Definition of Favourable Conservation Status for Lowland Calcareous Grassland

Defining Favourable Conservation Status Project

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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 **lowland calcareous grassland** in England. FCS is defined in terms of three parameters: natural range and distribution, area, and structure and function attributes.

This section provides the summary definition of FCS in England. Section 2 covers contextual information, section 3 the metrics used and section 4 describes the evidence considered when defining FCS for each of the three parameters. Section 5 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.

2. FCS in England
Lowland calcareous grassland is a widespread but localised habitat of high biodiversity value occurring throughout the English lowlands and along the upland fringe wherever there are suitable calcareous soils. It is normally maintained through 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 low 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, sward structure, soil nutrient and pH status, 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 6.5 to 8.5. The habitat should be grazed by livestock usually at a density of 0.15 to 0.6 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. Favourable status will require an increase in the current extent of the habitat by 149,000 ha (c. 390 % above baseline of c. 38,687ha) throughout its range and maintenance of its current range and distribution.

Definition and ecosystem context

3.1 Habitat definition and status

Habitat definition

The definition of this habitat embraces the enclosed and unenclosed calcareous grasslands found throughout the UK's lowlands and along the upland fringe but normally below c. 400m. Many habitat patches are confined to steep valley slopes, escarpments, and coastal cliffs and headlands. More rarely, they occur on relatively level ground, notably in the East Anglian Breckland and on Salisbury Plain. The habitat is usually managed by extensive sheep or cattle grazing or is more rarely maintained by rabbit grazing. Unenclosed swards in the uplands above the moor wall and managed as free-range rough grazing, sometimes in association with unenclosed tracts of other upland habitats, are not covered by the definition and fall within the upland calcareous grassland habitat.

Lowland calcareous grasslands occur throughout England on mostly shallow, free-draining, infertile lime-rich soils over chalk and limestone bedrock. They are occasionally found on other base-rich substrates such as basic igneous rocks and calcareous glacial drift deposits.

The lowland calcareous grassland priority habitat comprise ten National Vegetation Classification types (CG1-CG10) (Rodwell 1992) but only lowland examples of CG9 and CG10 are included within the definition as this is a lowland habitat as defined and described above. The ten types are as follows:

CG1 *Festuca ovina – Carlina vulgaris* grassland
CG2 *Festuca ovina – Avenula pratensis* grassland
CG3 *Bromus erectus* grassland
CG4 *Brachypodium pinnatum* grassland
CG5 *Bromus erectus – Brachypodium pinnatum* grassland
CG6 *Avenula pubescens* grassland
CG7 *Festuca ovina – Hieracium pilosella – Thymus praecox/pulegioides* grassland
CG8 *Sesleria albicans – Scabiosa columbaria* grassland
CG9 *Sesleria albicans – Galium sterneri* grassland
CG10 *Festuca ovina-Agrostis capillaris-Thymus praecox* grassland

This differs from the definition of the Habitats Directive Annex 1 type known as *H6210 Semi-natural dry grasslands and scrubland facies: on calcareous substrates (Festuco-Brometalia),* in the following ways:

- Both lowland and upland CG9 is included in H6210
- CG10 is excluded

It should also be noted that H6211 Semi-natural dry grasslands 'important orchid rich sites' is now included within H6210.

Habitat status

Lowland calcareous grassland is a S41 Priority Habitat in England reflecting its high conservation value. The habitat also supports a large number of priority species - see Ecosystem context for further details.

The recently published European Red List of Habitats (Janssen and others 2016) classified the equivalent to the lowland calcareous grassland (EUNIS type – Semi-dry perennial calcareous grassland - 1.2a) as Vulnerable (VU) primarily due to declines suffered over the last 50 years. Specifically, this means ≥ 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), lowland calcareous grassland can provide ecosystem services including nutrient capture, carbon storage, pollination, pest control, cultural benefits to society and genetic resources.

Sources: *Bullock and others 2011, Janssen and others 2016, JNCC Priority habitats definition, Jefferson and others 2014, Rodwell 1992, Rodwell and others 2007*

3.2 Ecosystem context

Vegetation similar to that of present day calcareous grassland was probably present in England in the early Holocene where it would probably have occurred on steep slopes, thin soils or exposed terrain which prevented tree growth and/or maintained by native herbivores in glades amongst woodland (e.g. Poschlod & WallisDeVries 2002). The limited evidence available supports this hypothesis (Bush & Flenley 1987). The clearance of forest in the Neolithic period onwards for pastoral agriculture would have led to an expansion of such grassland on suitable calcareous substrates.

Subsequently, these unproductive grasslands have had a long history of pastoral agricultural management, being typically used for sheep or cattle rearing.

The occurrence of lowland calcareous grassland in the landscape is largely determined by the occurrence of suitable calcareous geology and soils (rendzina or calcareous brown earths with a pH in the range 6.5 to 8.5) with individual species composition especially influenced by climate and microclimatic factors. The species composition is also affected by geographical location, altitude, topography and aspect. That said, there are examples of where the former quarrying of chalk or limestone, the creation of man-made structures using calcareous rock (e.g. railway embankments) or even the deposition of calcareous industrial wastes (Lee & Greenwood 1976) has resulted in the development, by natural colonisation, of calcareous grassland with very close affinities to 'ancient 'calcareous grassland (Jefferson & Usher 1986). In some cases, these dry grasslands may have developed in areas beyond their natural range due to the exposure of limestone substrates that may previously have been covered by drift or overburden.

Calcareous grasslands typically form mosaics with scrub and woodland communities (such as NVC types W8 *Fraxinus excelsior-Acer campestre -Mercurialis perennis* woodland, W9 *Fraxinus excelsior Sorbus aucuparia-Mercurialis perennis*, W12 *Fagus sylvatica- Mercurialis perennis* woodland, W13 *Taxus baccata* woodland and W21*Crataegus monogyna-Hedera helix* scrub).

These mosaics and transitions are mediated by past and current management which is usually related to grazing pressure, including cessation. Where soil type changes, due to drift or head deposits over calcareous rocks, then mosaics may be formed with neutral and acid grasslands and dwarf-shrub heath. Spring lines at the base of chalk or limestone slopes or escarpments may give rise to mire or wetland communities such as M22 *Juncus subnodulosus-Cirsium palustre* fen-meadow or M10 *Carex dioica-Pinguicula vulgaris* mire.

Where acid sands patchily overlie calcareous rocks such as in Breckland, then complex mosaics of calcareous and acid grassland may occur, and sometimes both may occur together with mosaics of heather (*Calluna vulgaris)*-dominated heathland. At a smaller scale, calcareous grasslands may support microhabitats such as short or long turf, grass tussocks, patches of bare ground, rock outcrops and scrub of different age classes.

In general terms, mosaics involving other habitats are more highly valued in conservation assessments (e.g. Jefferson and others 2014) and provide an important resource for species (especially invertebrates) that may require a range of habitats or habitat patches and often larger tracts of semi-natural vegetation to complete their life cycle (Webb and others 2009).They may also be indicative of areas or landscapes where natural processes relating to soils and hydrology have been less modified by intensive land management (Mainstone and others 2018).

Species of conservation concern

A large number of rare and threatened plants, lichens and fungi are associated with lowland calcareous grassland.

Vascular Plants

Around two-thirds of threatened and near threatened grassland vascular plants species are associated with calcareous grassland. The total includes some that are S41 Priority Species such as rare spring sedge (*Carex ericetorum*), basil thyme (*Clinopdium acinos*) and musk orchid (*Herminium monorchis*) or are listed on Annex II of the Habitats Directive e.g. early gentian (*Gentianella anglica*),

Threatened or near threatened species listed in the England vascular plant Red List (Stroh and others 2014) include purple milk-vetch (*Astragalus danicus*), hoary rock-rose (*Helianthemum oelandicum* subsp *incanum*) orchids such as burnt orchid (*Neottinea ustulata*) and man orchid (*Orchis anthropophorum*) and devil's bit-scabious (*Succisa pratensis*). Some of these species are range-restricted (hoary rock-rose) whilst others remain widespread (devil's-bit scabious) but all have suffered significant declines in recent years.

Many of these species are specialists of open, short swards normally maintained by grazing animals, both wild and domestic. This guild includes, for example, pasque flower (*Pulsatilla vulgaris*) which has suffered a 34% decline in Area of Occupancy over the Red List assessment period in part due to a decline in short swards as a result of lack of grazing (Walker & Pinches 2011) and is now regarded as "vulnerable to extinction" (VU). Another example is field fleawort (*Tephroseris integrifolia*) (classed as Vulnerable) which suffered a 45% decline at 22 sites in southern England over the period 1964-1967 to 2014-2016. A key factor resulting in unsuitable habitat conditions was under grazing or periods of management neglect (Stroh and others 2017).

By contrast, there are a number of threatened species that are associated with tall-herb/scrub margin vegetation/scrub especially on the northern limestones. Such species include bloody cranesbill (*Geranium sanguineum*), mezereon (*Daphne mezereum*) and common valerian (*Valeriana officinalis*).

All the component calcareous grassland NVC types are plant species-rich (c 20-40 + species 4m^2) when under favourable management.

Bryophytes

There are more bryophytes associated with calcareous grassland, in particular chalk grassland, than any other grassland type in Britain (Porley & Hodgetts, 2005). Many are strict calcicoles, including *Ctenidium molluscum*, *Campyliadelphus chrysophyllus*, *Homalothecium lutescens* and *Hypnum lacunosum*. On cool and damp north-facing calcareous slopes, bryophytes can be so abundant that their cover exceeds that of the vascular plants. One community of bryophytes on grazed north-facing chalk slopes on a small number of calcareous grassland sites is unusually rich in liverworts, including *Scapania aspera* and *Porella arboris-vitae*, and has been named the southern hepatic mat. This is considered to be of European conservation significance particular as it appears to be confined to Great Britain with most sites on the English chalk (Porley & Rose 2001).

On steep, south-facing calcareous slopes the combination of warmth from the sun, erosion and grazing by livestock may create a short, thin, parched and disturbed turf with many bare patches where thermophilous (warmth-loving) bryophytes thrive, including some threatened species. In undisturbed calcareous grassland, yellow meadow ants (*Lasius flavus*) may create large mounds, and these anthills provide a specific habitat which is favoured by certain bryophytes, including the uncommon and declining *Rhodobryum roseum*.

Four S41 bryophytes occur in short and open calcareous turf, namely the liverwort *Cephaloziella baumgartneri* and the mosses *Acaulon triquetrum*, *Weissia condensa* and *Weissia sterilis*.

Lichens

In addition to the lichen-dominated types of calcareous grassland (the *Cladonia* spp. and *Ditricum flexicaule-Diploschistes scuposus* sub-communities of CG7 *Festuca ovian-Hieracium pilosella-Thymus praecox/pulegiodes* grassland – CG7b and CG7c) calcareous grassland provides an extremely important habitat for the overall diversity of lichens including rare and threatened species (Gilbert 1993) of which two S41 species *Fulgensia fulgens* and scaly Breck lichen (*Squamarina lentigera*) are examples. The lichen flora may be associated with bare ground, ant hills, chalk pebbles or flints within the grassland. Grassland rich in terricolous lichens (= growing on soil or on the ground) is largely restricted to the Cretaceous chalk, especially in southern England. A key habitat requirement for this suite of lichens is the maintenance of open conditions either through disturbance generated by grazing, especially rabbits, or some other form of disturbance which can be anthropogenic (military training for example). Natural processes such as landslips or extreme environmental conditions (e.g. a combination of very shallow infertile soil coupled with high temperatures on south-facing slopes).

Fungi

Calcareous grassland along with other types of semi-natural acid and neutral grassland is considered to have international importance for its fungal assemblages especially of waxcap fungi and certain other fungi groups such as the earth tongues and Clavarioid fungi (Bosanquet and others 2018).
Fauna

A range of vertebrates utilise lowland calcareous grassland and associated habitats, especially scrub, for breeding, feeding or roosting. These include species of conservation concern such as stone curlew, grey partridge and adder.

The invertebrate fauna is very diverse and there are many specialist species associated with particular plant species or particular microhabitats found on calcareous bedrock and soils such as bare ground, rocky outcrops and more locally, springs and seepages.

The Pantheon database lists invertebrate species according to habitat traits, though these are rarely if ever exclusive to a particular habitat. A search of Pantheon (Webb and others 2017) using ‘calcareous substrate’ coupled with a search for eight specific calcareous grassland plant species produced a list of 206 invertebrate species illustrating the utility of Pantheon for conservation assessments and extraction of invertebrate data for specific habitats.

Lowland calcareous grassland supports a large number of rare and threatened invertebrate species. A high proportion of these are species with pronouncedly southern distributions in Britain many of which, at British latitudes, appear to require sunny situations on well-drained soils. These conditions are often particularly well met on lowland calcareous grassland.

Buglife (2018) list 18 S41 priority species as part of a longer list of 382 notable species associated with the habitat. The former include: leaf beetles such as the Hazel pot beetle (*Cryptocephalus coryli*); butterflies such as the Silver spotted skipper (*Hesperia comma*) and Adonis blue (*Lysandra bellargus*); the Wart-biter cricket (*Decticus verrucivorous*); the Phantom hoverfly (*Doros profuges*) and several moths including the Bordered gothic (*Heliophobus reticulata*), Pale shining brown (*Polia bombycina*) and the Four spotted (*Tyta luctuosa*).

As a final addendum, research over the last 40 years has demonstrated that the yellow meadow ant (*Lasius flavus*) is a keystone species in lowland calcareous grassland. It builds long-lasting mounds which considerably increase habitat heterogeneity and overall plant and animal species richness. The flora and fauna of the mounds is distinct from that of the surrounding grassland and often provides a refuge for annual and biennial plants that may have fewer niches in the adjacent grassland. For example, the uncommon winter annual wall whitlow-grass (*Draba muralis*) is often found on ant hills in calcareous grassland.

Ant hills are also an important resource for other faunal species such as green woodpecker (*Picus viridis*). The density, sizes and shapes of the mounds can be used to interpret grassland history. A more detailed but accessible summary is provided by King (2006).

Fagan and others (2010) also found that the ant *Myrmica sabuleti* abundance was significantly positively correlated with age of calcareous grassland restoration sites. The species was a good indicator for calcareous grassland restoration success.

GB and European context

Comparable grasslands are widespread through western and central Europe, with the parched types such as CG1 having affinities to calcareous grasslands in the sub-Mediterranean zone. Variations in calcareous grassland vegetation across Europe are largely related to differences in climate and soils with a clear geographic sequence from more neutral swards on less drought-prone soils in the Atlantic zone through to steppic grasslands and steppes on the very arid soils in the extreme continental climate of the Urals to south-east Europe.

However, one aspect of British calcareous grasslands that is distinctive is the fading of the more strictly Continental contingent of herbaceous species towards the north of England where lowland calcareous grassland of the Bromion phytosociological alliance (most British calcareous grassland types are placed within this alliance) reaches its north-western European limit. Here, in the Derbyshire Dales and the Pennines, calcareous swards conforming to the CG2d *Dicranum* sub-community of CG2 *Festuca ovina-Avenula pratensis* grassland represents a transition to more acidic swards of the Violion alliance with reduced frequency of typical calcicolous species.

Calcareous grasslands, which were once widespread in Europe, are now a scarce and threatened habitat. There are no overall estimates available for the extent of this habitat type in Europe as a whole. In the rest of the UK, calcareous grasslands occur widely on suitable limestone substrates in Wales, but are much more restricted in Scotland and Northern Ireland (Rodwell and others 2007).

The Annex 1 habitat H6210 occurs in 25 European countries within 7 biogeographical regions. The UK has the 6th largest area of H6210 in Europe and the 2nd largest area within the Atlantic Biogeographical region (European Union in prep).

Sources: *Barr 1997, Bosanquet 2018, Buglife 2018, Bullock and others 2011, Bush & Flenley 1987, Crofts & Jefferson 1999, Duffey and others 1974, European Union in prep, Fagan and others 2010, Gilbert 1993, Jefferson and others 2014, Jefferson & Usher 1986, King 2006, Lee & Greenwood 1976,Mainstone and others 2018, Mortimer and others 2000, Porley & Hodgetts 2005, Porley & Rose 2001, Poschlod & WallisDeVries 2002, Preston & Hill 1997, Rodwell 1991,1992, Smith 1980, Stroh and others 2014, Stroh and others 2017, UK Biodiversity Group 1998, Veen and others 2009, Walker & Pinches 2011, Webb and others 2009, Webb and others 2017.*

Metrics and attribute

4.1 Natural range and distribution
There is a close link between this habitat with geology and soils thus National Character Area (NCA) is considered as an appropriate metric. Figure 1 shows the distribution of the habitat by NCA and highlights the close link between distribution of the habitat and NCAs dominated by calcareous geology such as the Cotswolds, South Downs, Yorkshire Wolds & the Morecambe Bay limestones NCAs.
4.2 Area
Hectare
4.3 Structural and functional attributes
Grazing is a key factor in maintaining the structure and function of lowland calcareous grassland assuming the abiotic components of the ecosystem are suitable (soils including nutrient status) and there are no adverse external impacts such as point source or diffuse pollution. The presence of a moderate number of sheep, cattle or hardy ponies promotes the development and maintenance of the habitat and its component biodiversity by reducing the number of competitive, robust species and allowing other small pioneer plants to thrive. Some sites benefit from rabbit grazing combined with other forms of physical disturbance for maintaining the necessary open conditions, bare ground and short swards required for certain taxa especially invertebrates and lower plants. The detail of the structure and function attributes are listed in section 6.3

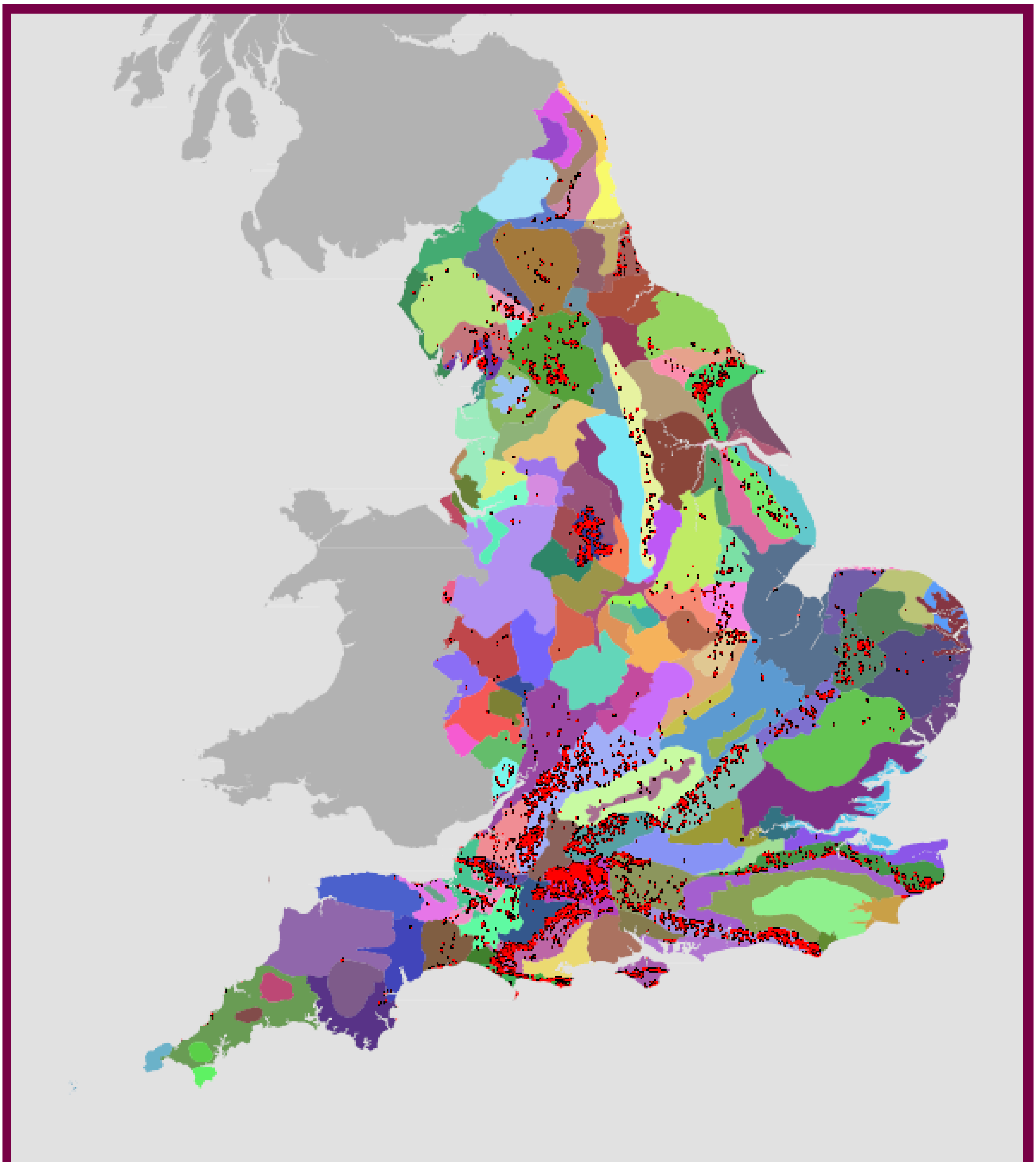
Evidence

5.1 Current situation

Natural range and distribution

The most up to date information on range/distribution is provided by Rodwell and others 2007 (see Figure 2 below). The number of occupied 10 km squares in the UK is 545 of which 399 (73%) are in England. England supports the greatest proportion of lowland calcareous grassland in the UK at around 95%.There remains the possibility that new sites may be discovered which could extend the current known distribution. However, the discovery of any significant new tract of calcareous grassland is unlikely as calcareous grassland is one of the best known habitat types in England and has been subject to much survey effort (Blackstock and others 1999). However, the range is ultimately dependent on the availability of suitable substrates although the grassland can sometimes occur beyond the range of suitable natural substrates where artificial lime-rich wastes have been colonised by the suite of species typical of the habitat.

Figure 1: Distribution of lowland calcareous grassland by National Character Area



Lowland Calcareous Grassland in England

Habitat type taken from the Priority Habitat Inventory, overlaid onto National Character Areas (NCAs)

Lowland Calcareous Grassland in England

- Lowland calcareous grassland extent
- Lowland calcareous grassland present - 1km grid

Map produced by Catherine Hudson (M995797), Evidence Services. Date: 14/01/2019.

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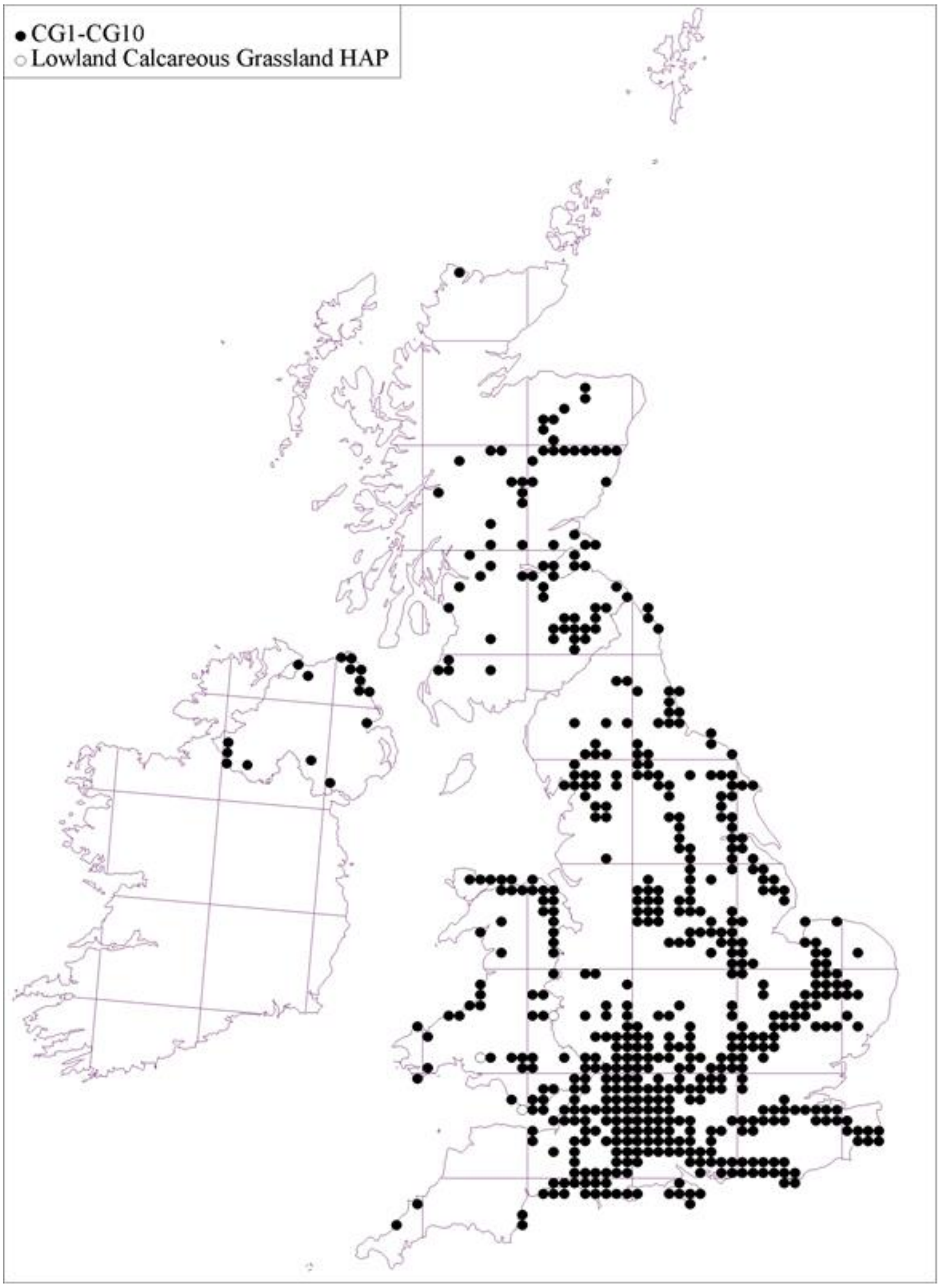
Figure 2: Distribution of lowland calcareous grassland by 10 km square



Area

It has been estimated that there is 38,687 ha of lowland calcareous grassland in England (Bullock and others 2011). An earlier assessment (Robertson & Jefferson 2000) was very similar at 38,450 ha

Network attributes:

1. **Patch size**

A recent analysis (Bullock and others 2011) showed that of the calcareous grassland sites in the Priority Habitat Inventory, 73% were less than 5 ha with only 7% over 20 ha. The Habitat Network Mapping gives a mean patch size value of 10.7 ha, a median of 1.9 ha with 90% of sites falling below 14.5 ha. As these areas of lowland calcareous grassland priority habitat have a skewed size distribution (i.e. many are very small), the median (derived by ranking the patches in size order and taking the size of the middle rank) is a better measure of the 'typical' size than the mean.

2. **Patch quality**

There is much less information on patch quality. Common standards monitoring (CSM) data for SSSIs provides an assessment of condition. In 2018, 45% (c. 17,100 ha) of the lowland calcareous grassland resource was in favourable condition with 55% unfavourable. A sample survey of non-statutory grasslands undertaken in 2004-2005 (Hewins and others 2005) showed that only 28% of lowland calcareous grasslands sites were in favourable condition. A repeat of the 2004-2005 sample survey was undertaken in 2017 & 2018 but as yet the results are not available.

Historically, (that is prior to the 1970s before the advent of large scale habitat surveys and assessment methodologies) there is little information on patch quality.

3. **Diversity**

Diversity is here defined as including both species density or richness and species diversity (the latter is a measurement of species richness combined with evenness, meaning it takes into account not only how many species are present but also how evenly distributed the numbers of each species are). Recent data on diversity is generally relatively limited – what exists is in the form of quadrat data from calcareous grassland surveys or specific research projects is widely scattered and not collated. The England lowland grassland data base contains quadrat data from calcareous grassland from the period 1980 to 1998 (Pinches & Jefferson 2011).

[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.

Sources: *Blackstock and others 1999, Bullock and others 2011, Hewins and others 2005, Pinches & Jefferson Robertson & Jefferson 2000, Rodwell and others 2007*

Confidence: *Moderate – Good*

5.2 Historical variation in the above parameters

All types of lowland semi-natural grassland, including calcareous grasslands, have suffered large losses in the 20th century in lowland England & Wales with an estimated 97% loss over the period 1930 to 1984 (Fuller 1987). More recently a 47% loss has been reported between 1960 and 2013 on sites known to have supported semi-natural grassland but SSSIs were found to have retained more grassland (91%), compared with non-protected sites (27%), thus highlighting their effectiveness as a means of protecting semi-natural grasslands (Ridding, Redhead & Pywell 2015).

Over the last 90 years, lowland calcareous grasslands have been degraded or lost due to agricultural intensification. These changes have involved conversion of grassland to arable, by ploughing, reseeding and treatment with fertilisers and herbicides.

In addition to direct loss, significant areas have ceased to be used for grazing and/or have experienced a loss of their rabbit populations, resulting, in many cases, in sites losing plant diversity, with fewer open areas for specialist species and/or larger areas becoming dominated by scrub. Abandonment of management can be as damaging for this type of grassland as agricultural intensification. Increasing fragmentation and isolation of sites has and is an ongoing threat, with many lowland calcareous grassland sites now small in extent (see section 5.1).

Loss & fragmentation

Island biogeography theory predicts that the decreasing extent and fragmentation of semi-natural grasslands over the last 50-100 years will ultimately result in losses of species from remaining areas of grassland habitat. Long transient times in response to decreasing habitat area and increasing isolation due to fragmentation may cause the present plant (and animal) species distribution to reflect the historical rather than the present landscape configuration. Hence, current species populations are possibly not yet in equilibrium with the current landscape configuration, but rather reflect that of the past.

Such 'extinction debt' has been demonstrated for semi-natural grasslands in continental Europe (Krauss and others 2010, Saar and others 2012) but to date, not for England/UK. However, the principles outlined in Lawton and others (2010) of 'better, bigger, more and joined' should be applied if they are to be conserved effectively. 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 (e.g. see Matthies and others 2004) .

Impact of these changes:

Natural range and distribution

The natural range of calcareous grassland is ultimately dependent on the availability of suitable calcareous substrates. It has probably not radically changed over the last 100 years. Some new areas of suitable substrate outside of the natural range have arisen due to limestone quarrying activities and waste generated by specific industries. These areas can support calcareous grassland due to natural colonisation by the suite of species typical of the habitat. However, within the range the distribution, extent and size of individual sites has markedly changed over the last 50-100 years as detailed below.

Area

Significant areas of lowland calcareous grassland have been lost during the last 60 years, though it is rarely possible to provide accurate figures. In addition, losses of calcareous grassland to arable cultivation also predate the post-war agricultural revolution and Keymer & Leach (1990) and Jefferson and others (2014) provide some figures of losses for selected geographical areas from the early 1800s to the 1990s. For example there was an estimated loss of 76% of the area of chalk grassland in Dorset between 1793 and 1811. At a smaller scale, but typical of more widespread losses, there was an 88% reduction in the area of chalk grassland on Chanctonbury Hill, West Sussex between 1947 and 1991 (Robertson & Jefferson 2002).

An analysis by Burnside and others 2003 found that there was a 42% loss of calcareous grassland in the western South Downs between 1971 and 1991 largely due to agricultural intensification, especially conversion of grassland to arable. Over the same time the number and density of patches of grassland also declined - a 72% decline in patch number.

Patch size

An assessment of patch size based on data from the late 1960s for chalk grassland (a subset of calcareous grassland) (Keymer & Leach 1990) showed that of 1225 documented sites or fragments 76% were between 2 and 20 ha in size with only around 12% exceeding 40 ha. A later analysis, although not fully comparable (Bullock and others 2011) showed that of the calcareous grassland sites in the Priority Habitat Inventory, 73% were less than 5 ha with only 7% over 20 ha. This indicates that in addition to an overall reduction in extent, there was also a decline in size of remaining patches.

Patch quality

Detailed data on patch quality (such as site condition assessments) is only available for a limited period (last 15-20 years) and mostly for SSSIs (see section 5.1). As for diversity (see below), patch quality is likely to have declined over the last 50-100 years although no detailed studies are available (see 5.3 for more detail).

Diversity

Diversity is likely to have declined both at the individual patch level and at the landscape scale over the last 50-100 years although no detailed studies are available. This assessment is based on what is known of the likely cumulative impacts of land use change, grazing intensity and point source and diffuse pollution.

Summary of ecological impacts

The known ecological impacts are summarised below but it is important to emphasise that actual detailed evidence to support these impacts is rarely available:-

- Reduction in the extent and variety of plant and animal-rich assemblages that occur on calcareous substrates managed by grazing
- Reduction in the species-richness of the calcareous grassland plant communities through impacts such as atmospheric nitrogen deposition and fertiliser overspread and at least the potential for species extinctions through ‘extinction debt’
- Reduction in the populations of specialist species associated with the habitat due to impacts such as grazing abandonment, insufficient habitat area to maintain viable populations and eutrophication of soils – see some examples given under ecosystem context (section 3.2)

Sources: *Barr 1997, Bobbink and others 1998, Bullock and others 2011, Burnside 2003, Janssen and others 2016, Jefferson & Pinches 2018, Jefferson and others 2014, Keymer & Leach 1990, Lawton and others 2011, Ridding and others 2015, Robertson & Jefferson 2002, Tilman and others 1994, Van den Berg and others 2011.*

Confidence: *Poor- Moderate*

5.3 Future maintenance of biological diversity and variation in the habitat

Current pressures and threats

The main pressure and threat is a lack of, reduced or inappropriate grazing. Other significant pressures include negative impacts from nutrient enrichment (nitrogen) from atmospheric sources (Van den Berg and others 2011), agricultural intensification including ploughing and grassland improvement via the use of fertilisers. Vulnerability to climate change has been assessed as low but recent work (Basto and others 2018) has highlighted potential negative impacts on vegetation composition and soil seed banks from long-term drought which is predicted to occur with climate change. Basto and others 2018 thus highlight a potential increased climate change vulnerability over the longer term.

Thus, the vulnerability assessment should be regularly reviewed as the results of further research are appraised.

Future prospects for*:*

Natural range and distribution

There is no existing evidence to suggest that there will be any change in range and distribution in the future and maintenance of the current range and distribution should conserve the floristic and faunal diversity associated with the habitat. However, given the evidence from European studies showing extinction debt for grasslands (Section 5.2) then this conclusion may need to be revised. It is expected to be relatively robust to the direct threats posed by climate change, although the climate space of some of its component species is projected to change. The potential range of the habitat is probably unlikely to change greatly over the next 50-100 years but there may be changes in the distribution of certain component species, including range expansions. In addition, with regards to southern calcareous grasslands, potential colonisation by species occurring in northern France in particular, will be constrained by the Channel therefore there is a risk of vacant niches.

Area

There is little information on which to make an assessment of the habitat area and site size required for the future maintenance of biodiversity. Some expansion would be very desirable to make up for historic losses and ensure sustainability of threatened species populations such as those mentioned in section 3.2 above.

There are 3 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 indicative area of habitat potential from Natural England’s Habitat Network Mapping project. This indicates that potentially 1,500,000 ha have appropriate soils for the development of lowland calcareous grassland.
2) 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 lowland

calcareous grassland, this indicates an ambition to restore 90-100% of the historical loss (based on the current status of the habitat as Vulnerable, a high number of associated threatened species 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 1,126,000 ha.

3) Use data produced by the NE National Habitat Network Mapping project. This would indicate an increase of approximately 149,000 ha (390% increase). This is based on the figure required to create a connected network of habitat incorporating existing habitat patches.

It is recommended that the area specified in 3) is adopted. Of the remaining two area expansion targets, 1) represents the full potential for the habitat and FCS is not considered to require the full potential. Option 2) is very ambitious and would represent over a 3000% increase on the current area. It is considered that option 2) is too ambitious and this level of increase is unlikely to be required to achieve FCS.

Option 3) is relatively ambitious. However, it is considered that the extent is justifiable given our knowledge of historical losses of calcareous grassland (Keymer & Leach 1990) and the likely negative impacts of decreased patch size and connectivity (see section 5.2). In addition, in terms of suitable habitats for restoration, there is likely to be sufficient areas of land that have the potential for restoration. Also, Barr (1997) calculated that the area of land in England that could potentially support the habitat in terms of suitable substrate amounted to 26.5 M hectares of which the current extent of calcareous grassland is c 1.5%. Barr (1997) also calculated that 1, 140 000 ha may have at one time of been calcareous grassland and was in a land use that could potentially revert. The current extent is around 3% of this estimate.

Patch size

Little is known on what constitutes a viable patch size for this habitat but seemingly, provided management is appropriate, patches as small as 0.5 ha may be viable in the long-term. This is the minimum size for qualification as an SSSI (Jefferson and others 2014).

A focus on conserving larger patch sizes and ensuring greater connectivity is clearly important (e.g. Lawton and others 2010). However, as pointed out by Reisch and others (2017), a comprehensive conservation approach should also consider the genetic diversity of calcareous grassland plant species. They concluded that populations in smaller grassland fragments may, depending on historical landscape configuration, substantially contribute to the genetic variation of the plant species even under conditions of habitat deterioration. These populations in small fragments should therefore be included in strategies to conserve calcareous grassland.

Certain animals require larger patch sizes, although precise details are often lacking. One species where some information is available is the Marsh Fritillary a species associated with both purple moor-grass and rush pastures and lowland calcareous grassland. 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. At a site level, optimal management usually involves extensive grazing regimes using cattle at around 0.4 livestock units per hectare. 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).

Patch quality & diversity

Although the evidence base is limited, there is a likelihood that patch quality and species diversity of calcareous grassland sites has probably declined over the last 90 years, at least in some geographical areas, due to a range of impacts including nutrient enrichment and management changes (see 5.2). The lack of available data on these changes makes it challenging to decide on what constitutes an appropriate baseline. However, there is definitely scope for analysis of historic calcareous grassland datasets to examine this issue in more detail.

A particular example of a shifting baseline, although not calcareous grassland, are data form the long-running Rothamsted Park Grass neutral grassland plots showed a shifting baseline of species richness in plots with the baseline dropping by 15 species m^2 over a 130 year period (Dodd and others 1994).

Should the CSM favourable condition baseline plus species richness and species composition variables from the National Vegetation Classification and other unpublished vegetation data (Rodwell 1992) be used as measures of quality and diversity then, assuming the pressures of nutrient enrichment and lack of management are reduced over time, then quality and diversity of patches can be maintained or even enhanced.

Sources: *Barr 1997, Basto and others 2018, Bulman and others 2007, Dodd and others, Jefferson and others 2014, Keymer & Leach 1990, Rodwell 1992, Van den Berg and others 2011.*

Confidence: Poor

5.4 Potential for restoration

The most common cause of unfavourable condition of existing sites is a lack of or inappropriate grazing. This can be readily addressed although practical reasons relating to the availability of grazing animals or the need for associated infrastructure (fencing, water supply, access etc) can hinder progress. In some cases, nutrient enrichment from local point sources can result in unfavourable conditions which can take several decades to reverse depending on the level of intervention. Calcareous grasslands are less prone than some other types of semi-natural grassland to the impact of atmospheric nitrogen deposition as they are P-limited systems.

Restoration and creation of new calcareous grasslands has been the focus of activity as a result of Biodiversity Action planning and agri-environment schemes over the last 20 years. The targeting and methodology of grassland habitat restoration is now well understood due to a considerable body of research effort (see Pywell and others 2013).

There are many examples of successful restoration (e.g. Wilson and others 2013) although the timescales for such grasslands to resemble ‘ancient’ examples, at least in terms of their floristic composition, may take up to at least a century (Gibson & Brown 1991, Redhead and others 2014, Wagner and others 2019).

The best examples of restoration though are where very infertile, exposed calcareous substrates border or are surrounded by existing calcareous grassland. These appear to readily re-colonise naturally over time (Wilson and others. 2013).

From an invertebrate perspective, Woodcock and others (2015) found that when the aim is to create new grasslands on ex-arable, establishing plant communities typical of species-rich grassland is a prerequisite for ensuring the success of grassland creation. This can be achieved by the use of appropriate seed-mixtures or the use of green hay / brush-harvested seed (natural seeding). However landscape factors, primarily the proximity of existing semi-natural grassland, plays an important role in determining whether invertebrates successfully colonise sites irrespective of their floral composition. Immediate proximity of existing sites is likely to be very important for colonisation by less mobile species such as some species of grasshoppers and crickets.

Allison and others (2016) provided evidence that for the conservation of specialist macro-moth species restricted to calcareous grassland, agri-environment scheme (AES) interventions are most effective if positioned close to the habitat.

Natural range and distribution

Natural range/distribution would be largely unaffected unless former quarrying created opportunities for restoration in areas beyond the natural distribution of calcareous geology and soils.

Area

In theory, there are no immovable constraints to increasing the area of the habitat subject to having a favourable policy and legislative environment and the necessary financial resources, the latter most likely via agri-environment payments.

The recommendations in Lawton and others 2011 are highly relevant here in that this report advocates i) the improvement of the quality of existing sites, ii) increasing the size of existing sites and iii) enhancing the connectivity of existing sites by way of habitat restoration and creation.

Patch size

Patch size and connectivity can readily be increased through habitat creation and restoration.

Patch quality

Given adequate resourcing, there should be no hindrance to achieving structural and functional requirements on sites though for newly created sites, as noted above, it may take many decades to achieve the quality attributes. In areas where calcareous grassland occurs in areas dominated by arable agriculture, there would be benefits in a general shift towards more mixed farming systems which might possibly be facilitated by provision of targeted incentive schemes. This would provide more opportunities for sustainable grazing management.

Diversity

The impact of lowland calcareous grassland restoration and expansion will be beneficial for grassland species assemblages, priority species and for certain species requiring larger areas of habitat such as stone curlew.

Sources: *Gibson & Brown 1991, Lawton and others 2010, Pywell and others 2013, Redhead and others 2014, Wilson and others 2013, Woodcock and others 2015.*

Confidence: *Good*

Conclusions

6.1 Favourable range and distribution
The current range (see section 5.1) is likely to be favourable for future maintenance of the habitat. The favourable area will fall within the current range (including historic and current occurrences) but will ultimately include the areas of restored habitat that constitute Favourable Conservation status for the habitat. The range could be monitored using a combination of climate, topographical and soil/substrate parameters.
6.2 Favourable area
The favourable area is set at c. 188,000 ha which is the current area increased by 149,000 ha. This would involve restoration largely from semi-improved grassland, arable and dense scrub. The rationale for this target is set out in section 5.2. Temporal changes in the 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 good prospect of monitoring favourable area.
6.3 Favourable structural and functional attributes
Structural attributes • Typical vegetation community and species composition at desired frequency and cover[1] • Natural pattern of vegetation zonation/transitions/mosaics • Low cover of undesirable species • The presence of some bare ground for regeneration niches and supporting habitat for specialist Invertebrates, vascular plants, bryophytes, lichens and fungi • The presence of rock outcrops, chalk/limestone pebbles and flints especially in relation to bryophytes and lichens • Micro and macro topographic heterogeneity • The presence of ant-hills of the yellow meadow ant in sites within the species natural range (see section 3.2) • Vegetation heterogeneity (including scattered scrub of different age classes) and suitable ‘floweriness’ (nectar/pollen resources) to benefit fauna especially invertebrates (See Webb and others 2009) **Functional attributes** • Properties of the underlying geology (solid and drift) – calcareous rocks and drift deposits, including equivalent artificial alkaline substrates

- Properties of the underlying soil types within typical values for the habitat, including; structure, bulk density, total carbon, pH, exchangeable soil calcium (Ca), exchangeable soil acidity, soil nutrient status and fungal: bacterial ratio. For this feature, soil P index should typically be index 0 (< 9 mg l -1). However, P indices of 1 or 2 have been measured on sites which may have been cultivated in the past.
- 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 at or below the site-relevant Critical Load or Level values.
- Suitable grazing management by livestock appropriate to deliver conservation objectives, usually within the range 0.15 to 0.6 LU/ha/year[1], depending on site productivity and conservation objectives
- Presence and activity of rabbits at sustainable levels (principally creation of bare ground and short turf) to deliver habitat and species objectives at selected sites
- Biotic and abiotic processes which create and maintain bare ground and early successional communities (e.g. slope processes – soil creep, solifluction)

[1] Annex 2 lists typical and positive indicator plant species for the habitat.

[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 calcareous grasslands but also other habitat types. The evidence is summarised in Lawton and others 2011 and further elucidated in the Natural England Nature Networks Handbook (Crick and others 2020).

Further refinement of the parameters of this attribute will depend on the use and application of a range of tools which can be deployed nationally and locally (e.g. NE Habitat Network mapping and Condatis, a decision support tool to identify the best locations for habitat creation and restoration to enhance existing habitat networks and increase connectivity across landscapes).

Note that the structure and function attributes apply to the habitat and it may be that certain species of conservation concern (see section 3.2) may require additional attributes to those detailed above to meet FCS.

1 May not apply under certain specific grazing regimes such as mob stocking

Sources: *Bullock and others 2011, Crick and others 2020, Critchley and others 2002, Crofts & Jefferson 1999, Duffey and others 1974, King 2006, Kirkham and others 2003, Lawton and others 2011, Robertson & Jefferson 2000, Rodwell 1992, Webb and others 2009.*

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Annex 2: Constant and positive indicator species for lowland calcareous grass

Constant species from component National Vegetation Classification types

Avenula pratensis, Avenula pubescens, ***Brachypodium rupestre*** (formerly **pinnatum**) , *Briza media,* ***Bromopsis erecta****,* ***Campanula rotundifolia****, Carex flacca,* ***Carlina vulgaris****,* ***Cirsium acaule****,, Ctenidium molluscum, Dactylis glomerata, Festuca ovina, Festuca rubra,* ***Galium sterneri****,* ***Helianthemum nummularium****, Hypnum cupressiforme, Koeleria macrantha,* ***Leontodon hispidus****,* ***Linum catharticum****,* ***Lotus corniculatus****,* ***Pilosella officinarum****, Plantago lanceolata,* ***Poterium sanguisorba****, Pseudoscleropdium purum,* ***Scabiosa columbaria****,* ***Sesleria caerulea****, Taraxacum agg,* ***Thymus polytrichus/pulegiodes****, Viola riviniana*

Typical species indicating favourable condition (from Robertson & Jefferson 2000 and additions from Robertson and others 2002)

Those in bold above plus:

Agrimonia eupatoria, Anthyllis vulnaria, Arenaria serpyllifolia, Asperula cyanachica, Astragalus danicus, Betonica officinalis, Blackstonia perfoliata, Campanula glomerata, Centaurea nigra agg*, Centaurea scabiosa, Centaurium erythraea, Cladonia spp, Clinopodium acinos, Clinopodium vulgare, Erigeron acris, Euphrasia* spp*, Filipendula vulgaris, Fragaria vesca, Gallium verum, Gentianella* spp*, Geranium sanguineum, Helianthemum appeninum, Helianthemum oelandicum, Hippocrepis comosa, Hypericum pulchrum, Knautia arvensis, ,Lathyrus pratensis, Leontodon saxatilis, Leucanthemum vulgare, Myosotis ramossisimia, Onobrychis viciifolia, Ononis repens/spinose, Orchidaceae* spp*, Origanum vulgare, Phyteuma tenerum, Pimpinella* spp*, Plantago media, Polygala spp, Primula veris, Scilla* spp*, Sedum* spp*, Serratula tinctoria, Succisa pratensis, Teucrium scorodonia, Tragopogon pratensis, Trinia glauca, Viola hirta.*

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** .

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