Definition of Favourable Conservation Status for Purple Moor-grass & Rush Pastures

Defining Favourable Conservation Status Project

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Acknowledgements

I would like to thank the following people for their contributions to the production of this document: Hannah Gibbons and Steve Payne at Devon Wildlife Trust, Mary-Rose Lane at Environment Agency, Helen Doherty at SNH and Stuart Smith at NRW.
Andy Brown, Catherine Burgess, Iain Diack, Jeff Edwards, Michael Knight, Sally Mousley, Clare Pinches, Keith Porter 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 **Purple moor-grass and rush pastures** 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

Purple moor-grass & rush pastures is a widespread but localised habitat of high biodiversity value occurring throughout the English lowlands and along the upland fringe wherever there are suitable substrates and hydrological regimes. It is normally maintained by extensive grazing by livestock. The extent of this type of grassland has declined significantly over the last 100 years although its overall range has remained stable. 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 6.3 are met over 95% of the favourable area. This includes attributes relating to floristic composition, patterns of vegetation zonation and transitions, cover of undesirable species, sward structure, soil and water nutrient and pH status, hydrological regime, grazing management and parcel size and connectivity. In particular, to achieve FCS the vegetation should be broadly typical of the relevant plant communities and their species composition. There should be some bare ground and variation in sward height including scattered scrub of various age classes. The soils should have properties typical of the habitat notably low soil P and a pH in the range 4.7 to 7.4. Surface water or groundwater status should normally be oligotrophic and the hydrological regime should provide a sub-surface water table during the summer and a winter water table ± at the surface with inundation absent or only to a minor degree in winter.

The habitat should be grazed by livestock usually at an average annual density of c. 0.4 LU/ha/year, depending on site productivity and conservation objectives. There should be at least some contiguous or connected areas of suitable semi-natural habitat.

The attainment of favourable status will require an increase in the current extent of the habitat by approximately 65,000 ha (c.620 % above baseline of c.10,500 ha) distributed throughout the range of the habitat and the maintenance of its current range and distribution.

FCS parameter	Favourable status	Confidence in the parameter
Range and distribution	The habitat is widely but discontinuously distributed in England with concentrations in south-west England, East Anglia and northern England. Potentially, the whole of England is able to support the habitat where suitable hydrological regimes and edaphic conditions exist.	High
Area *Note – Figures rounded to nearest 1000 ha*	Purple moor-grass and rush pasture - 76,000 ha Annex I *Molinia* meadows - 18,000 ha	Moderate
Structure and function	At least 95% of the favourable area of the habitat should meet the structure and function requirements.	Low

As at March 2020, based on a comparison of the favourable values with the current values, purple moor-grass and rush pastures are not in favourable conservation status. Note, this conclusion is based solely on the information within this document not on a formal assessment of status nor on focussed and/or comprehensive monitoring of status.

Definition and ecosystem context

3.1 Habitat definition and status

The purple moor-grass and rush pastures Priority Habitat (PMGRP) consists of five individual NVC communities:

M22 *Juncus subnodulosus-Cirsium palustre* fen-meadow. A highly variable species-rich rush-dominated vegetation which occurs on wet, base-rich peats and mineral soils in lowland Great Britain with notable concentrations in the chalk river valleys of south and eastern England. The majority of stands occupy more or less flat situations or hollows but a large number occur on seepage slopes. In base-rich mesotrophic-eutrophic conditions they can cover spring mounds.

M23 *Juncus effusus/acutiflorus-Galium palustre* rush-pasture is widespread on wet, moderately acid to neutral peaty and mineral soils primarily in the cool and wet lowlands and upland fringes of northern and western Britain. The M23a *Juncus acutiflorus* sub-community is typically more species-rich than the M23b *Juncus effusus* sub-community. The latter is often the product of attempts to agriculturally improve marshy grasslands by drainage, nutrient addition and possibly re-seeding.

M24 *Molinia caerulea – Cirsium dissectum* fen-meadow is the more widespread and diverse community. It is characteristic of moist base-rich to mildly acidic soils in the lowlands of England and Wales. It comprises a heathy form found mainly in south Wales, south-west England and Northern Ireland, a form with tall herbs mainly in the fen systems of East Anglia, and a more widespread 'typical' form widely but locally distributed in southern Britain. Some forms of *Molinia – Cirsium* fen-meadow with abundant *Cladium* are referable to Annex I type 7210 Calcareous fens with *Cladium mariscus* and species of the Caricion davallianae.

M25 *Molinia caerulea - Potentilla erecta* mire is considered as a floristically-impoverished degraded bog community. However more-species rich forms of M25 occur, particularly in the lowlands, and may co-occur in complex, intimate mosaics with M24 and may be difficult to distinguish from the latter (e.g. New Forest).

M26 *Molinia caerulea – Crepis paludosa* A very rare community occurring on moist, moderately base-rich peats and peaty mineral soils in England, Wales and Scotland with a stronghold in the sub-montane northern Pennines. A scatter of small sites occur in north Wales. The vegetation has a distinctive sub-montane character, manifested in the presence of species with a northern distribution, such as marsh hawk's-beard *Crepis paludosa* and globe-flower *Trollius europaeus*. The *Festuca rubra* sub-community often occurs on banks in enclosed meadows and pastures in association with MG3 and U4c. The *Sanguisorba officinalis* sub-community is more usually found in transitional vegetation around open water and is particularly uncommon.

This habitat includes the Annex I habitat *Molinia* meadows on calcareous, peaty or clayey-silt-laden soils (*Molinion caeruleae*) H6410. In the UK these grasslands are represented by two NVC types: M24 and M26. M25 *Molinia caerulea - Potentilla erecta* mire was excluded from the definition of H6410, probably because it is considered a degraded bog-community. However, the more species-rich forms, particularly those that occur in intimate mosaics with M24 should be covered by the definition of H6410. M22 and M23 were excluded from the definition of H6410 as *Molinia caerulea* is either absent or a subordinate component of the vegetation.

As far as the EUNIS classification is concerned, M22 & M23 appear to conform to E 3.4a moist/wet mesotrophic hay meadow and M24, M25 & M26 to E3.5 Temperate/boreal moist-wet oligotrophic grassland (John Rodwell pers. comm.).

In section 3.3, reference is made to the alkaline fen types M10 *Carex dioica-Pinguicula vulgaris* mire and M13 *Schoenus nigricans-Juncus subnodulosus* mire that may co-occur with the purple moor-grass /rush pasture types M22, M24 and M26. M10 & M13 are highly localised in England but may form hydrological and topographcal sequences with, or occur in close association with M22, M24 and M26 (Rodwell 1991, Diack in prep). Nonetheless M10 and M13 should be classified as Alkaline Fen Annex I habitat and M22, M24 and M26 as PMGRP Priority Habitat. From a practical and operational perspective, sites that have representation of both types (and potentially other habitats) should be treated holistically in relation to considering their particular edaphic, hydrological and grazing management requirements. Also, in some cases it is possible that stands of M22, M24 and M26 vegetation may have originally been alkaline fen but have become degraded and would be targeted for restoration of the much rarer fen habitat. Situations in which restoration to alkaline fen may be appropriate include sites where typical species were known to occur previously, where there are obvious modifications to the hydrological regime, e.g. drained springheads, and where lack of management has led to development of thatchy, dense and tall vegetation. Habitat that would be targeted for the restoration of alkaline fen does not fall within the scope of this definition.

Sources: *Diack in prep, Jefferson and others 2014; JNCC website; Robertson & Jefferson 2000; Rodwell 1991; Rodwell and others 2007; Tallowin and others 2014 (BD5103).*

3.2 Habitat status

Purple moor-grass & rush pasture is a S41 Priority Habitat in England reflecting its high conservation value. The habitat also supports a number of priority species - see section 5.1 for further details.

The recently published European Red List of Habitats (Janssen and others 2016) classified the component NVC types of purple moor-grass & rush pastures (EUNIS types – E3.4a moist/wet mesotrophic hay meadow & E3.5 Temperate/boreal moist-wet oligotrophic grassland) as Endangered (EN) primarily due to very substantial declines in quantity and quality suffered over the last 50 years. Specifically, this means ≥ 50% but < 80% decline over the last 50 years; a likely future decline ≥ 50% but < 80% and historic losses since c. 1750 of ≥ 70% but < 90%.

As with other types of semi-natural grassland (Bullock and others 2011), purple moor-grass & rush pastures can provide ecosystem services including nutrient capture, carbon storage, pollination, pest control, cultural benefits to society and genetic resources (see Ecosystem context).

Sources: *Bullock and others 2011, Janssen and others 2016, JNCC Priority habitats definition, Jefferson and others 2014, Rodwell 1991, Rodwell and others 2007*

3.3 Ecosystem context

Purple moor-grass & rush pastures are found mainly on infertile, moist, moderately to strongly base-rich, peats and humic or peaty gley soils, often with fluctuating water tables. They tend to be dominated by purple moor-grass and/or rush species and various sedges can be abundant. The vegetation is rarely subjected to significant surface drying, but the vegetation is normally dry enough to support extensive livestock grazing and some stands do dry out at the surface, at least locally under certain environmental conditions. Neglect through lack of grazing or cutting results in dominance by robust competive species, potentially leading to the development of tall-herb fen and/or invasion of woody species.

The pH range of the soils for the five component types is in the range 4.7 to 7.4. It occurs mostly on flat and gently sloping ground, often associated with valley-side springs and seepage lines, but also on river and lake flood plains.

Purple moor-grass & rush pastures may be very small, for example a few square metres around a discrete spring, or may consist of larger tracts often in association with other semi-natural habitats.

The habitat may occur as a component of wet pastures or fens, and often forms mosaics with dry grassland, heath, mire and scrub communities. In the Culm Measures of Devon and Cornwall for example, M24 may form mosaics and transitions to M16 *Erica tetralix-Sphagnum compactum* wet heath (forms part of Annex 1 type H4010 Northern Atlantic Wet heaths with *Erica tetralix*), M27 *Filipendula ulmaria-Angelica sylvestris* mire and neutral grassland (MG5c *Cynosurus cristatus-Centaurea nigra* grassland *Danthonia decumbens* sub-community) where soils are free-draining and often upslope from the *Molinia* meadows and other mire and fen vegetation. In calcareous landscapes, transitions from M22 to calcareous grasslands (e.g. CG2 *Festuca ovina-Avenula pratensis* grassland, CG3 *Bromus erectus* grassland, CG5 *Bromus erectus-Brachypodium pinnatum* grassland & CG9 *Sesleria albicans -Galium sterneri* grassland) and fens (M10 *Carex dioica-Pinguicula vulgaris* mire and M13 *Schoenus nigricans* mire), may occur.

Many of our existing sites are largely 'derived' habitats, with their species composition and structure resulting from past low-level drainage of other mire or fen types together with a history of traditional management by extensive grazing and, more rarely, by hay cutting and burning. More near-natural examples, though, may occur as part of transitions between mire vegetation and drier grassland or heathland habitats reflecting variations in the soil-water regime. Despite this, the derived 'agricultural grassland' versions of the habitat are valued for conservation in their own right and have their own particular suite of species and species composition compared to pre-cursor vegetation or near-natural examples.

There is increasing evidence that the presence of this and related vegetation types in catchments could be important for moderating stream/river flow rates after high rainfall events by absorbing substantial volumes of water thus contributing to aquifer/catchment re-charge after dry periods. Other ecosystem services include nutrient capture, improving water quality and carbon storage.

This habitat is widespread across central, northern and western Europe. It also occurs more rarely in the Mediterranean region (ETC BD 2012). It is widely but discontinuously distributed in Britain, with concentrations in south-west England, western and southern Wales, East Anglia, northern England and the south-west of Northern Ireland.

Sources: *Preston and others 2002; Rodwell 1991; Rodwell and others 2007; Tallowin and others 2014; Veen and others 2009.*

Metrics and attribute

4.1 Natural range and distribution

10 km square

The appropriate metric given the relatively wide distribution of the habitat across England.

4.2 Area

Hectare

4.3 Structural and functional attributes

Hydrology and hydro-chemistry are primary factors influencing the edaphic conditions of fen-meadows, rush pasture and mires (Rodwell 1991).

Structural attributes

- Vegetation community and species composition
- Pattern of vegetation zonation and transitions
- Cover of undesirable species

Functional attributes

- Properties of the underlying soils
- Surface water and groundwater quality
- Hydrological regime
- Supporting off-site habitat – to ensure optimal management of the habitat
- Functional connectivity with the wider landscape.
- Concentrations and deposition of air pollutants to at or below the site-relevant Critical Load or Level values.
- Grazing management and other vegetation management including cutting for hay and sustainable burning.

Sources: *Crofts & Jefferson 1999, Kirkham and others 2003, Robertson & Jefferson 2000, Rodwell 1991, Stevens and others 2011, Tallowin and others 2014.*

Evidence

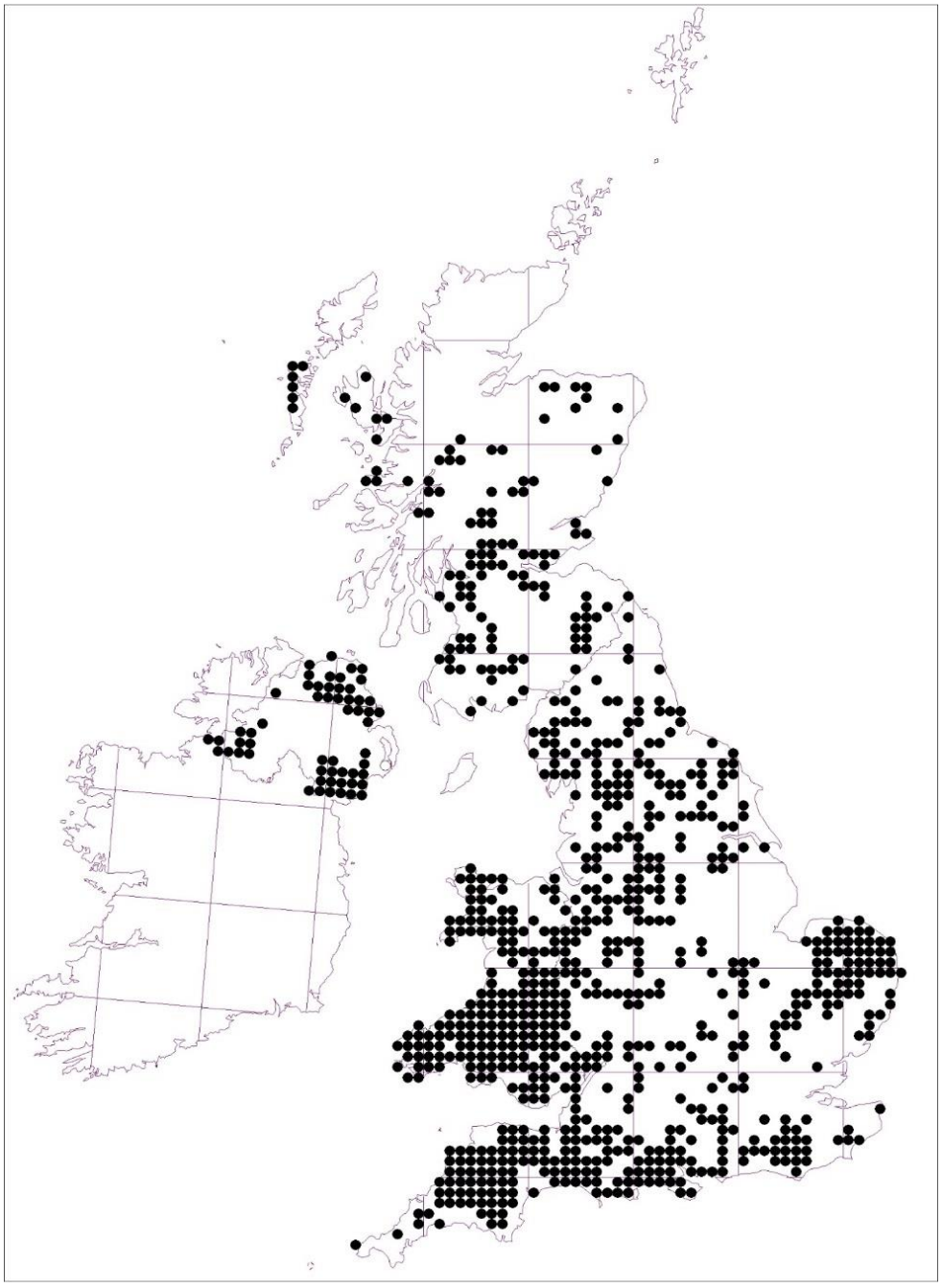
5.1 Current situation

Natural range and distribution

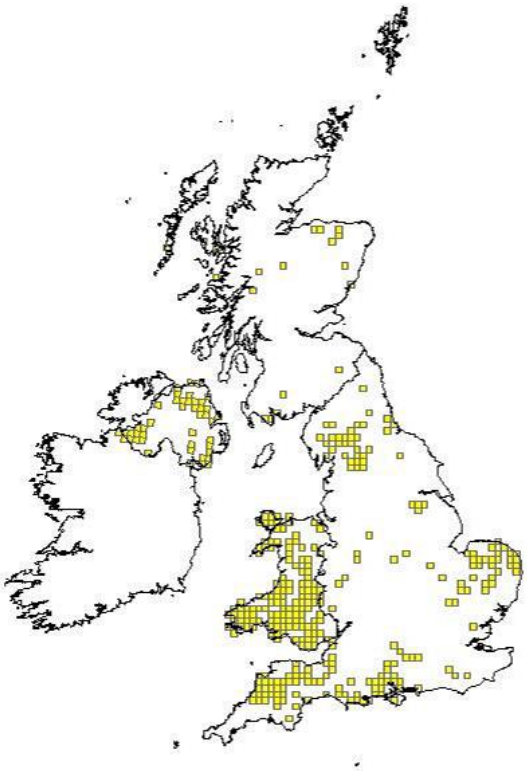
Potentially, the whole of England is able to support the habitat where suitable hydrological and soil conditions exist.

Confidence: Moderate

Map 1: Distribution of 10 km-squares supporting Purple moor-grass & rush pastures Priority Habitat in the UK



Map 2: Distribution of 10 km-squares supporting the Annex 1 habitat H6410 in the UK



Area

The current estimated area of the Priority Habitat in England is less than 10,500 ha of which the Annex I habitat (M24 & M26) is less than 2,500 ha (Robertson & Jefferson 2000).
The area of the habitat has probably remained broadly stable over the last 20 years or with some small losses probably compensated for by the restoration of sites/parts of sites that had succeeded to scrub. This assessment is based on expert opinion and not on quantitative data. This probable 'stability' has been largely due to the impact of conservation measures and programmes (both incentive schemes and statutory designations) and changes in land use policy.

Sources: *Blackstock and others 1999; Robertson & Jefferson 2000.*

Confidence: Low – moderate

Patch size

Purple moor-grass and rush pastures may be very small, for example a few square metres around a discrete spring, or may form part of larger tracts of semi-natural vegetation. Data from 2011 showed that 87% of purple moor-grass and rush pasture sites were less than 5 ha with only 6% being over 10 ha (Bullock and others 2011).

Quality of habitat patches

Purple moor-grass and rush pastures are usually managed as pasture or, more rarely nowadays, as hay meadows.

There is very little known about functional attributes as data are not routinely collected. Monitoring is based on structural attributes that partly act as a proxy for at least some of the functional attributes.

The data submitted to Europe for the latest Article 17 reporting, showed that there is approximately 50% of the PMGRP habitat in favourable condition and 50% in unfavourable condition in SSSIs. This contrasts with around 72% in favourable condition and 28% in unfavourable condition for the specific Annex 1 habitat H6410 (M24 & M26) in SACs.

There is a recorded 6,320 ha of PMGRP outside of SSSIs of which c. 62% is under an agri-environment scheme agreement and 38% not under agri-environment agreement. Whilst presence of an agri-environment scheme agreement provides some reassurance that the grassland is protected, internal scheme monitoring from a random sample of species-rich grasslands (mostly in maintenance and restoration options) indicate relatively modest improvements in condition for 25% of grasslands, with 64% showing no change and 11% declining (Wheeler & Wilson 2014). Sub-optimal performance of the scheme in improving grass condition has been attributed to poor targeting of options in the early days of Higher Level Stewardship (the previous scheme) and a lack of tailored interventionist restoration techniques (i.e. green hay introduction, seed introduction) without which recovery is unlikely within a 10 year agreement term, particularly when sites are isolated and opportunity for positive indicator species to colonise is limited.

A survey of 77 non-statutory grassland PMGRP sites resurveyed in 2017 found an overall decline in their condition since they were last surveyed in 2002. The presence of an agri-environment scheme appeared to have made little difference to site condition, although a cluster of sites within a specific focal area for Culm grassland restoration (Devon & Cornwall) that had been managed under stewardship agreements throughout the duration of the 15 year period were found to have significantly better condition compared to the rest of the sample, potentially demonstrating the value of highly-tailored advice and continued support (Wheeler & Wilson 2018). Interestingly, *Molinia*-dominated communities were found to be in better condition than those which are dominated by rushes.

For non-designated sites, data are only available from a sample survey of purple moor/grass & rush pasture as a whole 39% of stands were in favourable condition.

Sources: Hewins and others 2005; Robertson & Jefferson 2000; Tallowin and others 2014; Wheeler and others 2004, Wheeler & Wilson, 2014, Wheeler & Wilson, 2018

Confidence: Moderate

Threatened species

Purple moor-grass and rush pastures are important habitats for a number of S41 Priority species such as the Annex II butterfly marsh fritillary (*Eurodryas aurinia*), narrow-bordered bee hawk-moth (*Hemaris tityus*) and lesser butterfly orchid (*Platanthera bifolia*).

Some examples hold populations of threatened species listed in the England Red List of vascular plants (Stroh and others 2014, 2019), including bird's-eye primrose (*Primula farinosa* **Near Threatened**), Cambridge milk-parsley (*Selinum carvifolia*) – **Endangered***)*, milk-parsley (*Thyselium palustre* – **Vulnerable***)*, whorled caraway *(Carum verticillatum*) – **Vulnerable**), petty whin (*Genista anglica*) - **Vulnerable**, heath lobelia (*Lobelia urens*) - **Vulnerable**, lesser butterfly orchid (*Plantanthera bifolia*) - **Endangered**, ivy-leaved bellflower (*Wahlenbergia hederacea*) - **Near threatened** and flat-sedge (*Blysmus compressus*) - **Vulnerable**).

In addition, a range of mammals, reptiles and birds that utilise unimproved wet grassland and scrub and related habitats may use this habitat for breeding, feeding or roosting. These include several that are S41 priority species including otter, adder, grass snake, common lizard and waders such as lapwing (*Vanellus vanellus*) and curlew (*Numenius arquata*).

Sources: *Bullock and others 2011, Robertson & Jefferson 2000, Rodwell and other 2007, Stroh and others 2014 & 2019, UK Biodiversity Steering Group, 1995*

Confidence: Moderate

5.2 Historical variation in the above parameters

Much of this habitat was lost in the second half of the 20th century largely due to drainage, ploughing and conversion to reseeded, improved grassland or arable farmland. Some areas were also afforested with non-native conifers such as sitka spruce. In addition to these direct losses, some examples have been abandoned by livestock farmers, resulting, in many cases, in sites trending towards species-poor *Molinia*-dominated vegetation and/or scrub domination.

Increasing fragmentation and the isolation of sites has been an ongoing threat and there is clear ecological evidence of their negative effects on the populations of some of the species characteristic of this habitat (see Tallowin and others 2014). There is scope for analysing changes in the distribution of typical plant species of the habitat as a proxy for habitat change. For example, *Cirsium dissectum* declined between the two plant atlases (1960s to late 1990s) with a change index of -0.14 (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.

Natural range and distribution

The range has probably been stable because although there have been some losses in extent this is unlikely to have been sufficient to have affected the range of the habitat.

Area

The extent of the losses is mostly unknown but a study in Devon & Cornwall found that only 8% of the habitat that was present in 1900 remained in the 1990s with around 48% of the total area lost between 1984 and 1991.

Patch size

There is apparently no earlier data on patch size than the analysis by Bullock and others (2011) covered in section 5.1 above.

Quality of habitat patches

Very little is known of historic trends in the quality of the habitat, though decline in quality is probably more of a 20th century phenomenon as much is associated with eutrophication caused by diffuse pollution and aerial deposition of nitrogen and changes to hydrology due to water abstraction.

Threatened species

The marsh fritillary butterfly (*Euphydryas aurinia*) is closely associated with purple moor-grass and rush pastures and has experienced a significant decline in England in the number of 10 km squares occupied (> 50%) since 1970 until recently. This loss of populations is due to both habitat loss and fragmentation.

Sources: 3rd UK Habitats Directive Reporting 2013; Blackstock and others 1999; Bobbink and others 1998; Bullock and others 2011; Bulman and others 2007; Devon Wildlife Trust 1990; Fuller 1987; Hobson and others 2002; Porter & Ellis 2011; Preston and others 2002, Rodwell and others 2007; Tallowin and others 2014; UKBSG 1995.

Confidence: Low-Moderate

5.3 Future maintenance of biological diversity and variation in the habitat

The key pressures on this habitat are abandonment of management (usually the loss or insufficiency of grazing), deposition of atmospheric nitrogen and to a lesser extent, drainage, diffuse pollution, agricultural improvement and climate change.

As a nutrient-limited and usually oligotrophic habitat, it is sensitive to the deposition of atmospheric nitrogen. A critical load has been set at 15-25 kg N ha^{-1} yr^{-1} and deposition above this threshold causes negative changes in plant species composition through nutrient enrichment and soil acidification. Due to critical load exceedance in parts of its English range, air pollution is considered to be a significant pressure to the structure and function of this habitat (Stevens and others 2011).

Lack of, or insufficient livestock grazing and conversely over grazing are a threat to the conservation of the structure of this habitat type. Neglect results in dominance by *Molinia careulea* and sometimes a selection of tall herbaceous species resulting in more species-poor swards and a gradual invasion of woody species. Grazing and mowing of semi-natural grasslands with low agricultural productivity and/or difficult terrain has become less economically viable due to low forage yields, higher labour costs and limitations imposed by difficult terrain or isolation, especially in areas dominated by arable farming. Changes in social factors, including demographic changes, have also exacerbated the trend towards abandonment (Jefferson and others 2014).

A moderate presence of cattle or hardy ponies favours the permanence of the sites and can help maintain biodiversity by reducing the dominance by some species and allowing the regeneration of other small pioneer plants. In contrast, high and excessive pressure of livestock disturbs the soil structure and vegetation and can have destructive effects.

Natural England/RSPB assessed the vulnerability of this habitat to climate change as Medium. Purple moor-grass and rush pasture is sensitive to the direct impact of climate change being dependant on wet or waterlogged soils and is therefore sensitive to changes in the water table and flooding. Reduced summer rainfall is likely to promote the transition to drier habitats. Conversely, should hydrological conditions become too wet, there is potential for change to wetter swamp or fen communities. Lack of management of drainage systems may lead to wetter communities.

Natural range and distribution

The current range is adequate to maintain or restore the habitat over the next 50-100 years but the potential for range contraction is a risk in East Anglia and south-east England. This would result in a loss of examples of the habitat that express a species composition typical of these particular parts of England. Species with a southern/eastern distribution could also be adversely affected.

Area

There is little information on which to make an assessment of the habitat area required for the future maintenance of biodiversity other than some expansion would be very desirable to make up for historic losses and ensure sustainability of particular species populations such as marsh fritillary.

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.

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 the restoration of purple moor-grass and rush pasture, this indicates an ambition to restore 50% of the historical loss (based on the current status of the habitat as Endangered, a moderate number of associated threatened species/structure and function attributes somewhat degraded and the potential for restoration being moderate). Assuming a loss of 92% of the habitat (and therefore the current extent is 8% of the historical extent) this would require a minimum increase in area of c 60,000 ha.

2) Use data produced by the NE National Habitat Network Mapping project. This would indicate an increase of approximately 65,000 ha. This is based on the figure required to create a connected network of habitat incorporating existing habitat patches.

The figures are broadly similar and it is recommended that the area specified in 2) is adopted. It is justified by our knowledge of historical losses and the likely negative impacts of decreased patch size and connectivity.

Lacking any further information in relation to the increase in the area of the Annex I *Molinia* meadows required for biodiversity conservation, it is recommended that the area is increased in proportion to the increase in area of the purple moor-grass and rush pasture. Currently the Annex I habitat represents just under 24% of the purple moor-grass habitat therefore an area increase of c.16,000 ha in the Annex I habitat is recommended.

Patch size

Marsh Fritillary populations function on a landscape-scale. They are often highly cyclical with large fluctuations in population size, making them prone to local extinction, but this characteristic also allows the butterfly to colonise new sites in good years as well as patches of less suitable habitat. The butterfly persists in areas where large networks of suitable habitat exist, with groups of local populations being connected by occasional dispersal, known as metapopulations. To achieve long-term population stability, the butterfly requires an extensive network of well-connected habitat patches where the food plant, Devil's-bit Scabious (*Succisa pratensis*), is abundant. Research has shown that an area of between 80 ha and 142 ha per 1,600 ha (i.e. 5-9% of a landscape) is required to achieve persistence for 100 years, depending on the spatial location of the habitat (Bulman and others 2007).

Quality of habitat patches

The attributes listed in section 6.3 will be required to be met for maintenance of the condition of the habitat. The role and importance of functional connectivity and supporting off-site habitat are poorly understood. However, for certain component species, such factors may be critical to maintaining or expanding populations and to prevent genetic erosion.

Climate change interactions with nutrient enrichment from atmospheric deposition may accelerate negative change. Efforts to reduce nutrient enrichment from this source will continue to be necessary to maintain or restore favourable condition. Restoring natural hydrological processes on and around wetland sites is likely to improve the resilience of features. This may not always be appropriate, e.g. on sites that have been created and sustained largely by human intervention where cessation of grazing or cutting management and ditch maintenance, or other changes in hydrology or water chemistry, may lead to a shift to different, more mire/fen-like vegetation communities.

Sources: *Bulman and others 2007; Natural England/RSPB 2014; Tallowin & Smith 2001; Tallowin and others 2014.*

Confidence: Low-Moderate

5.4 Potential for restoration

Unlike drier grassland types, restoration of this habitat 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.

Restoration of the habitat from conifer plantations may present fewer difficulties especially if there has been less hydrological and soil modification and there is capacity for the typical species to spread from rides. There are examples of successful restoration from former forestry plantations (e.g. in the Culm measures in Devon and Cornwall).

Successful restoration of these communities requires a comprehensive assessment of the hydrological functioning of these wetland systems. 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, including rivers, streams, valleys and springs.

Several initiatives have contributed to the restoration of this habitat. For example on the Culm Measures (Culm Grasslands) in Devon and Cornwall, an initiative led by the Devon Wildlife Trust (DWT) is committed to restoring, re-creating and linking habitat to form more robust swathes. Degraded habitat has been restored and sites with low wildlife value prioritised for grassland re-creation. DWT has helped to develop innovative re-creation techniques including soil stripping and soil inversion, re-seeding and green hay methods and germination and establishment trials on key species such as *Molinia caerulea*. No figures are currently available for the amount of land that is under restoration (from semi-improved grassland or plantation).

There are several initiatives designed to restore former colonies of Marsh Fritillary on this and related habitats across England. This mostly involves improving the management of existing sites by scrub management and grazing. One example is the work in Cumbria that is reported in Porter & Ellis (2010).

The potential for restoration of the structural and functional attributes for existing examples of the habitat in unfavourable condition is generally good although more challenging if there has been hydrological or soil water chemistry changes due to water abstraction or pollution from diffuse or atmospheric sources. This may require action at a catchment scale in many cases.

Sources: *Porter 2014; Tallowin & Smith 2001; Tallowin and others 2014.*

Confidence: Low-Moderate

Conclusions

6.1 Favourable range and distribution

The current range for the habitat is the favourable range.

The range could be monitored using a combination of climate, topographical, soil and hydrological parameters.

6.2 Favourable area

The favourable area is 76,000 ha (the current area plus the area required to create a connected habitat network). Expansion would be by restoration from semi-improved grassland, forestry plantation or dense scrub.

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 attributes

- Typical vegetation community and species composition
- Natural pattern of vegetation zonation/transitions
- Low cover of undesirable species

Functional attributes

- Properties of the underlying soil types, including structure, bulk density, total carbon, pH, exchangeable soil Calcium (Ca), exchangeable soil acidity, soil nutrient status and fungal: bacterial ratio, are within typical values for the habitat. For this feature, soil P index should typically be index 0 (< 9 mg l^{-1}), although in a few cases, P indices of 1 or 2 have been measured on sites which may have had a past history of ploughing, for example.
- Surface water or groundwater status should be oligotrophic 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. Inundation should be absent or only occasional to a minor degree in winter. 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 e.g. contiguous or connected areas of suitable habitats[2]
- Functional connectivity with the wider landscape[2]
- Concentrations and deposition of air pollutants to at or below the site-relevant Critical Load or Level values.

- Grazing and other vegetation management including cutting for hay (combined with aftermath grazing) and sustainable burning in place. Grazing by livestock should aim to achieve an average annual density of c. 0.4 LU/ha/year, depending on site productivity and conservation objectives

[2] These two attributes are included as there is some evidence for the benefits of larger habitat patches and general connectivity of sites both between grasslands but also other habitat types. The evidence is summarised in Lawton and others 2011 and further elucidated in the forthcoming Natural England Nature Networks Evidence Handbook

At present, there is no agreed way of measuring or setting favourable values for off-site habitat or functional connectivity.

Patch size

Little is known on what constitutes a viable patch size for this habitat but seemingly, provided management is appropriate, patches of 0.5 ha or possibly smaller may be viable in the long-term, although certain fauna species will require larger patch sizes. There is much evidence for the benefits of larger patch sizes and increased connectivity a nominal target is that 95% of PMGRP by area should be in patches over 0.5 ha with no reduction in current patch size.

Quality of habitat patches

At least 95% of the favourable area of the habitat meets the structural and functional 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.

Monitoring

Favourable condition under CSM would be a good proxy but ensuring generic attribute targets and thresholds are tailored to local conditions, where appropriate. For non-statutory sites it might be worth considering slightly revised (lower) targets for favourable condition as used in Hewins (2005), although there is no doubt some non-statutory sites would meet the requirements for SSSI notification (Jefferson and others 2014). Of the other non-CSM attributes, soil nutrient status can easily be measured as can some of the hydrological requirements but the latter would require substantial additional resources.

Annex 1: References

Blackstock, T.H., Rimes, C.A., Stevens, D.P., Jefferson, R.G., Robertson, H.J., MacKintosh, J. and 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.

Bobbink, R., Hornung, M. and Roelofs, J.G.M. 1998 The effects of air-borne nitrogen pollutants on species diversity in natural and semi-natural European vegetation. *Journal of Ecology* 86, 717–738.

Bullock, J.M., Jefferson, R.G., Blackstock, T.H., Pakeman, R. J., Emmett, B. A., Pywell, R. J., Grime, J. P. and Silvertown, J. W. 2011. Chapter 6: Semi-natural grasslands. In: The UK National Ecosystem Assessment Technical Report. UK National Ecosystem Assessment, UNEP-WCMC, Cambridge.

Bulman C R, Wilson R J, Holt A. R, Bravo L G, Early R I, Warren M S, Thomas C D 2007. Minimum viable metapopulation size, extinction debt and the conservation of a declining species. *Ecological Applications* 17: 1460-1473.

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

Devon Wildlife Trust 1990. *Survey of Culm grasslands in Torridge District.* Devon Wildlife Trust, Exeter.

Diack, I in prep England FCS template change control: Alkaline fens. Natural England.

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.

Hewins, E.J., Pinches, C., Arnold, J., Lush, M., Robertson, H. and 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 636.* English Nature, Peterborough.

Hobson, R., Bourn, N. & Warren, M. 2002 Conserving the Marsh Fritillary in Britain. *British Wildlife*, 13, 404-411.

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, Peterborough, UK.

Kirkham, F.W., A Mole, A., Gardner, S.M. & Wilson, D.W. 2003. Review of Stocking Levels Recommended for Semi-natural Lowland Grasslands. *Countryside Council for Wales Contract Science Report* No. 596.

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.

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.

Porter, K. & Ellis, S. 2010 Securing viable metapopulations of the Marsh Fritillary butterfly, *Euphydryas aurinia*, (Lepidoptera: Nymphalidae) in Northern England. *Journal of Insect Conservation*, 15, 111-119.

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

Robertson, H.J. and 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, Peterborough.

Robertson, H.J., Jefferson, R.G., Wilson, P.J., Reed, M.E., McDonnell, E. & Wheeler, B. 2002 Monitoring grassland Biodiversity Action Plan targets: condition and restoration assessment methodologies for non-statutory grasslands. Interim Report, English Nature, Peterborough.

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

Rodwell, J.S., Morgan, V., Jefferson, R.G. and Moss, D. 2007. The European context of British lowland grasslands. *JNCC Report 394*. Joint Nature Conservation Committee, Peterborough.

Stevens, C.J., Smart, S.M., Henrys, P.A., Maskell, L.C., Walker, K.J., Preston, C.D., Crowe, A., Rowe, E.C., Gowing, D.J. & Emmett, B.A. 2011. Collation of evidence of nitrogen impacts on vegetation in relation to UK biodiversity objectives. *JNCC Report*, No. 447.

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.

Tallowin, J.R.B., Mountford, J.O., Savage, J., Shaw, S.C., Wallace, H.L., Prosser, M.V. & Gowing, D.J.G. 2014. *Fen-meadow, rush-pasture, mire and swamp communities: A review of knowledge gaps, restoration issues and their potential to deliver Ecosystem Services*. Defra Commissioned Research Report, Project BD5103. Defra, London.

Tallowin, J.R.B & Smith, R.E.N. 2001 Restoration of a *Cirsio-Molinietum* fen meadow on an agriculturally improved pasture*. Restoration Ecology* 9, 167-178.

UK Biodiversity Steering Group, 1995. *Biodiversity: the UK Steering Group Report. Volume 1: Meeting the Rio Challenge.* Volume 2: Action Plans. HMSO, London.

Veen, P., Jefferson, R.G., De Smidt, J & Van Der Straaten, J. eds 2009 *Grasslands in Europe of High Nature Value* KNNV Publishing, Zeist, The Netherlands.

Webb, J.R., Drewitt, A.L. & Measures, G.H. 2009 Managing for species: integrating the needs of England's priority species into habitat management. *Research Report NERR024*. Natural England, Sheffield.

Wheeler, B.D., Gowing, D.J.G., Shaw, S.C., Mountford J.O. & Money, R.P. 2004 Ecohydrological Guidelines for Lowland Wetland Plant Communities (ed. A.W. Brooks, P.V. José & M. I..Whiteman). Environment Agency - Anglian Region, Peterborough, UK.

Wheeler, B.D., Shaw, S.C. and Tanner, K. 2009 A Wetland Framework for Impact Assessment at Statutory Wetland Sites in England and Wales. Environment Agency Integrated Catchment Science Programme, Science Report SC0302. Environment Agency, Bristol.

Wheeler, B. & Wilson, P. 2014 The effectiveness of Higher Level Stewardship for maintaining and restoring species-rich grasslands: a resurvey of a sample of grasslands under HLS options HK6 and HK7. LM0443. Report to Defra.

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

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 RP2947
ISBN 978-1-78354-663-3

Cover image
Rush pasture, Devon
Rob Large, Natural England