Definition of Favourable Conservation Status for Upland Hay Meadows

Defining Favourable Conservation Status Project

Author: Richard Jefferson

www.gov.uk/natural-england

NATURAL ENGLAND

Acknowledgements

I would like to thank the following people for their contributions to the production of this document:
Helen Doherty at SNH.
Andy Brown, Claire Cornish, Robert Goodison, George Hinton, Michael Knight, Dave Martin, Sally Mousley, Ginny Swaile, Graham Walsh and the Defining Favourable Conservation Status team at Natural England.

Contents

About the DFCS 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 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 FCS based on the best available information at the time of production.

Introduction

This document sets out Natural England's view on Favourable Conservation Status (FCS) for **upland hay meadows** in England. FCS is defined in terms of three parameters: natural range and distribution, area, and structure and function attributes.

Section 2 provides the summary definition of FCS in England. Section 3 covers contextual information, section 4 the metrics used and section 5 describes the evidence considered when defining FCS for each of the three parameters. Section 6 sets out the conclusions on favourable values for each of the three parameters. Annex 1 lists the references.

This document does not include any action planning, or describe actions, to achieve or maintain FCS. 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 FCS.

2. FCS in England

Upland hay meadows are rare and confined to upland northern England between 200 m and 400 m altitude with a sub-montane climate. They are typically found as isolated fragments, as isolated fields, or groups of fields, on brown earth or humic soils on level to moderately sloping ground. The habitat consists of two National Vegetation Classification types – MG3 *Anthoxanthum odoratum – Geranium sylvaticum* grassland on drier, freely draining soils and MG8 *Cynosurus cristatus-Caltha palustris* grassland where the water table is high for much of the year. Management normally comprises hay cutting together with spring and autumn grazing. The extent of meadow grassland has declined steeply over the last 70 years. Its vulnerability to climate change has been assessed as medium, and like other semi-natural grasslands, it provides important ecosystem services.

The habitat will achieve FCS when the structural and functional attributes set out in section 4.3 are met over 95% of the favourable area. This includes attributes relating to floristic composition, sward structure, soil nutrient status, hydrological function, grazing and hay cutting management, parcel size and connectivity. In particular, to achieve FCS, the vegetation should be broadly typical of the geographically-relevant plant communities and their species composition. The soils and hydrological regime should have properties typical of the component plant communities' notably low soil P and a pH in the range 5-7. There should be at least some contiguous or connected areas of suitable semi-natural habitat.

All species associated with this habitat should be Least Concern, when assessed using IUCN criteria.

Favourable status will require both maintenance of the existing habitat in favourable status plus an increase in the current area by 24,000 ha distributed throughout the current range and distribution of the habitat.

Some of the additional area should be targeted at increasing the size of existing uplands hay meadow patches as larger sites are more likely to be better buffered from the negative impacts of surrounding intensively-managed land, may be easier to manage and may be more ecologically resilient.

FCS parameter	Favourable status	Confidence in the parameter
Range and distribution	Found in the following NCAs: Border Moors and Forests, Bowland Fells, Bowland Fringe and Pendle Hill, Cheviots, Cumbria High Fells, Durham Coalfield Pennine Fringe, Eden Valley, Howgill Fells, North Pennines, Orton Fells, Pennine Dales Fringe, South Cumbria Low Fells, Yorkshire Dales.	**High**
Area	25,000 ha for the upland hay meadow priority habitat and Annex I mountain hay meadows.	**Moderate**
Structure and function	At least 95% of the favourable area of the habitat should meet the structure and function requirements.	**Low**

As at February 2020, based on a comparison of the favourable values with the current values as set out in this document, upland hay meadow is not in favourable conservation status. Note, this conclusion is not based on a formal assessment of the status of the habitat nor on focussed and/or comprehensive assessment and monitoring.

Definitions and ecosystem context

3.1 Habitat definition

The upland hay meadows priority habitat comprises species-rich hay meadows on brown earth or humic soils. It is a northern and sub-montane counterpart to the **Lowland hay meadows priority habitat**. The vegetation corresponds to NVC type MG3 *Anthoxanthum odoratum – Geranium sylvaticum* grassland and upland forms of MG8 *Cynosurus cristatus-Caltha palustris* whereas the Annex I habitat type **Mountain hay meadows is synonymous with MG3** but does not include upland MG8.

MG3 *Anthoxanthum odoratum – Geranium sylvaticum* grassland comprises various grasses, including common bent *Agrostis capillaris*, sweet vernal-grass *Anthoxanthum odoratum* and cock's-foot *Dactylis glomerata*, that are prominent in the sward, and these are accompanied by a range of associated species, such as wood crane's-bill *Geranium sylvaticum*, great burnet *Sanguisorba officinalis* and pignut *Conopodium majus*. Populations of rare lady's-mantles (*Alchemilla* species) are found in some meadows.

Upland forms of MG8 *Cynosurus cristatus-Caltha palustris* grassland consist of a mixture of grasses such as sweet vernal-grass *Anthoxanthum odoratum,* crested-dog's-tail *Cynosurus cristatus,* rough-stalked meadow grass *Poa trivialis*, perennial rye-grass *Lolium perenne* and herbaceous species include marsh marigold *Caltha palustris*, red clover *Trifolium pratense*, white clover *Trifolium repens*, daisy *Bellis perennis*, yellow rattle *Rhinanthus minor*, common sorrel *Rumex acetosa*. Globe flower *Trollius europaeus* and marsh hawksbeard *Crepis paludosa* can form a distinctive northern upland element to the vegetation.

Both MG3 and upland forms of MG8 are covered by a single EUNIS type – Mountain hay meadows – E2.3

Constant species for MG3 (Rodwell 1992):

Plantago lanceolata, Rumex acetosa, Ranunculus acris, ***Geranium sylvaticum****, Anthoxanthum odoratum,* ***Conopodium majus****, Cerastium fontanum, Dactylis glomerata,* ***Alchemilla glabra****, Trifolium repens, Poa trivialis, Festuca rubra, Agrostis capillaris, Holcus lanatus,* ***Sanguisorba officinalis***

Species indicating favourable condition:

Those in bold above plus: *Alchemilla spp , Anemone nemorosa, Centaurea nigra, Cirsium heterophyllum, Euphrasia spp., Filipendula ulmaria, Geranium sylvaticum, Geum rivale, Lathyrus pratensis, Leontodon spp, Lotus corniculatus, Persicaria bistorta, Rhinanthus minor, Succisa pratensis, Trollius europaeus.*

Constant species for MG8 (Rodwell 1992 & Wallace& Prosser 2016):

Anthoxanthum odoratum, Caltha palustris, Carex panicea, Cerastium fontana, *Cynosurus cristatus*, *Festuca rubra, Filipendula ulmaria, Holcus lanatus, Plantago lanceolata, Poa trivialis, Ranunculus acris, Rumex acetosa, Scorzoneroides autumnalis, Trifolium repens*

Species indicating favourable condition:

Achillea ptarmica, Ajuga reptans, Caltha palustris, Carex flacca, Carex nigra, Carex panicea, Euphrasia spp., Filipendula ulmaria, Geum rivale, Leontodon spp, Orchidaceae spp., Potentilla erecta, Rhinanthus minor, Sanguisorba officinalis, Silene flos-cuculi,, Serratula tinctoria, Succisa pratensis, Trollius europaeus and Valeriana dioica.

Sources: *Robertson & Jefferson 2000**,** Rodwell 1992, Rodwell and others 2007, Wallace & Prosser 2016*

3.2 Habitat status

Upland hay meadow is listed as a Habitat of Principal Importance under Section 41 (S41) of the Natural Environment and Rural Communities (NERC) Act 2006 reflecting its high nature conservation value. The habitat supports a number of threatened plants including six that are listed as S41 priority species – see Ecosystem context (section 3.3) for further details. Mountain hay meadow (equivalent to MG3 grassland) is listed under Annex I of the Habitats Directive.

The vegetation type comprising upland hay meadows is listed as **Vulnerable (VU)** (MG3 – EUNIS E2.3 Mountain hay meadows) under the European Red List of Habitats (Janssen and others 2016), primarily due to losses over the last 50 years. Specifically, this means either ≥ 30% but < 50% decline over the last 50 years; a likely future decline ≥ 30% but < 50% and historic losses since c. 1750 of ≥ 50% but < 70%.

As with other types of semi-natural grassland (Bullock and others 2011), upland hay meadows can provide a range of ecosystem services including nutrient capture, carbon storage, pollination, pest control, genetic resources and cultural benefits to society.

Sources: *Bullock and others 2011**,** Janssen and others 2016*

3.3 Ecosystem context

Upland hay meadows are confined to areas where non-intensive hay-meadow management has been applied in a sub-montane climate. They are most characteristic of brown earth or humic soils on level to moderately sloping ground between 200 m and 400 m altitude. Upland hay meadows are typically found in isolated fields, or groups of fields, where many are still managed as hay meadows. They also occur as remnants in otherwise agriculturally-improved fields on banks and other steep areas and on river banks, road verges and in woodland glades. Those stands on river banks and in open woodland (usually MG3) probably represent the most near-natural examples and have affinities with tall-herb and cliff ledge vegetation in sub-montane regions.

The wetter sites, often at higher altitudes, usually conform to MG8 and usually occur as small stands on banks and around flushes in a mosaic with MG3 or occupy extensive hill sides where soil conditions are favourable. Here high precipitation and low evapotranspiration maintain constantly damp soil conditions.

The hydrological requirement (Gowing and others 2002) for the community is a constantly high water table throughout the year, without being subject to prolonged periods of flooding but conversely not experiencing extended periods of drought in the growing season. In the uplands the community occurs on mostly humic soils with a few on alluvial soils in river valleys and where hydrological conditions ensure a relatively constant water table throughout the year. Transitions

between MG3 and MG8 vegetation may often occur which are largely mediated by hydrology (Robertson & Jefferson 2000).

Much of the variation within the MG3 component of this habitat is attributable to the way it has and is managed. Meadow in fields are grazed in winter, mainly by sheep, except in the worst weather. The intensity and duration of the grazing varies considerably with some meadows receiving no spring grazing and others being grazed until mid-May. In late April to mid-May, stock is removed to allow the grass to grow tall for eventual cutting as hay. Mowing takes place in mid-July to early August though, in unfavourable seasons, it may be delayed as late as September. The aftermath is then grazed once more, often by cattle, until the weather deteriorates. Traditionally, most meadows have been given a light dressing of farmyard manure in the spring (Crofts & Jefferson, Kirkham and others 2014, Pinches and others 2013) and this, together with dunging from livestock and occasional liming, has helped maintain the characteristic floristic composition.

The meadows are an integral part of upland pastoral hill farms that includes rough pastures and moorland. They provide forage for winter feeding of sheep and cattle and more nutritious grazing at key times of the annual livestock calendar such as for spring lambing.

The plant species that characterise the meadows, including constant species (Rodwell 1992) at least for MG3 vegetation, are largely made up of relatively widespread species which may occur in other habitats such as roadside verges, woodland margins, riverbanks, cliffs etc and including semi-improved grasslands such as MG6. The habitat value lies in the assemblage of these species, plus characteristic sub-montane tall-herb species, co-existing in a meadow environment.

There is not a great deal of information on the use of species make of upland hay meadows, other than for birds. It appears that few invertebrate species are typical or characteristic of this habitat, many sharing affinities with other less intensively managed grasslands. Many once characteristic birds of hay meadows, including lapwing, yellow wagtail and corncrake have lost much of their and declined enormously in numbers over the last few decades, with the latter all but lost from England.

The meadows can co-occur or form transitions to rush pasture M23 *Juncus effusus/acutiflorus-Galium palustre* rush-pasture. Steeper banks in MG3 meadows may support species-rich vegetation of the Violion (U4c in the British National Vegetation Classification, Rodwell 1992) and locally, in flushed situations, small-sedge mire (M10 *Carex dioica-Pinguicula vulgaris* fen) and M26 *Molinia caerulea-Crepis paludosa* mire (Rodwell 1991).

In addition, there may be transitions to woodland particularly W9 *Fraxinus excelsior-Sorbus aucuparia-Mercurialis perennis* woodland and in more near-natural situations to W16 *Quercus* spp.-*Betula* spp.-*Deschampsia flexuosa* woodland and W17 *Quercus petraea-Betula pubescens-Dicranum majus* woodland.

GB and European context

Within a wider European frame, MG3 vegetation included in this priority habitat is clearly recognisable as part of the **Triseto-Polygonion** alliance that includes low-input meadows of well-drained, relatively fertile mineral soils through the sub-montane and montane zones of northern and central Europe. Our own MG3 vegetation is very similar to a European sub-type that is essentially sub-Atlantic in distribution and has been described from various countries including Norway and Sweden. While British examples have certain floristic differences they are nonetheless very similar to examples from Atlantic countries in Europe.

In western and central Europe, MG8 vegetation would fall within the wet meadows and pastures of fertile, often manured soils, in the Calthion alliance (a complex and diverse group of habitats which include wet pastures of the MG8 *Cynosurus-Caltha* type). This latter community is an especially poorly-defined vegetation type in the published NVC (Rodwell 1992) but more recent data acquisition and interpretation has helped to further refine this and related types of wet grassland in the UK (Wallace & Prosser 2016). This has included recognition of four sub-communities of which MG8d *Caltha palustris-Bellis perennis* is the type that occurs in upland northern environments.

Sources: *BAP priority habitat definition: Rodwell 1991,1992: Buglife 2016; Cheffings and others 2005; Crofts & Jefferson 1999, Gowing and others 2002, Jefferson 2005, Kirkham and others 2014, Jefferson & Rodwell 2009, Pacha 2005; Pinches and others 2013, Robertson & Jefferson 2000, Rodwell 1992, Rodwell and others 2007, Small 200, Stroh and others 2019, Wallace & Prosser 2016.*

Metrics and attributes

4.1 Natural range and distribution

National Character Area (NCA).

The metric used in this section are the National Character Areas which are appropriate divisions as they are largely based on factors such as topography/altitude, geology, soils and landscape history which are important determinants of the distribution of mountain hay meadows.

4.2 Area

Hectare

4.3 Structural and functional attributes

Structural attributes

- The presence of characteristic plant species.
- The proportion of herbs (including *Carex* spp.) within the vegetation community between 50% and 90%.
- A low cover of undesirable plant species, including agricultural weeds and invasive aliens.
- Cover of rushes in MG8 – no more than 50% cover of all rush species combined.
- On sites where they occur, the presence of vegetation community transitions such as to other to mire types and woodland
- A range of sward heights during the spring and aftermath grazing periods.
- The presence of some bare ground for regeneration niches.

Functional attributes

- The key functional requirement for the maintenance of the habitat is the continuation of low intensity hay meadow management including traditional patterns of spring and autumn grazing. Shut up fields for hay by mid-May at latest and preferably earlier.
- Maintenance of characteristic low productivity soils. The Critical Load for all sources of nutrients is estimated to be 10-20 kg N ha^{-1} $year^{-1}$
- Maintenance and repair of drainage structures – some sites have sub-surface drainage (e.g. tile drains). In the absence of maintenance, there is a risk that MG3 meadow vegetation could shift to wetter vegetation. This attribute though only applies to meadows that only support MG3 grassland
- For MG8:
    - surface water or groundwater of quality and quantity to a standard which provides the necessary conditions to support the habitat.
    - 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.

- Supporting off-site habitat may be helpful in some cases to buffer from intensive management and provide alternative land for optimal management.
- Functional connectivity with the wider landscape may be necessary although there is little evidence. Nectar feeders will need alternative food sources when the hay is cut. There may be populations of typical plant species in nearby road verges, woodland margins and river banks which provide functional connectivity for fragmented habitats. Where such populations are adjacent to sites undergoing restoration this may enhance restoration potential and may be critical to maintaining or expanding populations and preventing genetic erosion

Evidence

5.1 Current situation

Natural range and distribution

Found in the following NCAs:

Border Moors and Forests, Bowland Fells, Bowland Fringe and Pendle Hill, Cheviots, Cumbria High Fells, Durham Coalfield Pennine Fringe, Eden Valley, Howgill Fells, North Pennines, Orton Fells, Pennine Dales Fringe, South Cumbria Low Fells, Yorkshire Dales.

Area

Less than 1,000 ha. However, various estimates have been used for total extent and 1,000 ha is likely to be an over-estimate. The limited evidence available suggests the habitat continues to decline, both in extent and condition. A survey of grassland inventory upland hay meadows outside SSSIs in 2001/02 revealed that only 12% were in favourable condition and 42% showed closest botanical similarity to agriculturally improved NVC types (Hewins and others 2005). If this figure is extrapolated – the remaining area of habitat actually equating to upland hay meadows may be closer to or less than 600 ha.

Patch size

Current data indicates that sites are small and fragmented such that the average size of all sites from the England Priority Habitat Inventory (PHI) is around 2.5 ha with only about 10% exceeding 5 ha. Most sites are less than 2 ha. However, due to the limitations of the data, these data should be treated with caution.

Habitat quality

The majority of the information on the state of the structure and function attributes comes from the monitoring of upland hay meadow protected sites and includes both NVC types (MG3 & MG8). At 31/05/2012, 83.7% of the designated resource in SACs was in favourable (21%) or unfavourable recovering (62.7%) condition. For SSSIs outwith SACs the figure was 90% in favourable (58%) or unfavourable recovering (32%). Note the caveat that the condition data is based on SSSI/SAC units and the habitat feature may or may not cover the whole unit.

For non-designated sites, data are available from sample surveys of priority grasslands, including upland hay meadows, which used CSM methods (Hewins and others 2005, Wheeler and others in prep.). In 2002/2003 only 12% of sites were classified as in favourable or good condition but in the repeat survey in 2017/2018, 19% were favourable. A site having an agri-environment scheme agreement had an overall positive impact on the condition of upland hay meadows within the sample.

[1] Note: This habitat area estimate may differ from the national Priority Habitat area used for the England Biodiversity Indicator Report. 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 (used in England Biodiversity Indicator reporting) are a good indication of the location of known high quality grassland sites.

Threatened species

There are twelve species that occur in upland hay meadows which are listed as endangered or vulnerable in the England Red Data Book (RDB) for vascular plants, namely *Alchemilla acutiloba, A. glomerulans, A. monticola, A. subcrenata, A. wichurae, Blysmus compressus, Coeloglossum viride, Crepis mollis Parnassis palustris*, *Pinguicula vulgaris* and *Ranunculus flammula*.

The following species are classed as Near Threatened: *Briza media*, *Carex pulicaris*, *Cirsium heterophyllum*, *Comarum palustre, Geranium sylvaticum, Potentilla erecta*, *Silene flos-cuculi*, *Succisa pratensis*, *Valeriana dioica* and *Valeriana officinalis.*

Six of these Red Data Book listed vascular plant species are also S41 Priority Species. The ecology and management requirements of most of the threatened species is detailed in Stroh and others 2019.

The enclosed meadows, together with other components of the upland landscape, provide important nesting and feeding habitat for various waders, notably redshank *Tringa totanus*, (GB IUCN VU) northern lapwing *Vanellus vanellus* (GB IUCN Endangered), snipe *Gallinago gallinago*, oystercatcher *Haematopus ostralegus* and curlew *Numenius arquata* (GB IUCN Endangered). In addition, passerines, such as yellow wagtail *Motacilla flava* (GB IUCN NT), skylark *Alauda arvensis* (GBIUCN VU) meadow pipit *Anthus pratensis*, linnet *Carduelis cannabina* (GB IUCN EN) and twite *C.flavirostris*(GB IUCN NT) and others such as black grouse (GB IUCN VU) are closely associated with hay meadows either for feeding or breeding. One other species, the corncrake, once characteristic of upland hay meadows is now all but lost from England (though of Least Concern at a GB level). All are birds of conservation concern in the UK and black grouse, corncrake, northern lapwing, curlew, yellow wagtail skylark, linnet and twite are S41 Priority Species.

Upland hay meadows have been little studied from an invertebrate perspective as the nature of the management has tended to deter entomologists from studying meadows which are thought of as being of limited interest (see for example Jefferson & Porter 2014). Buglife [https://www.buglife.org.uk/advice-and-publications/advice-on-managing-bap-habitats/upland-hay-meadows] list a few nationally scarce species of insects including weevils (Coleoptera;Curculionidae) and click beetles (Coleoptera: Elateridae).They are, though, likely to support a suite of generalist insect species foraging for nectar and pollen (bumblebees, hoverflies) plus specialist species that will exploit the flowers and seeds (Jefferson & Porter 2014).

Sources: *Buglife 2016, CMSi 2016, Hewins and others 2005, Jefferson & Porter 2014, Natural England 2008, Robertson & Jefferson 2000, Rodwell and others 2007, Starr-Keddle 2014, Stroh and others 2019, UK Biodiversity Group 1999*

Confidence: Moderate

5.2 Historical variation in the above parameters

Natural range and distribution

There is no evidence that the range of this habitat has changed.

Area

There are few data on the historical extent of this habitat. In the first half of the 20th century, this habitat was not widely recognised as a semi-natural habitat of nature conservation significance but considered as a locally abundant agricultural grassland type. It became widely recognised as a habitat type of conservation value when major declines were observed in the 1960s and 1970s. There is known to have been a significant decline in extent but the size of that decline is unknown. An oft-quoted figure is 97% loss of all lowland (including enclosed upland meadow) semi-natural grassland between 1930 and 1980. Losses of this habitat continued into late 1980s. There are no concrete data on losses since the introduction of the Habitats Directive but there has certainly been further loss and degradation in this period. Some losses have potentially been counterbalanced by habitat creation.

There is scope for analysing changes in the distribution of typical plant species of the habitat as a proxy for habitat change. For example one such species*, Geranium sylvaticum,* declined locally between the two plant atlases (1960s to the late 1990s) with a change index of -0.45 (Preston and others 2002). The change index is a measure of the relative performance of a species between the two national atlas surveys allowing for overall variation in recording effort between the two surveys and is explained more fully in Preston and others 2002. A negative value means a decline.

Patch size

There is no quantitative data on changes in patch size but expert opinion would suggest that while there may have not have been much change in the size of individual meadows, the actual number of semi-natural sites by dale or other geographical area metric has declined significantly.

Habitat quality

Very little is known about historic trends in quality although loss of quality, like direct loss such as through ploughing and reseeding, is probably largely more of a 20th century phenomenon due to eutrophication from fertiliser/manure use and aerial deposition of nitrogen.

Despite considerable conservation activity, notably associated with the widespread promotion and take up of agri-environment scheme agreements and the designation of a significant proportion of meadow as SSSIs, there has been a continued decline in floristic richness and deterioration in botanical quality in some of the highest quality meadows over the last twenty years (Critchley and others 2004, O'Reilly 2010, Starr-Keddle 2014) with a significant proportion now showing closest botanical similarity to semi-improved grasslands (Hewins and others 2005).

Threatened species

Pacha & Petit (2007) and Bradshaw (2009) have identified declines in characteristic upland hay meadows species such as *G. sylvaticum, Trollius europaeus, Cirsium heterophyllum* and the *Alchemilla vulgaris* aggregate. Declines have also been recorded in the populations of a number of breeding bird species (Wilson and others 2001; Fuller and others 2002; Court and others 2001) for which hay meadows provide important nesting and/or or feeding habitat, in association

with other components of the upland landscape and a large proportion are IUCN Threatened in a GB context.

Sources: Blackstock and others 1999; BSBI 2016; Bullock and others 2011; Court and others 2011; Critchley and others 2007; Fuller 1987; Fuller and others 2002; Jefferson 2005; Jefferson & Rodwell 2009; Natural England 2008; O'Reilly 2010; Pacha & Petit 2007; Pinches and others 2014; Preston and others 2002; Starr-Keddle 2014; Stroh 2014; Wilson and others 2001.

Confidence: *High – range & distribution; Low – area; Low/Moderate – Structural and functional attributes.*

5.3 Future maintenance of biological diversity and variation in the habitat

The habitat is still under threat, especially from agricultural intensification and climate change.

Upland meadows are naturally stressed, by climate (short growing season, low temperatures), by low nutrients and (sometimes) thin soils. If these stresses are being slowly and gradually moderated by climate warming and ongoing nutrient inputs then vegetation will reflect this through loss of characteristic stress-tolerant species as they are out-competed by more vigorous species, especially grasses. The regular addition of manure and in some cases, the past application of inorganic NPK appears to have left soils with residual levels of P that are available for utilisation when other soil conditions are right, e.g. when enough N is available. This effect has been seen in studies of several meadow communities, e.g. Kirkham and others (1996), Smith and others (2003) and Mountford and others (1993). It is possible that these cumulative effects are visible in the sample of upland hay meadows surveyed in a recent agri-environment monitoring project (Hamilton and others 2014).

In the light of this, particularly where restoration is an objective, management agreements may need to consider further limiting soil fertility. Quite a body of literature supports further reduction or cessation of farmyard manure application, e.g. Smith and others (2003) and Smith & Jones (1991).

Atmospheric nitrogen deposition may be having a detrimental impact on the habitat in some areas of the range especially where this occurs in conjunction with farmyard manure applications that may exceed low levels but there has been no detailed research on specific nutrient budgets.

There is a high threat from climate change although the precise effects are not certain. Boreal and montane species are characteristic of this habitat. With an increase in temperature these species are likely to be lost and the habitat could change into ostensibly a lowland hay meadow habitat. In addition, milder winters and springs may favour more competitive species over some of the characteristic species. In a UK context, there may be scope for expansion of the habitat within the Scottish part of the range including in apparent gaps in the current distribution. Climate trend data over the last 40-50 years has shown increases in annual average daily mean temperatures of around 1.4°C in northern England (north-west, north-east and Yorkshire & Humberside). Overall precipitation in this region has shown no overall significant change but there have been significant decreases in summer precipitation and significant increases in winter rainfall and many fewer days of air frost.

Recent evidence has revealed a potentially significant interaction between climate and management; the prolongation of grazing in spring increases the impact on plants as they begin to grow. The evidence suggests that the impacts of grazing later into spring are more pronounced in warm (advanced) spring as plants are repeatedly arrested in their development through continual defoliation. Whilst perennial species may tolerate periods of prolonged

grazing into the growing season, annuals such as hay rattle can suffer from high losses of germinating seedlings.

An increase in wetness may cause some upland hay meadow MG3 vegetation to change into vegetation more akin to MG8 or M23 rush pasture and could potentially lead to the development of more M10 flushes, although an increase in the frequency of droughts and dry periods will reduce this risk. An increase in rushes due to climate change (often compounded by lack of maintenance of drainage structures) may have knock on impacts such as more soil compaction due to the need to control rushes by increased mechanical cutting as well as reduced value of the forage for livestock.

Although the reality of extinction debt has not been demonstrated for grasslands in England/UK, the principles outlined in Lawton and others (2010) of 'better, bigger and more joined' up should be applied. Also, practically, at an individual site level, species populations on small or isolated patches are undoubtedly at a greater risk of extinction for a number of reasons: increased ratio of edge to area increases their susceptibility to external factors such as fertiliser drift; increased probability that stochastic events such as drought and fire will cause extinction across the entire site; tendency to be at greater risk of deterioration in habitat quality over time and their dependence on migrants from larger habitat patches to maintain viable populations.

There is ecological evidence of the negative effects of fragmentation and isolation on the populations of some of the characteristic vascular plants of this and other semi-natural grassland habitats through, for example, genetic erosion.

Ecological studies of breeding waders in the Pennine Dales (Small 2002) showed that in general, fields in which waders were recorded were larger, had higher sward species-richness, more wet areas, higher rush cover, shorter swards in June and more surface features (e.g. molehills, muck heaps, tussocks) in comparison with fields without waders. The data also imply that hay meadows with wet areas and lower fertility were also favoured by waders. The nature of the surrounding landscape also had a significant effect on the abundance and distribution of breeding waders with negative factors being proximity to dwellings, woodland and a high proportion of drained, intensive species-poor grassland.

Natural range and distribution

It is unclear whether the current range in England will ensure maintenance of the habitat in the future. The range may ensure future maintenance of the habitat if there is flexibility for migration of the habitat 'up the hill' from the valley bottoms and valley sides.

Area

There is no historical data on the range of variation in the habitat on which to base an accurate figure. The original target in the UK Biodiversity Action Plan was an increase of around 7.5 %. More recently, the indicative target for expansion/restoration within Biodiversity 2020 is 300 ha amounting to an increase of 30-33% (based on an area of 1,000ha). However, given the likely historic losses, the current difficulties in ensuring existing sites are in favourable condition and the likely negative impact of climate change, the possibility of so-called extinction debt (see Tilman and others 1994) and the need to buffer or make the habitat more resilient from these impacts, a larger expansion target is justifiable for favourable status. An expansion target based on detailed ecological evidence is unrealistic both in terms of what might be sustainable for the meadow plant community and for the breeding bird assemblage. There are two possible

approaches to deriving a figure for the habitat area required for the future maintenance of biological diversity:

1) Use the guidance within *Defining Favourable Conservation Status in England* (Natural England 2017 v 0.6). 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 upland hay meadows, this indicates an ambition to restore at least 90% of the historical loss (based on the current status of the habitat as Vulnerable/Endangered, highly degraded structure and function attributes 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) this would require a minimum increase in area of c 29,200 ha.
2) Use data produced by the NE National Habitat Network Mapping project. This would indicate an increase of approximately 24,000 ha. This is based on the figure required to create a connected network of habitat incorporating existing habitat patches.

Given the historical losses in habitat extent and the likely negative impacts of increased fragmentation and isolation, it is recommended that an increase in area of 24,000 ha is adopted to create a network of connected habitat. As the area of the MG8 community represents only a small proportion of the upland hay meadow habitat, and is usually found in an intimate mixture with the MG3 community forming the Annex I habitat, it is proposed that an increase in area of 24,000 ha is adopted for the Annex I habitat.

Patch size

In general, there are benefits to increasing the size of existing patches of the upland hay meadow habitat. Larger sites are more likely to be better buffered from the negative impacts where sites are adjacent to intensively-managed land such as improved silage fields. They may also be easier to manage by grazing and cutting management compared to smaller sites. They may also ultimately be more ecologically resilient.

For example, should populations of meadow species be increased as a result of patch-size expansion they may be at a lesser risk of extinction due to: decreased ratio of edge to area which decreases their susceptibility to external factors such as fertiliser drift; decreased probability that stochastic events such as drought and flooding will cause extinction across the entire site; tendency to be at lesser risk of deterioration in habitat quality over time and reduced dependence on migrants from larger habitat patches to maintain viable populations and less risk of genetic erosion.

Habitat quality

95% of the favourable area needs to have the required structure and function attributes for the habitat to be in favourable status. There could be exceptions for some of the soil attributes, connectivity, supporting off-site habitat but we do not have enough information to be certain.

Sources: *Hamilton and others 2014, Jefferson & Rodwell 2009; Kirkham and others 1996, Lawton and others 2010, Mountford and others 1993,Smith and others 2016, Natural England and RSPB 2014, Smith and others 2003, Tilman and others.*

Confidence: Moderate

5.4 Potential for restoration

This habitat can be restored where the correct soil conditions are available, where the land is put under appropriate management and where characteristic species are re-introduced if there is not a nearby source of propagules for natural re-establishment. The Colt Park experimental plots show that it is possible to recreate this habitat from semi-improved grassland within 20 years. However, the composition of these created swards may not have the diversity of those meadows which have had a long history of continuity.

There is no information on the extent of land that may be available for restoration but in general terms restoration should be targeted at enclosed land and possibly river margins and open woodland in the relevant National Character Areas.

For restoration of this habitat the soil attributes are key as they can only be restored with difficulty. However, the management and vegetation characteristics can be restored given time and the presence of core areas of habitat or other seed sources. Any impacts from air quality can potentially be mitigated through reduced agricultural inputs. Approaches including the reduction or cessation of manure applications coupled with seed addition to restore missing species have been successful (Cornish and Hooley 2012). In addition, earlier shut-up dates (at least before May) and cutting from mid-July and into August seem to be practices associated with successful restoration of upland hay meadow communities (e.g. Jefferson 2005, Kirkham and others 2012, Smith and others 2003).

Sources: *Cornish and Hooley 2012, Jefferson 2005; Kirkham and others 2012, Smith 2010, Smith and others 2003.*

Confidence: Moderate - High

Conclusions

6.1 Favourable range and distribution

The natural range is the current range of the habitat.

The range could be monitored using a combination of altitudinal, climate and soil parameters which would require careful refinement.

6.2 Favourable area

The favourable area is 25,000 ha (the current area plus the area required to create a connected habitat network).

Area could be monitored by a combination of field-based sample-based monitoring 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.

6.3 Favourable structural and functional attributes

Structural and functional attributes

At least 95% of the favourable area of the habitat should meet the structure and function requirements.

Favourable condition under CSM would be a good proxy but ensuring generic attribute targets and thresholds are tailored to local conditions, where appropriate. This is important as O'Reilly (2010) demonstrated that relying on the generic CSM attribute targets could mean that very high quality sites could decline markedly before falling below the target for frequency of positive indicator species, for example. For non-statutory sites it might be worth considering slightly revised (lower) targets for favourable condition as used in Hewins (2005). Of the other non-CSM attributes, soil nutrient status can easily be measured but at present there is no agreed way of measuring or setting targets for off-site habitat or functional connectivity.

Patch size

Some of the increased area proposed should be targeted at increasing the size of existing patches of the upland hay meadow habitat. Larger sites are more likely to be better buffered from the negative impacts of surrounding intensively-managed land, may be easier to manage and may be more ecologically resilient (see 5.3).

Threatened species

All species associated with this habitat should be Least Concern, when assessed using IUCN criteria, in relation to this habitat.

Annex 1: References

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.

Botanical Society of Britain & Ireland (2016) BSBI Atlas 2020 URL: http://bsbi.org/atlas-2020 [accessed 6.12.16]

Bradshaw, M.E. 2009. The decline of Lady's-mantles (*Alchemilla vulgaris* L. agg.) and other hay-meadow species in Northern England since the 1950s. *Watsonia* 27, 315–321.

Buglife 2016 Upland hay meadows. URL: https://www.buglife.org.uk/advice-and-publications/advice-on-managing-bap-habitats/upland-hay-meadows [accessed 6.12.16]

Bullock, J.M., Jefferson, R.G., Blackstock, T.H., Pakeman, R. J., Emmett, B. A., PywelL, R. J., Grime, J. P. & Silvertown, J. W. 2011. *Chapter 6: Semi-natural grasslands*. In: The UK National Ecosystem Assessment Technical Report. UK National Ecosystem Assessment, UNEP-WCMC, Cambridge.WCMC, Cambridge. URL: uknea.unep-wcmc.org/Resources/tabid/82/Default.asp

Cheffings, C.M. & Farrell, L. eds, Dines, T.D., Jones, R.A., Leach, S.J., McKean, D.R., Pearman, D.A., Preston, C.D., Rumsey, F.J. & Taylor, I. 2005 *The Vascular Plant Red Data List for Great Britain*. Species status, 7, 1-116. Joint Nature Conservation Committee, Peterborough, UK.

Cooch, S. & Rodwell, J.S. 1996. *Preliminary study of key issues in relation to northern hay meadows.* University of Lancaster Unit of Vegetation Science report to World WideFund for Nature (UK), Lancaster.

Cornish, C. & Hooley, J. 2012 "Going for gold (purple and pink) in 2012" Results from five years of hay meadow restoration in Cumbria. In: Peel, S., Chesterton, C., Cooke, A., Jefferson, R.G., Martin, D., Smith, B., Smith, S. & Tallowin, J.R.B. eds *Restoring diverse grasslands: What can be achieved where, and what will it do for us? Aspects of Applied Biology* 115, 171-178.

Court, I. Barker, D. Cleasby, I. Gibson, M. Smith, J., Straker, C & Thom, T J. 2001. A survey of yellow wagtails in the Yorkshire Dales National Park in 2000 and a Review of their Historical Population Status. YDNPA, Grassington.

Critchley, C.N.R., Fowbert, J.A., & Wright, B. 2007. Dynamics of species-rich upland hay meadows over 15 years and their relation with agricultural management practices. *Applied Vegetation Science*, 10, 307-314.

Crofts, A. & Jefferson, R.G. 1999 *The Lowland Grassland Management Handbook*. English Nature & The Wildlife Trusts, Peterborough.

Fuller, R. M. 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.

Fuller, R.J, Ward, E., Hird, D., & Brown, A.F. 2002. Declines in ground nesting birds in two areas of upland farmland in the South Pennines of England. *Bird Study*, 49, 146-152.

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. and 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.

Hamilton, H., Jackson, S. and Blackshaw, A. 2014 Natural England long-term effectiveness of environmental stewardship in conserving upland hay meadows in the Pennine dales. *Natural England Commissioned Report* No. 138. Natural England, Sheffield.

Hewins E.J., Pinches C., Arnold J., Lush M., Robertson H.J. & Escott S. 2005. The Condition of Lowland BAP Priority Grasslands: Results from a Sample Survey of Non-Statutory Stands in England. *English Nature Research Report* No. 636. Peterborough, UK.

Jefferson, R.G. 2005 The conservation management of upland hay meadows in Britain: a review. *Grass & Forage Science*, 60, 322-331.

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

Jefferson, R.G. & Rodwell, J.S. 2009 Pennine Dales upland hay meadows, England. In: Veen, P., Jefferson, R.G., de Smidt, J & van der Straaten, J. eds *Grasslands in Europe of High Nature Value* KNNV Publishing, Zeist, The Netherlands. pp 134-143.

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.

Kirkham, F.W., Bhogal, A., Chambers, B.T., Dunn, R.M.& Tallowin, J.R.B. 2012 Effects of spreading species-rich green hay on the botanical composition of an agriculturally improved meadow in England. *Grass & Forage Science*, 68, 260-270.

Kirkham, F.W., Tallowin, J.R.B., Dunn, R. M., Bhogal, A., Chambers, B.J. & Bardgett, R.D. 2014. Ecologically sustainable fertility management for the maintenance of species-rich hay meadows: 12-year fertilizer and lime experiment. *Journal of Applied Ecology* 2014, 51, 152–161.

Lawton, J.H., Brotherton, P.N.M., Brown, V.K., Elphick, C., Fitter, A.H., Forshaw, J., Haddow, R.W., Hilborne, S., Leafe, R.N., Mace, G.M., Southgate, M.P., Sutherland, W.J., Tew, T.E., Varley, J. and Wynne, G.R. 2010. *Making Space for Nature: a Review of England's Wildlife Sites and Ecological Network*. Report submitted to the Secretary of State, the Department for Environment, Food and Rural Affairs on 16 September 2010. Defra, London.

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.

Natural England 2008. *State of the Natural Environment 2008*. Natural England, Sheffield.

Natural England and RSPB 2014 Climate Change Adaptation Manual: Evidence to support nature conservation in a changing climate. Natural England Commissioned Research Report no. 546.

O'Reilly, J. 2010. The state of upland hay meadows in the north Pennines. *British Wildlife*, 21, 184-192

Pacha, M.J. 2004. Fragmentation of northern hay meadows and the populations of *Geranium sylvaticum* in the Yorkshire Dales National Park. (pp. xii, 328p.). Lancaster: University of Lancaster.

Pacha, M.J., & Petit, S. 2008. The effect of landscape structure and habitat quality on the occurrence of *Geranium sylvaticum* in fragmented hay meadows. *Agriculture Ecosystems & Environment*, 123, 81-87.

Pinches, C.E., Gowing, D.J.G., Stevens, C.J., Fagan, K. & Brotherton, P.N.M. 2013. *Natural England review of upland evidence - Upland Hay Meadows: what management regimes maintain the diversity of meadow flora and populations of breeding birds?* Natural England Evidence Review, Number 005.

Preston C.D., Pearman D.A. & Dines T.D. 2002 *New Atlas of the British and Irish Flora*. Oxford University Press, UK.

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*, No 315. English Nature, Peterborough.

Rodwell, J.S. (ed). 1991. *British Plant Communities. Volume 2: Mires and heaths*. Cambridge University Press, Cambridge.

Rodwell, J. S. (ed.) 1992. *British Plant Communities: Grasslands and Montane Communities.* Cambridge University Press, Cambridge.

Rodwell, J.S., Morgan, V., Jefferson, R.G. & Moss, D., 2007. The European Context of British Lowland Grasslands. *Joint Nature Conservation Committee Report* 394. Joint Nature Conservation Committee, Peterborough.

Small C.J. 2002 Waders, habitats and landscape in the Pennine Dales. Ph.D. thesis, University of Lancaster.

Smith, R.S.2010 Understanding grassland systems: the scientific evidence base for conservation management of plant diversity. In: D. Gamble, & T. St. Pierre (Eds.), *Hay time: the natural, cultural and land management history of hay meadows in the Yorkshire Dales*. (pp. 145-177). Lancaster: Scotforth Books Yorkshire Dales Millennium Trust.

Smith, R.S., & Jones, L. 1991. The phenology of mesotrophic grassland in the Pennine Dales, Northern England – Historic hay cutting dates, vegetation variation and plant-species phenologies. *Journal of Applied Ecology*, 28, 42-59.

Smith R.S., Shiel R.S., Bardgett R.D., Millward D., Corkhill P., Rolph G., Hobbs P.J. and Peacock S. (2003) Soil microbial community, fertility, vegetation and diversity as targets in the restoration management of meadow grassland. *Journal of Applied Ecology*, 40, 51–64.

Smith, R.S., Sheil, R.S., Millward, D., Simkin, J.M. 2016 Effects of sheep stocking on the plant community and agricultural characteristics of upland *Anthoxanthum odoratum–Geranium sylvaticum* meadow in northern England. *Grass & Forage Science*, doi:10.1111/gfs.12251.

Starr-Keddle, R.E. 2014. Upper Teesdale: changes in upland hay meadow vegetation over the past twenty to thirty years - results presented from botanical surveys*. Natural England. Commissioned Report NECR* 139.

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*. Botanical Society for Britain and Ireland, UK.

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.* Botanical Society of Britain and Ireland, Hertfordshire.

Tilman, D., May, R.M., C.L. Lehman, C.L. & M.A. Nowak, M.A. 1994 Habitat destruction and the extinction debt*. Nature*, 371, 65–66.

UK Biodiversity Group 1998. *Tranche 2 Action Plans. Volume II – terrestrial and freshwater habitats*. English Nature, Peterborough, UK.

Wallace H. and Prosser A. 2016 *A review of the National Vegetation Classification for the Calthion group of plant communities in England and Wales*. Flood Plain Meadows Partnership, Milton Keynes.

Wheeler, B. R., Wilson, P.J. & Pinches, C.E. (in prep). Re-survey of a sample of priority grasslands outside of SSSIs to determine impact and effectiveness of Environmental Stewardship agreements in delivering outcomes. *Natural England Commissioned Research Report.* Natural England, Sheffield.

Wilson, A.M., Vickery, J.A. & Browne, S.J. 2001. Numbers and distribution of Northern lapwings breeding in England and Wales in 1998. *Bird Study*, 48, 2-17.

Further information

Natural England evidence can be downloaded from our **Access to Evidence Catalogue**. For more information about Natural England and our work see **Gov.UK**. For any queries contact the Natural England Enquiry Service on 0300 060 3900 or e-mail **enquiries@naturalengland.org.uk** .

Report number RP2948

ISBN 978-1-78354-664-0

Cover image

Moor House- Upper Teesdale, National Nature Reserve

Natural England