Definition of Favourable Conservation Status for lowland meadows

Defining Favourable Conservation Status Project

Natural England

January 2023

NATURAL ENGLAND

www.gov.uk/natural-england

Acknowledgements

This definition draws heavily on unpublished material for Natural England prepared by Danny Ardeshir and Steven Shepherd of ADAS completed in 2019.

We wish to thank the following for their help in the production of this definition:

- Richard Jefferson, previously Senior Grasslands Specialist in Natural England.
- The Floodplain Meadows Partnership in particular Emma Rothero and Professor David Gowing.
- Dominic Coath from the Environment Agency.
- Cath Shellswell from Plantlife.
- Dan Abrahams, Sean Cooch, Iain Diack, George Hinton, Fran Randerson and Katey Stephen from Natural England.
- Current and past members of Natural England's Technical Steering Group in particular Andy Brown.

Executive summary

This document sets out Natural England's view on favourable conservation status for lowland meadows in England.

Favourable conservation status is the situation when the habitat can be regarded as thriving in England and is expected to continue to thrive sustainably in the future. The definition is based on the available evidence on the ecology of lowland meadows. Favourable conservation status is defined in terms of three parameters: natural range and distribution; extent; structure and function attributes (habitat quality).

A summary definition of favourable conservation status in England follows. Section 1 of this document describes the habitat and its ecosystem context, Section 2 the units used to define favourable conservation status and Section 3 describes the evidence considered when defining favourable conservation status for each of the three parameters. Section 4 sets out the conclusions on favourable values for each of the three parameters.

This document does not include any action planning, or describe actions, to achieve or maintain favourable conservation status. These will be presented separately, for example within strategy documents.

The guidance document Defining Favourable Conservation Status in England describes the Natural England approach to defining favourable conservation status.

Summary definition of favourable conservation status

Lowland meadows are semi-natural, neutral grasslands defined by a characteristic species-rich flora, which exceptionally may exceed 40 species per 4 m^2 and may often include a few uncommon species.

These grasslands have experienced a dramatic decline in extent, particularly since around 1945, and today small fragments remain within landscapes now dominated by intensive agricultural activity. The intensification of agriculture during the second half of the 20th century is the main cause of loss through conversion of long-established, and in some cases ancient, grassland to arable, ploughing and reseeding with low diversity grass mixes, the addition of artificial fertilisers and high levels of organic manures, and the shift from hay making to multiple cropping for silage. Similar, but less destructive practices, are causing an ongoing loss of quality and species diversity of the remaining fragments.

Lowland meadows are found throughout England up to the fringes of the uplands at approximately 350 m. Significant aggregations are found in southern counties, but their distribution extends into northern and western areas, notably in Derbyshire and the Welsh borders. The average area of a lowland meadow is around 2.8 ha, with only approximately 50% protected by SSSI status. The great majority of sites outside SSSIs are in poor condition and Common Standards Monitoring (CSM) data from 2018 shows that under a half of lowland meadows within SSSIs are in favourable condition, however this

information is under review. The most significant reasons for unfavourable condition are a loss of characteristic species, dominance by species indicative of higher nutrient levels, reductions in vegetation management and an increase in species indicative of wetter conditions.

Favourable conservation status will be attained when:

- The range and distribution of the drier meadow types embraces all hectads (10 km squares) that constitute its known historical range – 1,381 hectads - and the current distribution of the wetter meadow types is maintained at 1,823 monads (1 km squares).

- The area of the wetter types is increased by 72,000 ha from 2,800 ha to 74,800 ha and the extent of the drier meadow types is increased by 147,000 ha from 5,600 ha to 152,600 ha.

- At least 95% of the habitat reaches the structure and function requirements and all species associated with the habitat are Least Concern.

Table 1 Confidence levels for the favourable values

Favourable conservation status parameter	Favourable value	Confidence in the favourable value
Range and distribution	The drier meadow types are present in 1,381 hectads. The wetter meadow types are present in 1,823 monads.	Moderate
Extent	The extent of the drier meadow types is increased by 147,000 ha to 152,600 ha. The extent of the wetter meadow types is increased by 72,000 ha to 74,800 ha.	Low
Structure and function	95% of the favourable area meets the structure and function requirements. All species associated with the habitat are Least Concern.	Moderate

As of July 2022, based on a comparison of the favourable values with the current values, lowland meadows are not in favourable conservation status. Note, this conclusion is based solely on the information within this document and not on a formal assessment of status nor on focussed and/or comprehensive monitoring of status.

Contents

About the Defining Favourable Conservation Status project

Natural England's Defining Favourable Conservation Status (DFCS) project is defining the minimum threshold at which habitats and species in England can be considered to be thriving. Our Favourable Conservation Status (FCS) definitions are based on ecological evidence and the expertise of specialists.

We are doing this so we can say what good looks like and to set our aspiration for species and habitats in England, which will inform decision making and actions to achieve and sustain thriving wildlife.

We are publishing FCS definitions so that you, our partners and decision-makers can do your bit for nature, better.

As we publish more of our work, the format of our definitions may evolve, however the content will remain largely the same.

This definition has been prepared using current data and evidence. It represents Natural England's view of favourable conservation status based on the best available information at the time of production.

1. Habitat definition and ecosystem context

1.1 Habitat definition

This definition embraces a range of semi-natural neutral grasslands, some of great antiquity, found across England. Lowland meadows are associated with low-input agriculture and tend to be managed as hay meadows or permanent pastures. A small, and typically fragmented, proportion of these grasslands are found outside of an agricultural context, such as on road verges, churchyards and railway embankments with some managed in ways which mimic an agricultural use.

Lowland meadows are typically species-rich, and in addition, may include specialist suites of threatened, range-restricted and uncommon species. The sward structure is generally uniform but can vary across areas, dependent on management regime, soil nutrient status and climatic conditions.

The habitat originally included the following National Vegetation Classification (NVC) grassland plant communities:

MG4 *Alopecurus pratensis – Sanguisorbia officinalis* grassland

MG5 *Cynosurus cristatus – Centaurea nigra* grassland

MG8 *Cynosurus cristatus – Caltha palustris* grassland.

However, a review of the wet neutral grasslands of the *Calthion* alliance by the Floodplain Meadows Partnership, which addressed widely acknowledged weaknesses in their treatment within the NVC, has proposed additional NVC communities. Three of these are also now encompassed by the UK lowland meadows definition. These are:

MG14 *Carex nigra – Agrostis stolonifera – Senecio aquaticus* grassland

MG15 *Alopecurus pratensis – Poa trivialis – Cardamine pratensis* grassland

MG16 (provisional) *Agrostis stolonifera – Eleocharis palustris* inundation grassland

In addition, MG8 has been revised and now comprises four sub-communities and a revised name: *Cynosurus cristatus-Carex panicea-Caltha palustris* grassland (Wallace & Prosser 2017)

Furthermore, following a revision of SSSI guidelines, species-rich forms of MG1 are now also included in the UK definition of lowland meadows. These are:

MG1c *Arrhenatherum elatius* grassland *Filipendula ulmaria* sub-community

MG1d *Arrhenatherum elatius* grassland *Pastinaca sativa* sub-community

MG1e *Arrhenatherum elatius* grassland *Centaurea nigra* sub-community

Plant species associated with lowland meadows vary with grassland NVC type. However, grasses such as red fescue *Festuca rubra*, crested dog's-tail *Cynosurus cristatus*, sweet vernal-grass *Anthoxanthum odoratum* and meadow foxtail *Alopecurus pratensis* are typical, along with forbs such as: common knapweed *Centaurea nigra*, bird's-foot trefoil *Lotus corniculatus*, autumn hawkbit *Scorzoneroides autumnalis,* meadow buttercup *Ranunculus acris* and meadow vetchling *Lathyrus pratensis* with meadowsweet *Filipendula ulmaria,* great burnet *Sanguisorba officinalis* and marsh marigold *Caltha palustris* in damper stands.

Herbaceous plants frequently comprise a considerable proportion of the sward. Plant species-richness is characteristically varied and across all lowland meadow types typically ranges from 12 species to 41 species per 4 m^2, with a mean number of species per quadrat of 26 per 4 m^2 (Rodwell 1992). Data from a sample of one square metre quadrats provided by the Floodplain Meadows Partnership for MG4 and MG8 gave mean values of 20 species per square metre (range 6-44) and 22 species per square metre (8-41) respectively. However, there was variation between the different sub-communities with MG4a *Dactylis glomerata* sub-community and MG8a *Sanguisorba officinalis* sub-community being the most species rich. Because of the smaller quadrat size these values are likely to be lower than would be achieved in a 4 m^2 plot as used in the NVC.

1.2 Habitat status

The high conservation value of lowland meadows is reflected in its designation as a Habitat of Principal Importance under Section 41 of the Natural Environment and Rural Communities (NERC) Act 2006.

Of the lowland meadow types covered by the NERC Act 2006, MG4 falls within the European Annex 1 habitat type Lowland hay meadows (*Alopecurus pratensis, Sanguisorba officinalis).*

At a European scale, 53 discrete forms of grassland are described following the EUNIS (the European Nature Information System) definitions. Lowland meadows encompass four habitats as defined by EUNIS. Table 1 details the relationship between lowland meadows and the equivalent European Red List habitats and their status.

Table 2 Relationship between lowland meadows and the equivalent European Red List habitats and their status

EUNIS European Habitat	Status	Red List Criterion
E3.4a Moist or wet mesotrophic to eutrophic hay meadow	Endangered	A1 Present decline (over the last 50 years)
E3.4b Moist or wet eutrophic and mesotrophic grassland	Endangered	A1 Present decline (over the last 50 years)
E2.1a Mesic permanent pasture of lowlands and mountains	Vulnerable	A1 Present decline (over the last 50 years)
E2.2 Low and medium altitude hay meadow	Vulnerable	A1 Present decline (over the last 50 years), A3 Historic decline, C/D1 Reduction in quality over the last 50 years

Sources: Janssen and others 2016; Jackson & McLeod (Eds.) 2000; Jefferson 2013; Jefferson, Smith & Mackintosh 2014; Rodwell and others 2007; UK BAP 2008.

1.3 Ecosystem context

Lowland meadows are associated with free-draining to moist and infertile to moderately fertile brown soils that have developed over superficial deposits; usually within a pH range of 5.0 to 6.5. The occurrence of lowland meadows is a function of geology, soils, hydrology, climate and management practice.

The drier forms (MG5 and MG1) can be found on level ground or shallow slopes that comprise relatively deep circumneutral soils that are managed for hay cropping and/or grazing throughout the lowland landscape up to the limits of agricultural enclosure (approximately 350 m above sea level).

The communities of damper conditions (MG4, MG8, MG14-16) occur on a range of soils, from freely drained alluvial soils, through gleyed clays to humic gleys and can notionally occur throughout the lowlands. However, they are largely confined to alluvial soils in river valleys in the lowlands with periodic winter flooding or seasonally high water tables and areas of seepage or flushing. Some sites are underlain by river-terrace deposits of coarse sand or gravel which may supply water during summer by sub-irrigation and facilitate sub-surface drainage in winter. In the north and west where rainfall is high, and

evapotranspiration is low, suitable conditions occur for these wetter communities outside of floodplains and may occur around groundwater-fed springs and seepages within drier grasslands. As a consequence, these communities have an edaphically and hydrologically restricted potential distribution. Some examples of these communities may be maintained by artificial surface drainage that removes water from sites and ensures the meadow communities (principally MG4 but also MG8) are not replaced by inundation grassland or swamp or fen communities (Crofts & Jefferson 1999; Rothero, Lake & Gowing 2016).

The different forms of lowland meadows can form mosaics and transitions along various environmental gradients including with other semi-natural grassland communities. However, mosaics or transitions are not as common as with some other, more widespread, habitat types and a relatively high proportion of lowland meadows occur as small remnants in otherwise intensively managed landscapes.

On alluvial floodplains, where soil moisture varies across the landscape, wetter MG5 grassland may be transitional to MG4 and MG8. Furthermore, Wallace & Prosser (in Jefferson, Smith & Mackintosh 2014), highlight that MG7c may form a central component of the spatial and temporal sequence of floodplain meadow vegetation with communities such as MG4 and MG8. With increasing inundation, and in situations that favour seasonal pasture management, other grassland communities such as MG11 *Festuca rubra-Agrostis stolonifera-Potentilla anserina* and MG13 *Agrostis stolonifera-Alopecurus geniculatus* may be encountered. Relationships within the *Calthion* group of communities have been extensively studied. However, Wallace & Prosser (2017) have shown that, following more prolonged periods of seasonal inundation, MG13 may be replaced by MG16, both communities of more fertile soils. MG14 tends to occur towards the wetter end of the hydrological range along with the sub-communities of MG8, and transitions to MG14 from MG8b, via the sedge-dominated MG8c, have been recorded. However, MG14 is generally on more fertile soils than sub-types of MG8. MG15 tends to occur on soils of similar fertility to those of MG14 but which are less frequently inundated.

In situations where soil moisture content is high, and especially on peaty gleys and shallow peats, there are transitions to M23 *Juncus effusus/acutiflorus-Galium palustre* rush-pasture and, particularly in the warmer parts of England, transitions to M24 *Molinia caerulea-Cirsium dissectum* fen-meadow.

In locations where shallow calcareous soils are found overlying limestone rocks, lowland meadows, in particular MG5b *Cynosurus cristatus – Centaurea nigra* grassland *Galium verum* sub-community, may be found with calcareous grassland. Conversely, on acid soils, that are typically found overlying sands and gravels, hard volcanic rocks or sandstones, acid grassland, especially U4 *Festuca ovina-Agrostis capillaris-Galium saxatile* grassland, may form a coexisting habitat. It is also possible that forms of MG5 grassland, in particular MG5c, may originate from acid grassland that has been subject to agricultural improvement in the form of inputs of lime and/or nutrients. High rainfall can cause the acidification of neutral grasslands, especially where they occur over thin/skeletal, readily leached soils, and such conditions lead to the development of or reversion to acid grassland and heath.

Most lowland meadows are thought to be anthropogenic, a result of post-Neolithic farming activity. Therefore, a change in management, including the maintenance of drainage structures within the damper forms of lowland meadows, can lead to succession to different communities. This may result in the development of more complex habitat mosaics (depending on the original habitat type and other factors such as soil type, climate and hydrology), comprising, for example, other semi-natural grassland or scrub communities. For example, a reduction in grazing or cutting may result in succession to MG1 *Arrhenatherum elatius* grassland, or W24 *Rubus fruticosus-Holcus lanatus* and W25 *Pteridum aquilinum-Rubus fruticosus* underscrub communities or to a scrub or woodland community. Where lowland meadows occur over damper soils (especially over gleyed soils), neglect of drainage may again result in the proliferation of coarser grasses and/or *Juncus* species with the consequent succession to MG9 *Holcus lanatus – Deschampsia cespitosa* grassland, MG10 *Holcus lanatus – Juncus effusus* rush pasture, M23 *Juncus effusus/acutiflorus-Galium palustre* rush pasture and swamp communities. Conversely, sustained heavy grazing can also lead to a shift towards MG6 *Lolium perenne - Cynosurus cristatus* grassland.

Lowland meadows may occur within woodland glades or parkland landscapes with scattered trees and form transitions with scrub and woodland communities such as W8 *Fraxinus excelsior – Sorbus aucuparia – Mercurialis perennis* woodland and W21 *Crataegus monogyna – Hedera helix* scrub. The drier meadow type (MG5) will often be bordered by hedgerows with hedgerow trees.

European context

In a European context, lowland meadows are grouped within three or four alliances of the *Molinio-Arrhenatheretea* community which occurs across the temperate lowlands of north-west Europe, though the relationship between the UK definition of lowland meadows and European grassland habitats remains complex. Much of the European resource has been lost, with a 30% to 50% reduction in the total lowland meadow grassland resource within Europe over the last 50 years, and a 50% to 70% reduction since 1750.

Information on the proportion of the European resource in the UK or its constituent countries is limited. Natura 2000 Habitat 6510 Lowland Hay Meadows (*Alopecurus pratensis, Sanguisorba officinalis*) that equate to MG4 (Rodwell and others 2007) is found throughout Europe from Spain, Portugal and Italy in the south to the UK, Ireland, and Scandinavia in the north. The number of Special Areas of Conservation (SAC) designated for this habitat in the other European countries suggests that the significance of the UK resource is small. However, the UK has a relatively narrow interpretation of the definition of this habitat, and it is likely that the significance of the resource is understated.

Other sources: Balmer and others 2013; Buglife 2018; Crofts & Jefferson 1999; Duffey and others 1974; Jefferson 2013; Natural England 2013; Rodwell and others 2007; Rodwell 1992; Rothero, Lake & Gowing 2016; Stroh and others 2014.

2. Units and attributes

2.1 Natural range and distribution

10 km square and 1 km square. The units proposed are the 10 km square (hectad) for drier MG5 lowland meadows and 1 km square (monad) for the wetter meadows, reflecting the small size and fragmented distribution of British examples, the former of which are widespread but the latter of which are largely confined to floodplains.

2.2 Extent

Hectare

Given the fragmented nature of lowland meadows and the generally small extant patch size, hectare is the appropriate unit for measuring the area of the habitat.

2.3 Structure and function attributes

Structure attributes

- Species composition - the presence of characteristic plant species.
- Minimum herb content - the proportion of herbs (including the smaller sedges *Carex* spp.) within the vegetation community.
- Cover of non-woody negative indicators or undesirable species, including those indicating nutrient enrichment and excessive waterlogging such as large sedges and rushes, and invasive non-native species.
- Cover and frequency of tree and shrub species.
- Sward height, litter accumulation and bare ground. Open conditions, bare ground and short swards are required for certain taxa especially invertebrates and lower plants. The presence of some bare ground is necessary for regeneration niches. A range of sward heights is important for some taxa.
- The presence of vegetation community transitions such as to other grassland and mire types and woodland

Function attributes

- The key functional requirement for the maintenance of the habitat is the continuation of low intensity management.

- Soil characteristics. Lowland meadows are characteristic of low productivity soils, any changes can have negative impacts on associated species.

- Hydrological function, water chemistry and water nutrient status to support the wetter meadow types (Gowing and others 2002; Rothero, Lake & Gowing 2016).

- Functional connectivity with the wider landscape may be necessary although there is little evidence. For hay meadow communities nectar feeders will need alternative food sources when the hay is cut although re-flowering of certain species in the aftermath can extend the provision of nectar and pollen late into the season.

Sources: Crofts & Jefferson 1999*;* Duffey and others 1974; Gibson 1997; Jefferson & Porter 2014; Natural England 2013; Robertson & Jefferson 2000; Rodwell 1992.

3. Evidence

3.1 Current situation

Natural range and distribution

The most comprehensive information on distribution is provided by JNCC and is shown in Figure 1. This draws on Rodwell and others (2007). In the UK there are 1,412 hectads with lowland meadows, with 965 of these in England, approximately two thirds of all hectads in England. Figure 1 shows that lowland meadows are distributed throughout England.

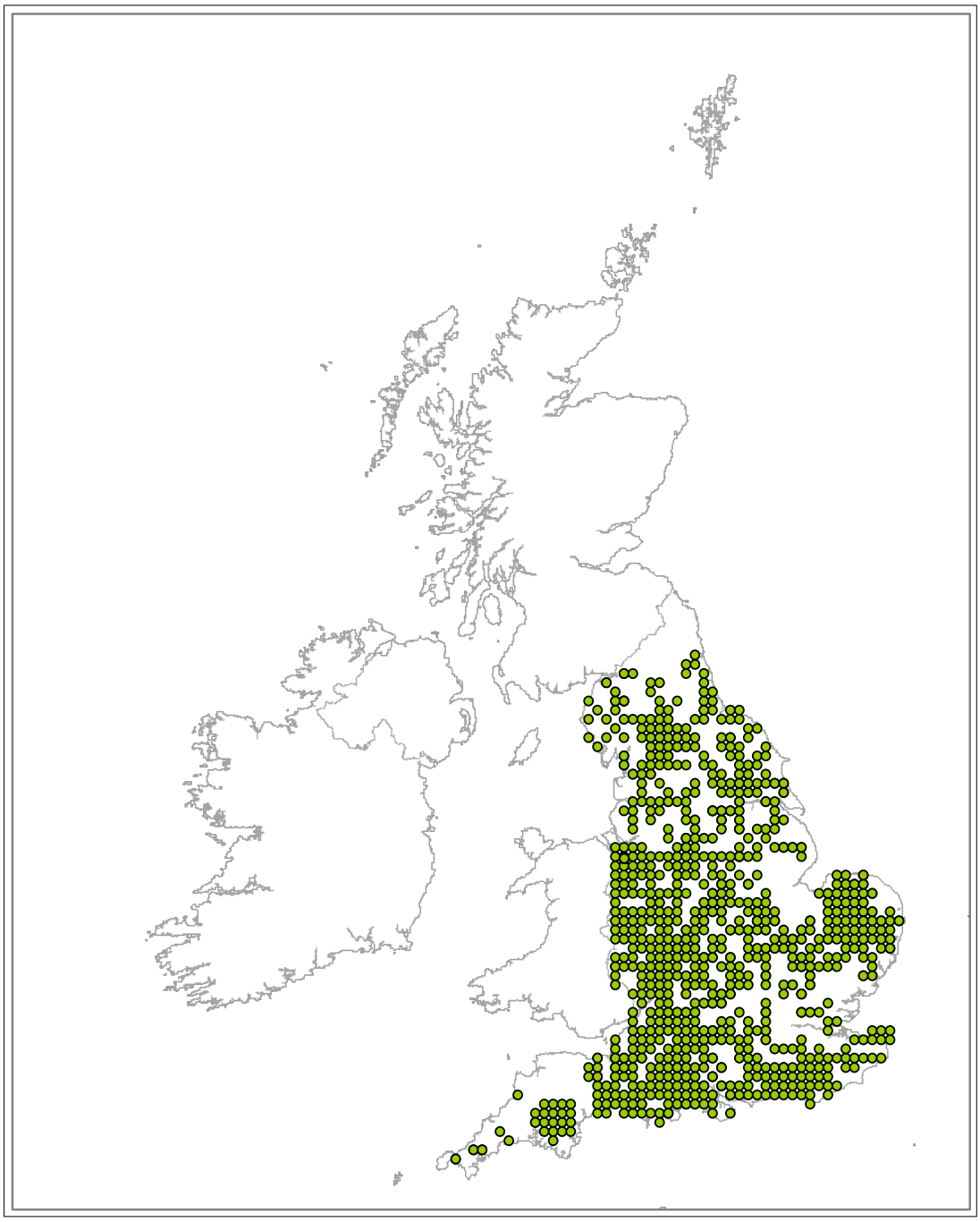

Figure 1 Lowland meadows England distribution. Data filtered for MG1c, MG1e, MG4, MG5 & MG8. Map excludes MG1d, MG14, MG15 & MG16. See Rodwell 1992 & Wallace & Prosser 2017 for distribution of these types. © Natural England 2023. © Joint Nature Conservation Committee, 2008. Basemap used is OS Coast and Country. Contains Ordnance Survey data © Crown Copyright and database right 2019. By using this data you are accepting the terms of the Open Government Licence (Open Government Licence (nationalarchives.gov.uk)). For further info contact Natural England 0300 060 3900 enquiries@naturalengland.org.uk

The drier community, MG5, is the most widespread, present in 713 hectads, with important concentrations in Worcestershire, Somerset, Dorset, Wiltshire, Derbyshire and East Sussex.

The damper lowland meadows are much more localised. An analysis by Natural England of areas identified as lowland meadows in the Priority Habitat Inventory (PHI) found within Flood Zone 3 (land assessed by the Environment Agency as having a 1 in 100 or greater annual probability of river flooding (greater than 1%)) showed that lowland meadows were present in 1,823 monads. Figure 2 shows the percentage of lowland meadow in Flood Zone 3 within one kilometre squares. Squares with a high proportion of the damper lowland meadows are shown in green. MG4 is found in scattered sites from the Thames Valley through the Midlands and Welsh borders to the Ouse catchment in Yorkshire with some outliers further north. Examples include well-known but now very rare Lammas meadows, such as North Meadow, Cricklade, and Pixey and Yarnton Meads near Oxford. MG8 is particularly scarce with extant examples centred in the English counties of Wiltshire, Somerset, Dorset and Hampshire plus a significant concentration in the Lower Derwent valley in North and East Yorkshire.

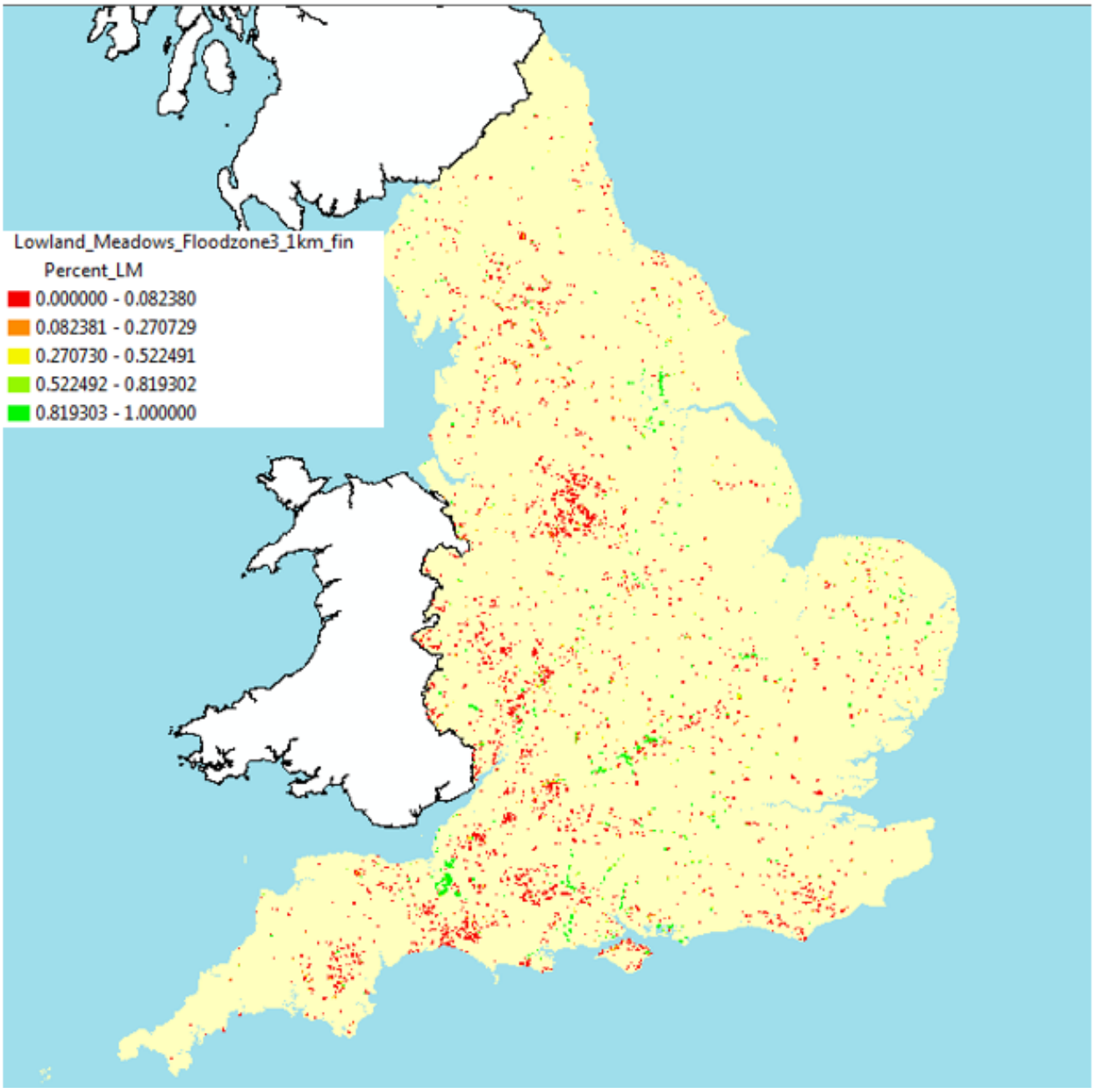

Figure 2 Lowland Meadows Priority Habitat: Percentage within Flood Zone 3

Extent

Various estimates are given for the current resource of lowland meadows, mostly dating from 10-20 years ago. Natural England consider the figure provided by Robertson & Jefferson (2000) of 8,400 ha for the combined resource of MG4, MG5 and MG8 in England to be the most accurate. The JNCC 2014 Lowland Grassland SSSI guidelines use this 8,400 ha figure. Note: This habitat area estimate may differ from the national Priority Habitat area. The process of mapping inventories in England rounds areas up to parcel level, is based on old survey data so does not necessarily reflect recent changes and takes a broader definition of 'grassland' – including partially degraded and less species-rich grassland. Overall, this leads to an overestimate of Priority Habitat cover in England. While extent figures may differ, the England national inventory maps are a good indication of the location of known high quality grassland sites.

An analysis by Natural England shows that the wetter types (MG4, MG8, MG14-MG16) comprise around 33% of the total lowland meadows resource (approximately 2,800 ha). These types are largely restricted to river and stream floodplains and areas of seepage or flushing often on the floodplain margin. Figure 2 shows the percentage of the Lowland Meadows Priority Habitat in Flood Zone 3 much of which will conform to the wetter types. A small sample of sites identified within the Flood Zone in this analysis were checked against vegetation community data and found to comprise MG4 and MG8 grassland.

A high proportion of the wetter meadow types are within SSSIs (Holmes and others 2005). For example, by 2011, about 69% of the resource of MG4 and 84% of MG8 was within SSSIs. There are currently nine SSSIs that support both communities, while 104 just have MG8 and 84 just have MG4. The revised Lowland Grassland SSSI guidelines (Jefferson, Smith & Mackintosh 2014) lists both communities as nationally rare grassland types of high botanical value; sites supporting 0.5 ha or more would qualify as SSSIs. Some 1,420 ha of floodplain meadow also fall within five SACs (Rothero, Lake & Gowing 2016).

Patch size

Data on BAP priority habitats from 2009 (published in Bullock and others 2011) shows that the great majority of sites were then less than 5 ha in extent. Table 3 is based on sites with more certainty about the size of constituent habitats.

Table 3 Percentage of priority lowland meadow (all component NVC types) sites by size class

Size class	0 to 5 ha	5 to 9.99 ha	10 to 19.99 ha	20 ha or more
Lowland meadows	84	9	4	3

Table 4 shows data on size classes of sites supporting the wetter meadow types, MG4 and MG8. Note that this data represents the size of the sites that support these

communities not necessarily the size of the habitat patches. This shows that for MG4, in particular, the size distribution is slightly different and reflects the large size of some of the ancient MG4 meadows. For MG4, the size distribution picture is broadly similar to that reported by Jefferson (1997) although he used fewer size classes.

Table 4 Percentage of the sites for the wetter meadow types (MG4, MG8) by size class. Source: Floodplain Meadows Partnership

Size class	0 to 5 ha	5 to 9.99 ha	10 to 19.99 ha	20 ha or more
MG4	59	19	10	12
MG8	70	12	14	4

Quality of habitat patches

Natural England data from 2018 for lowland meadows within SSSIs indicates that 46% are in favourable condition, 54% are unfavourable of which 49% was unfavourable recovering and 5% unfavourable no change.

The main causes of unfavourable condition were the loss of key species and species-richness in general caused by nutrient enrichment, in particular the use of artificial fertilisers, under-grazing (lack of aftermath grazing), inappropriate use of herbicides and inappropriate water level management. Of these, nutrient enrichment through fertilisers and agricultural improvement is by far the most significant but under-grazing is probably the most important contemporary management issue.

For sites outside SSSIs, the situation is far worse. Of a sample of lowland meadows investigated, Hewins and others (2005) found that only 22% were in favourable condition. Stands failed most frequently because they lacked positive indicator species in sufficient number and at frequency levels that are characteristic of good quality semi-natural grasslands. Similarly, many stands failed because the proportion of herbaceous plant species in the swards was too low. A re-survey of the sample sites showed a marginal improvement of stands which were in favourable condition, increasing from 22% in 2002/3 to 28% in 2017 (Wheeler & Wilson 2018).

Other management issues that may contribute to unfavourable condition for both statutory and non-statutory sites include abandonment of management coupled with a loss or dilapidation of necessary infrastructure such as fencing or hedgerows and lack of water supply, which can impair management. Also, persistent late cutting or missed cuts can lead to gradual decline in condition and quality.

Threatened species

Vascular plants

In general, lowland meadows are characterised by relatively widespread rather than range-restricted and/or rare plant species. However, they typically occur in a species-rich assemblage with a high proportion of herbaceous species. Notwithstanding this, a few England Red List species such as green-winged orchid *Anacamptis morio* (Vunerable), creeping marshwort *Helosciadium repens* (Endangered), quaking grass *Briza media (*Near Threatened*),* tuberous thistle *Cirsium tuberosum* (Near Threatened), dyer's greenweed *Genista tinctoria* (Vulnerable), round-fruited rush *Juncus compressus* (Vulnerable), tubular water dropwort *Oenanthe fistulosa* (Vulnerable), sulphur clover *Trifolium ochroleucon* (Vulnerable) and wood bitter vetch *Vicia orobus* (Vulnerable) are found within lowland meadows. The following species are Near Threatened within the GB Red List but Least Concern within the England Red List: autumn crocus *Colchicum autumnale,* narrow-leaved water-dropwort *Oenanthe silaifolia* and greater butterfly-orchid *Platanthera chlorantha.*

Fungi

Along with other drier semi-natural grasslands, MG5 lowland meadows, in particular, can provide a habitat for communities of macro-fungi, including waxcaps and pinkgills and, indeed some may independently qualify as SSSI for their fungal interest (Griffith, Bratton & Easton 2004; Sanderson and others 2018).

Fauna

Lowland wet grasslands (which include damper forms of lowland meadows) are a particularly important habitat for breeding and wintering waders and wildfowl. These include the Endangered curlew *Numenius arquata* and lapwing *Vanellus vanellus,* Vulnerable redshank and snipe *Gallinago gallinago* (Stanbury and others 2021). A small number of passerines are also closely associated with lowland wet grasslands including the Near Threatened yellow wagtail *Motacilla flava*. Upland meadows provide important feeding grounds for twite (Least Concern in GB, but close to regional extinction in England) and for the Vulnerable black grouse.

Invertebrates

Although invertebrate assemblages associated with lowland meadows have not been intensively studied, they are noted for their wide variety of notable invertebrates. Wet forms of lowland meadows, and associated ditches, are likely to support significant assemblages of invertebrates and are known to support several species of notable hoverflies, soldierflies and their relatives.

Priority species

In an analysis of the requirements of priority species within all lowland grasslands, Webb, Drewitt & Measures (2010) concluded that grassland structural diversity was critical, including at the larger scale in adjacent areas such as hedgerows as well as at the smaller scale within the sward, together with an abundance of flowers to provide nectar, pollen,

food plants and shelter. However, they noted that hay meadows were poorly represented by this analysis, so these conclusions should be treated with caution with respect to lowland meadows.

Sources: Floodplain Meadows Partnership website*;* Griffiths, Bratton & Easton 2004*;* Hewins and others 2005; UKBAP 2008; Jefferson 1997; Jefferson & Pinches 2009; Natural England 2016; JNCC NVC Mapping tool**,** Stroh and others 2019; Townshend 2004; Wheeler & Wilson 2018.

Confidence: Moderate - High

3.2 Historical variation in the above parameters

Most lowland meadows are thought to be anthropogenic, a result of post-Neolithic farming activity. However, it is possible that meadow-like vegetation communities, analogous to modern-day examples of MG5 and MG8, may have existed prior to the Neolithic period (Ingrouille 1995; Peterken 2009). Vegetation akin to MG4 is less likely to have occurred prior to the advent of settled agriculture due to its dependence on interventions such as low-level drainage and hay cropping. Greig (1984) presents evidence that suggests this meadow type has existed since at least the Iron Age. On the other hand, Lambrick & Robinson (1988) suggest that the community has probably been a feature of the Thames floodplain for less than 2,000 years.

There is no doubt that many lowland meadows are the product of historic interventions such as drainage, liming and manuring with subsequent management by grazing and/or cutting. Both dry and damper types may, at least in some situations, have been derived from different vegetation (acid and calcareous grassland and fens or mires) by these historic interventions.

Oliver Rackham estimated from Domesday book entries, that 80% of settlements in England managed hay meadows, and that there were then around 121,000 ha of lowland meadows in England.

Since then, semi-natural grassland has greatly declined in area, almost entirely due to changing agricultural practice. It is estimated that by 1984 in lowland England and Wales, semi-natural grassland had declined by 97% over the previous 50 years to approximately 0.2 million ha (Fuller 1987). Losses continued throughout the 1980s and 1990s, with regional English studies indicating declines in specific lowland grassland types ranging from 24% to 62% over various timescales within this period. A more recent GIS analysis comparing historical and current databases found a 47% loss of semi-natural grasslands over a 32 to 53 year period ending in 2013 (Ridding and others 2017).

More recently however, this decline appears to have slowed. The Countryside Survey 2007 showed that there was generally no change in area of acid, neutral and calcareous grasslands in each of the UK countries between 1998 and 2007.

Most of the loss of lowland meadows was due to conversion to intensively managed grassland, through ploughing and re-seeding and/or the addition of fertilisers and the use of herbicides, and conversion to arable cultivation. There has also been a switch to silage rather than hay production. Silage, unlike hay production, may take place on multiple occasions during the year. It has the disadvantage that it removes pollen and seed sources for invertebrates and birds, removes for much of the year the structural elements of meadows required by, for example, ground nesting birds or the completion of insect life cycles and much viable seed is destroyed or contained and unable to spread through the process of silage making. This reduces the long-term viability of meadows within the locality and wider landscape.

Patch size

According to Rackham (referenced in Peterken (2013)), in the 11th century, meadows were generally less than 12 ha in extent, they were scattered in location and found in over 10,000 individual patches. Data from the UK BAP priority lowland grassland types from the Natural England inventory indicate that approximately 80% of sites are now less than 5 ha in extent (Bullock and others 2011).

Quality of habitat patches

Clearly the extent and patch size of the remaining resource of lowland meadows is much reduced when compared to historical levels. The diversity of swards has also declined, driven mainly by changed farming practices, leading to increased nutrient loads, fewer seed sources and poor sward structure. External factors such as atmospheric nitrogen deposition are also exacerbating these nutrient loads.

There has been a significant decrease in plant species richness and butterfly and farmland bird food resources in botanically-rich neutral grasslands. Bullock and others (2011) also found a significant increase in more competitive, nutrient-demanding plant species between 1998 and 2007.

Sources: Historic England 2013; Jefferson and others 2014; Mountford and others 1993; Rackham 1993; UK Biodiversity Group 1998.

Confidence: Moderate

3.3 Future maintenance of biological diversity and variation in the habitat

Pressures and threats

In the last twenty years the loss of neutral grassland appears to have slowed, but there is a continuing decline in the condition of high-quality examples, with ongoing loss of rarer species and a general reduction in species richness.

Atmospheric nitrogen deposition will be having a detrimental impact on plant species richness, especially where this occurs in conjunction with higher farmyard manure applications. The critical load for nitrogen (from all sources) is estimated to be 10-20 kg N per hectare per year.

Although there is little research on nutrient budgets for drier meadows, there has been some work undertaken on nutrient budgets for floodplain meadows and the primary driver for species change is phosphorus rather than nitrogen. Inundation with heavily-enriched river water is a significant cause of loss of plant species richness (Rothero, Lake & Gowing 2016; Gilbert and others 2009).

Natural England & RSPB (2019) assess the sensitivity of wet lowland meadows to climate change as Medium and the sensitivity of dry lowland meadows as Low. Climate change is predicted to bring increased storminess and more frequent extreme weather events, including extreme or prolonged droughts, increased annual average temperatures with hotter and drier summers, increased winter rainfall and an increased number of floods. Climate change projections suggest that particularly the south and east of England may receive less rainfall and be warmer, leading to increased evapotranspiration. For wet grasslands including lowland meadow types MG4, MG8, MG14, MG15 & MG16 this could negatively affect the communities and dependent species. However, studies on North Meadow Cricklade and the Somerset Levels (Flood Plain Meadows Partnership website) have demonstrated that the threat to wetter meadow types is from wetter and more extended flooding events, especially in spring. These events have a greater impact than droughts, with the loss of diversity always being linked to extended flood events, summer or spring time and raised water levels, and not to drought. The reduction in the species diversity at the study sites showed there is a lag time of 7-10 years before recovery of species diversity is seen. If there is increased frequency of floods, then recovery may not be possible.

Natural function

Lowland meadows are arguably some of the most anthropogenic of the English semi-natural grasslands, given their likely origins and maintenance by low-input traditional agricultural management. Their biodiversity value in part reflects a suite of species drawn from both grasslands and natural wetlands which would be changed by cessation of certain interventions. However, they are still dependent on well-structured, relatively infertile soils which retain fungi-dominated soil microbial communities, and for the wetter

types, water chemistry and nutrient status that reflects natural background levels. They are also dependent on continuation of some form of vegetation management by grazing and/or cutting.

Many wetter meadows occur on the floodplains of highly modified (straightened, re-profiled and embanked) rivers or streams. There is rightly a desire to restore more naturally functioning floodplains supporting mosaics of wetland habitats. Because of their dependence on non-natural interventions, initiatives designed to restore natural function to some rivers and floodplains could threaten the loss of, or damage to, floodplain meadows. However, it is possible that vegetation akin to the wetter grasslands can still find a niche even on naturally functioning river floodplains that support wetland habitat mosaics, such as on more freely draining floodplain slopes and margins. That said, it is not known how much wet meadow habitat would be present and what its spatial configuration would look like within naturally functioning floodplains. However, it suggests that at least a proportion of the ambition for favourable status can be delivered in the context of restored natural-functioning floodplains. Therefore, potential impacts on floodplain meadows should not debar such initiatives, but careful consideration will need to be given as to how to conserve floodplain meadow habitat within a more dynamic river-floodplain habitat mosaic. An approach will be needed that accepts some habitat loss and creation as the river moves across the floodplain. Likewise, inclusion of floodplain meadows within a more 'naturally managed' approach to floodplains requires the need to respect the cultural and biodiversity values of existing sites, and the contribution they make to a more sustainable agriculture and the provision of ecosystem services.

Natural range and distribution

Lowland meadows would have originally occurred throughout lowland England on suitable circumneutral soils, although within this broad distribution and range, the wetter types (MG4, MG8, MG14-MG16) have a more restricted local distribution due to their requirements for specific hydrological conditions. For favourable status the aim should be to reinstate lowland meadows to their historical natural range throughout lowland England to benefit biodiversity and ecosystem services and enhance landscape quality.

Natural England analysed Soilscapes data which indicated that approximately 93% of hectads within England – 1,381 hectads - have soils suitable for lowland meadows. This excludes 57 hectads where the predominant meadow habitat is upland hay meadows.

Extent

To counteract the large-scale losses of this habitat over the last 60 years, the extent of lowland meadows will need to be expanded to achieve favourable status.

There is little information on which to assess the habitat area and site size required for the future sustainability of lowland meadows. Blackstock and others (1999), stated that it will be necessary to expand lowland grassland habitats to counteract the negative impacts of fragmentation and isolation of various community types, such as the *Centaureo-Cynosuretum* (MG5), which is widely but thinly distributed.

There are two possible approaches to deriving a figure for the habitat area required for the future maintenance of biological diversity or Favourable Conservation Status for lowland meadow types.

1) Use the guidance within Defining Favourable Conservation Status in England (Mousley & van Vliet 2021). This method uses a “rule-of-thumb” to derive a figure for restoring a proportion of the historical loss of the habitat. When applied to the restoration of lowland meadows, this indicates an ambition to restore 75% of the historical loss (based on the current status of the habitat as Vulnerable, a moderate number of associated threatened species/structure and function attributes somewhat degraded and the potential for restoration being ‘good’). Assuming a loss of 97% of the habitat (and therefore the current extent is 3% of the historical extent) applying this method would require an increase in area of approximately 204,000 ha.

2) Use data produced by Natural England’s National Habitat Network Mapping Project. This is based on the figure required to create a connected network of habitat incorporating existing habitat patches. This would indicate an increase of approximately 219,000 ha.

It is recommended that an increase of 219,000 ha is adopted. It is considered that this increase in extent is justifiable given our knowledge of historical losses of meadows and the likely negative impacts of decreased patch size and connectivity. The percentage split between the extent of drier types and the wetter types is 67% to 33%. Thus, an increase of approximately 147,000 ha and 72,000 ha of the drier and wetter types respectively is proposed.

There are some risks to adopting a high level of ambition for the wetter meadows including a risk of prioritising wet meadow restoration or creation in areas where the focus should be on the restoration of more naturally functioning habitat mosaics. The ambition of 72,000 ha represents around 10% of English floodplain area and it is important that this ambition does not constrain the move towards more naturally functioning floodplains. It is thus proposed that the ambition of 72,000 ha should be kept under regular review.

Patch size

Little is known on what constitutes a viable patch size for lowland meadows but, provided management is appropriate, patches of 0.5 ha or smaller may be viable for maintenance and provide a valuable contribution to biodiversity and ecosystem services, especially when present within a wider natural or semi-natural landscape. The minimum size for qualification for SSSI selection is 0.5 ha (with some caveats (Jefferson and others 2014)). Certain fauna species though may require larger patch sizes.

Extent is best measured as the entire resource, and it is appropriate that individual sites should not fail because they are too small. Some of the ‘flush’ forms of MG8, for example, are inherently small in extent, but rely on sympathetic management of the surrounding field or catchment for their survival. These and other small patches elsewhere are also at

increasing risk from inappropriate tree planting activities being small ‘less productive’ areas within a wider matrix ultimately leading to degradation and loss.

However, while all sites will contribute to the overall resource, bigger sites are, for a variety of reasons including practicalities of management, habitat buffering and resilience to stochastic extinctions, generally better.

Quality of habitat patches

Attributes relating to habitat extent and species composition should be considered as primary, with those relating to structure and management secondary. Species richness and characteristic species are key attributes of habitat quality, though lower levels of such may be acceptable where a site supports rare or notable species.

Sources: Blackstock and others 1999; Flood Plain Meadows Partnership website; Greig 1984; Ingrouille 1995; Jefferson and others 2014; Lambrick & Roblnson1988; Mainstone and others 2018; Natural England 2014; Natural England 2016; Peterken 2009; Rothero, Lake & Gowing 2016.

Confidence: Moderate

3.4 Constraints to expansion or restoration

Evidence from a wide variety of practical experiments and research have shown that it is possible to successfully re-establish at least MG4 & MG5 lowland meadows from arable or semi-improved grassland within timescales of around 20 years (see Pywell and others 2013; Wilson and others 2013). However, the timescales for such grasslands to resemble ‘ancient’ examples, at least in terms of their floristic composition, may take up to at least a century (Gibson 1998).

The habitat can be restored where suitable soil and hydrological conditions are available, where the land is put under appropriate management and where characteristic species are re-introduced via seed or green hay (Natural England 2010b,g). Natural colonisation is very rarely likely to be a suitable approach for this habitat due to the lack of sites with suitable low-fertility substrates adjacent to existing sites and the usually slow dispersal and colonisation by the suite of characteristic species although the latter can sometimes be facilitated by allowing the movement of livestock between an existing site and the restoration area.

Unlike drier grassland types, restoration of MG8 from semi-improved (damp) grassland (and possibly arable) is technically challenging due to the need to establish suitable soil and hydrological conditions and processes. It is probably feasible on sites with high potential in terms of possessing suitable topography, soils, hydrological regime, soil/water chemistry and nutrient status and proximity to existing areas of the habitat. There are no examples of restoration of the habitat/community on semi-improved habitat although there may be a few examples where restoration is in progress. It is likely to take decades to get to a point where restoration is complete.

Successful restoration of this wetter meadow type requires a comprehensive assessment of the hydrological functioning of the site. This type of habitat is sensitive to variations in the level of soil moisture; therefore, it is essential to pay particular attention to the conservation of these conditions and respect the ecological factors that cause them: rivers, streams, valleys, springs and other (Gowing and others 2002; Rothero, Lake & Gowing 2016).

Sources: Floodplain Meadows Partnership website ***;*** Gibson 1998; Gowing and others 2002; Hewins 2012; McCrea, Trueman & Fullen 2001; Natural England 2002; Natural England 2008; Natural England 2009; Natural England 2010 a-i; Natural England 2016; Plantlife, Wildlife Trusts & Rare Breeds Survival Trust 2016; Pywell 2006; Pywell and others 2012; Rothero, Lake & Gowing 2016; Rothero & Tatarenko 2018; Townshend, Stace & Radley 2004; Walker and others 2001; Wilson and others 2013.

Confidence: Moderate – High

4. Conclusions

4.1 Favourable range and distribution

The distribution of lowland meadows (MG5) will extend to most areas of England below approximately 350 m altitude – equating to1,381 hectads.

The damper lowland meadow communities (MG4, MG8 and MG14-16) will continue to be found in most areas of England where there are suitable soil and hydrological conditions, currently some 1,823 monads.

4.2 Favourable extent

An area of 74,800 ha is proposed as the extent of the wetter meadow types in favourable status, this represents an increase of 72,000 ha on the current area.

For the drier meadow types an increase of 147,000 ha is proposed to give an area of 152,600 ha when in favourable status.

As such, monitoring of the presence and condition of lowland meadows could be undertaken by a combination of field-based sampling and earth observation methods. The latter are likely to become increasingly sophisticated and may, in combination with traditional field monitoring, offer a method of monitoring favourable area.

4.3 Favourable structure and function attributes

Structure attributes

Species composition

Full range of positive indicator species (see JNCC 2004 & Robertson & Jefferson 2000) represented over the extent of the habitat, and no decrease in cover.

Minimum herb content

Average herb cover at least 40% (NB no threshold set for this attribute MG8, MG14-MG16 in CSM)

Negative indicators/undesirable species

Non-woody negative indicators no more than Occasional. Tree and shrub cover no more than occasional or less than 1% cover (MG4) or no more than occasional or less than 5% cover (MG1, MG5, MG8, MG14-MG16). There should be flexibility around thresholds for scrub cover, where there is inherent interest, and a higher level of scrub may be acceptable or even desirable.

Sward height, litter accumulation, bare ground

Average sward height in pastures only (5-15 cm), litter no more than 25% cover and bare ground less than 5% cover in MG4, MG5 and less than 15% cover in MG8, MG14-MG16.

Vegetation community transitions

Presence of vegetation community transitions such as to other to grassland/mire types and woodland.

Function attributes

Management

Continuation of low intensity management. The biodiversity value can only be sustained by either hay meadow management (hay cut typically mid-June to early July with late summer/autumn aftermath grazing) or livestock grazing. If aftermath hay meadow grazing is not possible, either because livestock cannot graze the meadow or there are no livestock available, there is the possibility of replicating similar management by taking an autumn grass cut removing the arisings followed by tine and chain harrowing to remove any thatch and moss.

Soils

Maintenance of low-nutrient availability soils characteristic of unmodified local conditions. Soil chemical properties of lowland meadows include P less than 25 mg l^{-1} (Index 0-1), K less than 200 mg l^{-1} (Index 2+), pH 5-7.

Hydrology

For MG4 & MG8: surface water or groundwater of quality and quantity to a standard which provides the necessary conditions to support the habitat.

The MG4 community has two basic requirements: i) an aerated root zone during the growing season and ii) an adequate water supply so as not to limit plant growth in early summer. This translates into a hydrological regime that provides a sub-surface mean water table of between -0.45 and -0.7 m between March and November and -0.35 m in winter with no more than 10 days of surface flooding covering greater than 10% of the area between September and February.

MG8: A hydrological regime that provides a sub-surface water table during the summer (range -2 to -48 cm below ground level) and a winter water table ± at the surface. Lateral and horizontal water movement at various depths may be important but there is little information on what constitutes a sustainable regime.

Functional connectivity

Sites should be situated in locations adjacent to or connected to other areas of similar habitat.

Note: Floodplain meadows are dynamic systems and reflect climatic conditions in the year preceding. Thus, for an individual site, some of the structural attributes will need to be flexible to accommodate this dynamism.

Patch size

95% of lowland meadows by area should be in patches over 0.5 ha. 50% by area should be present in patches greater than 5 ha extent

Quality of habitat patches

At least 95% of the favourable area of the habitat meets the structure and function requirements as described above.

Threatened species

All species partially or wholly dependent on this habitat should be Least Concern, when assessed using IUCN criteria (or considered to be Least Concern if not formally assessed), as regards to this habitat.

References

BALMER, D.E., GILLINGS, S., CAFFREY, B.J., SWANN, R.L., DOWNIE, I.S. & FULLER, R.J. 2013. *Bird Atlas 2007 – 11 The breeding and wintering birds of Britain and Ireland.* British Trust for Ornithology, Thetford.

BLACKSTOCK, T.H., RIMES, C.A., STEVENS, D.P., JEFFERSON, R.G., ROBERTSON, H.J., MACKINTOSH, J. & HOPKINS, J.J. 1999. The extent of semi-natural grassland communities in lowland England and Wales: a review of conservation surveys 1978-96. *Grass and Forage Science* 54, 1-18.

BUGLIFE. www.buglife.org.uk/advice-and-publications/advice-on-managing-bap-habitats/lowland-meadows [Date Accessed 06/12/18]

BULLOCK, J.M., JEFFERSON, R.G., BLACKSTOCK, T.H., PAKEMAN, R.J., EMMETT, B.A., PYWELL, R.J., GRIME, J.P. & SILVERTOWN, J. 2011. Semi-natural grasslands. *In*: The UK National Ecosystem Assessment Technical Report. UK National Ecosystem Assessment, UNEP-WCMC, Cambridge, 162-195.

CROFTS, A. & JEFFERSON, R.G. (eds.). 1999. *The Lowland Grassland Management Handbook. Second edition*. English Nature/The Wildlife Trusts, Peterborough. http://publications.naturalengland.org.uk/publication/35034

DUFFEY E., MORRIS M.G., SHEAIL J., WARD L.K., WELLS D. A. & WELLS C.E. 1974. *Grassland ecology and wildlife management*. London, UK: Chapman and Hall.

EVERARD, M. 2005. *Water Meadows Living Treasures in the English Landscape*. Forrest Text, Tresaith.

FLOOD PLAIN MEADOWS PARTNERSHIP website: http://www.floodplainmeadows.org.uk/

FULLER, R. 1987. The changing extent and conservation interest of lowland grasslands in England and Wales: A review of grassland surveys 1930–1984. *Biological Conservation* 40, 281-300.

GIBSON, C.W.D. 1997. *The effects of horse and cattle grazing on English species-rich grasslands.* English Nature Research Reports, No. 210. English Nature.

GIBSON, C.W.D. 1998. *South Somerset SSSIs a study of successive MG5 grassland*. English Nature Research Reports, No. 266. English Nature.

GILBERT, J.C., GOWING, D.J.G. & WALLACE, H.L. 2009. Available soil phosphorus in semi-natural grasslands: assessment methods and community tolerances. *Biological Conservation*, 142, 1074-1083.

GOWING, D.J.G., LAWSON, C.S., YOUNGS, E.G., BARBER, K.R., RODWELL, J.S., PROSSER, M.V., WALLACE, H.L., MOUNTFORD, J.O. & SPOOR, G. 2002. *The water*

regime requirements and the response to hydrological change of grassland plant communities. DEFRA-commissioned project BD1310, Final report. Institute of Water and Environment, Silsoe, Bedfordshire.

GOWING, D.J.G., LAWSON, C.S., BARBER, K.R. & YOUNGS, E.G. 2005. *Response of grassland plant communities to altered hydrological management*. DEFRA research project BD1321. Institute of Water and Environment, Silsoe,Beds.

GREIG, J.R.A. 1984. The paleoecology of some British hay meadow types. *Plants and ancient man, studies in paleoethnobotany* (ed. by W. van Zeist and W.A. Casparie) 213-226. Balkema, A.A. Rotterdam.

GRIFFITH, G.W., BRATTON, J.L. & EASTON, G.L. 2004. Charismatic megafungi: the conservation of waxcap grasslands. *British Wildlife*, 15, 31-43.

HEWINS, E., PINCHES, C., ARNOLD, J., LUSH, M., ROBERTSON, H. & ESCOTT, S. 2005. *The condition of lowland BAP priority grasslands: results from a sample survey of non-statutory stands in England.* English Nature Research Reports, No. 636. English Nature.

HEWINS, E. 2012. *A survey of selected agri-environment grassland and heathland creation and restoration sites: Part 1*. Natural England Commissioned Report, NECR107. Natural England.

HISTORIC ENGLAND. 2013. *Introductions to Heritage Assets - Water Meadows.*

HOLMES, P., PINCHES, C. & JEFFERSON, R.G. 2005. *National Assessment of lowland neutral grassland.* Unpublished paper (GC P05 07) tabled to English Nature General Committee of Council. English Nature, Peterborough.

INGROUILLE, M. 1995. *Historical Ecology of the British Flora.* London: Chapman & Hall.

JACKSON, D.L. 2000. *Guidance on the interpretation of the Biodiversity Broad Habitat Classification (terrestrial and freshwater types). Definition and the relationship with other habitat*. JNCC Report No. 307. JNCC.

JACKSON, D.L. & MCLEOD, C.R. (Eds). 2000. *The 2002 UK status of EC Habitats Directive interest features* (originally published by JNCC as Report 312).

JANSSEN, J.A.M., RODWELL, J.S., GARCÍA CRIADO, M., GUBBAY, S., HAYNES, T., NIETO, A., SANDERS, N., LANDUCCI, F., LOIDI, J., SSYMANK, A., TAHVANAINEN, T., VALDERRABANO, M., ACOSTA, A., ARONSSON, M., ARTS, G., ATTORRE, F., BERGMEIER, E., BIJLSMA, R.-J., BIORET, F., BIŢĂ- NICOLAE, C., BIURRUN, I., CALIX, M., CAPELO, J., ČARNI, A., CHYTRÝ, M., DENGLER, J., DIMOPOULOS, P., ESSL, F., GARDFJELL, H., GIGANTE, D., GIUSSO DEL GALDO, G., HÁJEK, M., JANSEN, F., JANSEN, J., KAPFER, J., MICKOLAJCZAK, A., MOLINA, J.A., MOLNÁR, Z., PATERNOSTER, D., PIERNIK, A., POULIN, B., RENAUX, B., SCHAMINÉE, J.H.J., ŠUMBEROVÁ, K., TOIVONEN, H., TONTERI, T., TSIRIPIDIS, I., TZONEV, R. &

VALACHOVIČ, M. 2016. *European Red List of Habitats. Part 2. Terrestrial and freshwater habitats*. Publications Office, European Union.

JEFFERSON, R.G. 1997. *Distribution, status and conservation of Alopecurus pratensis - Sanguisorba officinalis flood-plain meadows in England*. English Nature Research Reports, No. 249. English Nature.

JEFFERSON, R.G. 2013. *National Vegetation Classification: MG5 grassland.* Natural England Technical Information Note 147. Natural England.

JEFFERSON, R.G. & PINCHES, C.E. 2009. The conservation of flood-plain meadows in Great Britain: an overview. *Fritillary* 5, 4-17. URL: https://anhso.org.uk/wp-content/uploads/Fritillary/frit5-conservation.pdf

JEFFERSON, R.G. & PORTER, K. 2014. Insects and meadow flowers. *Antenna* 38, 149-157.

JEFFERSON, R.G., SMITH, S.L.N. & MACKINTOSH, E.J. 2014. *Guidelines for the Selection of Biological SSSIs. Part 2: Detailed Guidelines for Habitats and Species Groups. Chapter 3 Lowland Grasslands*. Joint Nature Conservation Committee.

JNCC. *Distribution Maps of NVC Types*. URL: http://jncc.defra.gov.uk/page-4267 [Date Accessed 07/03/19]

JNCC. 2004. C*ommon Standards Monitoring Guidance for Lowland Grassland Habitats* Version February 2004 ISSN 1743-8160 (online)

KIRKHAM, F.W., MOUNTFORD, J.O., & WILKINS, R.J. 1996. The effects of nitrogen, potassium and phosphorus addition on the vegetation of a Somerset peat moor under cutting management. *Journal of Applied Ecology,* 33, 1013-1029.

LAMBRICK, G. & ROBLNSON, M. 1988. The development of floodplain grassland in the Upper Thames Valley. *Archaeology and the flora of the British Isles* (Ed. by M. Jones) 55-75. BSBI conference Report No. 19. Botanical Society of the British Isles, London.

LAWSON, C., ROTHERO, E., GOWING, D., NISBET, T., BARSOUM N., BROADMEADOW, S. & SKINNER, A. 2018. *The natural capital of floodplains: management, protection and restoration to deliver greater benefits*. Valuing Nature Natural Capital Synthesis Report VNP09.

MCCREA A.R, TRUEMAN I.C. & FULLEN M.A. 2001. A comparison of the effects of four arable crops on the fertility depletion of a sandy silt loam destined for grassland habitat creation. *Biological Conservation* 97:181-187.

MCGINLAY, J., GOWING, D.J.G. & BUDDS, J. 2016. Conserving socio-ecological landscapes: An analysis of traditional and responsive management practices for floodplain meadows in England. *Environmental Science & Policy*, 234-241.

MAINSTONE, C., JEFFERSON, R.G., DIACK, I., ALONSO, I., CROWLE, A., REES, S., GOLDBERG, E., WEBB, J., DREWITT, A., TAYLOR, I., COX, J., EDGAR, P. & WALSH, K. 2018. *Generating more integrated biodiversity objectives – rationale, principles and practice*. Natural England Research Reports, No. 071 + lowland grassland Appendix C.

MOUNTFORD, J.D., LAKHANI, K.H. & KIRKHAM, F.W. 1993. Experimental assessment of the effects of nitrogen addition under hay-cutting and aftermath grazing on the vegetation of meadows on a Somerset peat moor. *Journal of Applied Ecology*, 30, 321-332.

MOUSLEY, S. & VAN VLIET, W. 2021. *Defining favourable conservation status in England: Natural England approach*. Natural England Evidence Information Note EIN062. Natural England.

NATURAL ENGLAND. 2002. *Internal Report Terrestrial Biodiversity Group Task & Finish Group 2 – Report.*

NATURAL ENGLAND & RSPB. 2019. *Climate Change Adaptation Manual - Evidence to support nature conservation in a changing climate, 2nd Edition*. Natural England.

NATURAL ENGLAND. 2008. *State of the Natural Environment* (NE85). http://publications.naturalengland.org.uk/publication/31043

NATURAL ENGLAND. 2009. *The use of yellow rattle to facilitate grassland diversification.* Technical Information Note TIN060.

NATURAL ENGLAND. 2010a. *Arable reversion to species-rich grassland: early management of the new sward.* Technical Information Note TIN068.

NATURAL ENGLAND. 2010b. *Sward enhancement: selection of suitable sites*. Technical Information Note TIN061.

NATURAL ENGLAND. 2010c. *Sward enhancement: choice of methods*. Technical Information Note TIN062.

NATURAL ENGLAND. 2010d. *Sward enhancement: diversifying grassland by spreading species-rich green hay.* Technical Information Note TIN063.

NATURAL ENGLAND. 2010e. *Sward enhancement: diversifying grassland by oversowing and slot seeding*. Technical Information Note TIN064.

NATURAL ENGLAND. 2010f. *Sward enhancement: diversifying grassland using pot-grown wildflowers or seedling plugs.* Technical Information Note TIN065.

NATURAL ENGLAND. 2010g. *Arable reversion to species-rich grassland: site selection and choice of methods*. Technical Information Note TIN066.

NATURAL ENGLAND. 2010h. *Arable reversion to species-rich grassland: establishing a sown sward. Natural England*. Technical Information Note TIN067.

NATURAL ENGLAND. 2010i. *Arable reversion to species-rich grassland: early management of the new sward*. Technical Information Note TIN068.

NATURAL ENGLAND. 2016. *Status of threatened habitats: Extent and condition of priority habitats. Strategy for England's Wildlife and Ecosystem Services, Biodiversity 2020 indicators*. https://data.gov.uk/dataset/5ed45f27-7f4e-4c35-8108-2f545223c9ac/strategy-for-england-s-wildlife-and-ecosystem-services-biodiversity-2020-indicators. [Accessed 07/12/2018]

PEARSON, A.A. & SOAR, P.J. 2018. Meadowlands in time: re-envisioning the lost meadows of the Rother valley, West Sussex, UK. *Landscape History*, 39, 25-55. DOI: 10.1080/01433768.2018.1466549

PETERKEN, G. 2013. *Meadows*. British Wildlife Publishing, Milton-on-Stour, Gillingham.

PLANTLIFE, WILDLIFE TRUSTS & RARE BREEDS SURVIVAL TRUST. 2016. *Meadow restoration practitioner's workshop.* National Wildflower Centre Liverpool.

PYWELL, R.F. 2006. *A Literature Review and Gap Analysis of Grassland Restoration Research in the UK and Europe.* Defra Project Code BD1458. Defra, London.

PYWELL, R.F., WOODCOCK, B., TALLOWIN, J.R.B., MORTIMER, S.R. & BULLOCK, J.M. 2012. Restoring species-rich grassland: principles and techniques. *In*: S. Peel, C. Chesterton, A. Cooke, R.G. Jefferson, D. Martin, B. Smith, S. Smith, S. & J.R.B. Tallowin, eds. Restoring diverse grasslands: What can be achieved where, and what will it do for us? *Aspects of Applied Biology,* 115, 11-21.

RACKHAM, O. 1986. *The History of the Countryside*. J.M. Dent, London.

RIDDING, L., REDHEAD, J. & PYWELL, R. 2017. Fate of semi-natural grassland in England between 1960 and 2013: A test of national conservation policy. *Global Ecology and Conservation,* 4, 516–525.

ROBERTSON, H.J. & JEFFERSON, R.G. 2000. *Monitoring the condition of lowland grassland SSSIs. Volume I: English Nature's rapid assessment system.* English Nature Research Reports 315, Volume I. English Nature.

RODWELL, J.S. ed. 1992. *British Plant Communities: Volume III Grasslands and Montane Communities*. University Press: Cambridge.

RODWELL J.S., MORGAN V., JEFFERSON R.G & MOSS D. 2007. *The European context of British Lowland Grasslands.* JNCC Report 394. JNCC.

ROTHERO, E., LAKE, S. & GOWING, D. (eds). 2016. *Floodplain Meadows – Beauty and Utility. A Technical Handbook*. Milton Keynes: Floodplain Meadows Partnership.

ROTHERO, E. & TATARENKO, I. 2018. Restoration success of British floodplain meadows. *In*: R. Feber, N. Jones, R. Marrs, S. Mortimer, C. Peters, I. Rotherham, T.

Sparks & D. Westbury, eds. Ecosystem and Habitat Management: Research, Policy, Practice. *Aspects of Applied Biology,* 139, 1-10.

SANDERSON, N.A., WILKINS, T.C., BOSANQUET, S.D.S & GENNEY, D.R. 2018. *Guidelines for the Selection of Biological SSSIs. Part 2: Detailed Guidelines for Habitats and Species Groups. Chapter 13 Lichens and associated microfungi.* Peterborough: Joint Nature Conservation Committee.

SHELLSWELL, C.H. 2017. *Is the rye-grass always greener? An evidence review of the nutritional, medicinal and production value of species-rich grassland.* Plantlife: Save Our Magnificent Meadows Project. http://www.magnificentmeadows.org.uk/assets/pdfs/Is_the_rye-grass_always_greener_An_evidence_review.pdf

STANBURY, A., EATON, M., AEBISCHER, N., BALMER, D., BROWN, A., DOUSE, A., LINDLEY, P., MCCULLOCH, N., NOBLE, D. & WIN, I. 2021. The status of our bird populations: the fifth Birds of Conservation Concern in the United Kingdom, Channel Islands and Isle of Man and second IUCN Red List assessment of extinction risk for Great Britain. *British Birds* 114: 723-747.

STROH, P.A., LEACH, S.J., AUGUST, T.A., WALKER, K.J., PEARMAN, D.A., RUMSEY, F.J., HARROWER, C.A., FAY, M.F., MARTIN, J.P., PANKHURST, T., PRESTON, C.D. & TAYLOR, I. 2014. *A vascular plant red list for England.* Bristol: Botanical Society of Britain and Ireland.

STROH, P.A., WALKER, K.J., SMITH, S.L.N., JEFFERSON, R.G., PINCHES, C. & BLACKSTOCK, T.H. 2019. *Grassland plants of the British and Irish lowlands: ecology, threats and management*. Hertfordshire: Botanical Society of Britain and Ireland.

TOWNSHEND, D., STACE, H., & RADLEY, D. 2004. *State of nature: Lowlands - future landscapes for wildlife*. English Nature.

UK BIODIVERSITY GROUP. 1998. *Tranche 2 Action Plans. Volume II – terrestrial and freshwater habitats*. English Nature.

UK BAP. 2008. *UK Biodiversity Action Plan Priority Habitat Descriptions Lowland Meadows.* JNCC.

WALKER, K., MANCHESTER, S., MOUNTFORD, O., STEVENS, D. & PYWELL, R. 2001. *Methodologies for restoring and re-creating semi-natural lowland grassland: a review and quantitative model.* NERC Centre for Ecology and Hydrology. CCW Contract Science Report FC 73-01-273A.

WALLACE, H. & PROSSER, A. 2017. *A review of the National Vegetation Classification for the Calthion group of plant communities in England and Wales*. Natural England Joint Publication JP021.

WEBB, J.R., DREWITT, A.L., & MEASURES, G.H. 2010. *Managing for species: Integrating the needs of England's priority species into habitat management. Part 1 Report.* Natural England Research Reports, Number 024.

WHEELER, B.R. & WILSON, P.J. 2018. *Re-survey of a sample of priority grasslands outside of SSSIs to determine impact and effectiveness of Environmental Stewardship agreements in delivering outcomes.* Interim Progress Report to Natural England on Year 1 of 2: the 2017 field survey results.

WILSON, P., WHEELER, B., REED, M & STRANGE, A. 2013. *A survey of selected agri-environment grassland and heathland creation and restoration sites.: Part 2.* Natural England Commissioned Report, NECR107. Natural England.

About Natural England

Natural England is here to secure a healthy natural environment for people to enjoy, where wildlife is protected and England's traditional landscapes are safeguarded for future generations.

Further Information

This report can be downloaded from the Natural England Access to Evidence Catalogue. For information on Natural England publications or if you require an alternative format, please contact the Natural England Enquiry Service on 0300 060 3900 or email enquiries@naturalengland.org.uk.

Citation

Natural England. 2023. Definition of Favourable Conservation Status for lowland meadows. RP2971. Natural England.

Copyright

Catalogue code: RP2971

www.gov.uk/natural-england

NATURAL ENGLAND