivation, although it does ask for the reason for the visit. This could present an opportunity for further analysis.

Bequest

This represents the importance people place on preserving ecosystems for future generations. The amount paid by individuals for bequest gains from managing areas of SNG could be considered for valuation. This requires further research for UK-wide valuation.

Existence

This is the utility or benefit to an individual simply by knowing that a resource exists – this can be the case even if the individual never expects to see (or use) the resource. Charity contributions towards conservation of SNG could be used to estimate the value of this service. Again, this requires further research for UK-wide valuation.

12 . Monetary stock account

The asset accounts value the ecosystem services provided by the asset, in this case semi-natural grassland, for the life of the asset. Services such as recreation and water filtration are seen as renewable, so the asset life is set at 100 years.

The value of the asset is obtained by estimating the net present value (NPV) of the future services expected to be provided by the asset. The annual value of all ecosystem services provided by semi-natural grassland habitats are projected for the life of the asset and discounted. For more information on monetary flow and asset accounts, please refer to the Principles of Natural Capital Accounting.

13 . Recommendations and further research

When developing the extent account, acid grassland, calcareous grassland and neutral grassland should be included and the Centre for Ecology and Hydrology Land Cover Map 2015 used. The account should include bracken, but exclude purple moor grass and rush pastures, heathland grassland, improved grassland and amenity grassland.

Further research would be recommended to distinguish between upland and lowland grasslands for the extent accounts. Given the significance of upland acidic grassland, it is important to distinguish between the two.

When developing the condition account, the broad habitat indicators outlined earlier in the study (Table 14) should be included and the suggested indicators should be further explored. It is expected further indicators will be added and some of those suggested may be replaced as the account develops further and new data sources become available.

Table 17 summarises the services that could be feasibly included when initially developing the physical and monetary service flow accounts, although this is likely to change when more knowledge into the habitat is gained.

Table 17: Services to include when developing the physical and monetary service flow accounts for semi-natural grassland

UK			
Service	**Valuation method**	**Significance of service**	**Feasibility**
Provisioning Services			
Grass Fodder	Feed value cost of re-seeding	Low/Medium	Low/Medium (more work needed)
Water Supply	Resource rent approach Replacement cost approach	Medium	Medium (more work needed)
Regulating Services			
Carbon Sequestration	Carbon price Welfare value approach	High	High (available)
Pollution Removal	Exposure and health costs	High	High (available)
Water Quality	Replacement cost approach	High	Medium
Cultural Services			
Recreation	Financial expenditure approach	High	High
Tourism	Resource rent approach	Low	Low/Medium
Military Use	Replacement cost approach	Low	Low/Medium
Aesthetics	Hedonic price method	Medium/High	Low/Medium

Source: Office for National Statistics

There are some much needed areas of future research to establish methods to measure other services provided by semi-natural grassland – for example, bio-energy. Once methods of valuation can be established for the services that are difficult to measure, it is encouraged that these should also be added to the service flow accounts.

14 . Annex A: Defining upland and lowland grasslands

As mentioned in Section 5, following guidance from the UK Biodiversity Action Plan (UK BAP), upland and lowland grasslands can be defined as in Table 18.

Table 18: Definitions of lowland and upland semi-natural grassland sub-habitats

UK	
Sub-habitat	**Definition**
Lowland dry acid grassland	Characterised by vegetation dominated by grasses and herbs on a range of lime-deficient soils, with presence and abundance depending on community type and locality. It includes both enclosed and unenclosed acid grassland, normally below 300m.
Upland acid grassland	This is defined as both enclosed and unenclosed acid grassland, usually above 250-300m altitude.
Lowland meadow (neutral grassland)	Characterised by vegetation dominated by grasses and herbs on a range of circumneutral soils. They are taken to include most forms of unimproved neutral grassland across the enclosed lowland landscapes of the UK.
Upland hay meadow (Neutral grassland)	These are confined to areas where non-intensive treatment has been applied in a sub-montane climate. They are most characteristic of brown earth soils on sites between 200-400m altitude. This habitat is characterised by a dense growth of grasses and herbaceous dicotyledons which can grow up to 60 - 80 cm high.
Lowland calcareous grassland	Characterised by vegetation dominated by grasses and herbs on shallow, well-drained soils which are rich in bases (principally calcium carbonate). Lowland is defined as below the level of agricultural enclosure, but the altitude at which this occurs varies across the UK.
Upland calcareous grassland	Characterised by vegetation dominated by grasses and herbs on shallow, well-drained soils which are rich in bases (principally calcium carbonate). Upland is defined as above the level of agricultural enclosure, but the altitude at which this occurs varies across the UK.

Source: UK Biodiversity Action Plan (UK BAP)

15 . Annex B: Valuation approaches

The Office for National Statistics and Department for Environment, Food and Rural Affairs (ONS-Defra) publication, Principles of Natural Capital Accounting suggests possible categories of valuation:

- market-based approaches
- revealed preference approaches
- cost-based approaches
- stated preference approaches

All suggested ecosystem valuation approaches have various valuation methods and techniques, coupled with their own advantages and limitations. Some of these methods are discussed in this annex.

Resource rent (market-based approach)

The resource rent or residual value (RR or RV) approach is an example of a market-based valuation method, as this approach uses data directly from existing markets that are within the System of National Accounts 2008 (SNA 2008). The UN System of Environmental-Economic Accounting: 2012 Central Framework (SEEA CF, 2014a) describes resource rents in paragraph 5.113 as “the surplus value accruing to the extractor or user of an asset calculated after all costs and normal returns have been taken into account.” In other words, this is calculated by subtracting the value of all other input uses from the natural asset (that is, labour, real capital, land and produced inputs).

Hedonic price method (revealed preference approaches)

The hedonic price method (HPM) is based on the theory that a good or service is valued for the attributes or characteristics it possesses. This perception of value suggests that implicit (or hedonic) prices exist for product attributes and these prices can be determined from the explicit price of the product, which can be applied to an environmental context (Callan and others, 2013).

This approach can be used to estimate the extent to which the characteristics and factors affect the price through running a regression of house prices on explanatory variables (the structural and the relevant socio-economic or environmental characteristics). However, a study of England by Gibbons and others (2014) found that semi-natural grassland land cover does not appear to have much of an effect on price (PDF, 944KB) , so this may not be the best method to use. Another limitation is that it is hard to differentiate between the recreational and health benefit from improved access to the natural resource, since the HPM puts a value on more than one service. It also generates a capital value that may not be readily integrated into the flow accounts and it is difficult to update any estimate on an annual basis.

Replacement cost (cost-based approach)

This method imputes the benefits from any costs avoided by the presence of an ecosystem service. The Principles of Natural Capital Accounting define replacement costs as “costs of man-made alternatives that would be incurred if the ecosystem asset was lost”. With regards to semi-natural grassland, this method could be used to estimate the cost incurred if this ecosystem stopped providing important services, such as flood and erosion protection, as well as soil fertility.

Damage cost (cost-based approach)

This method is a simple way to value changes in air pollution. The cost to society is estimates of a change in pollutant emissions. This can be used in this account for both pollution removal estimates and carbon sequestration estimates.