National Vegetation Classification: MG5 grassland

Unimproved neutral grassland, including hay meadows, known under the National Vegetation Classification (NVC) system as MG5 grassland, was once the ubiquitous type of old meadow and pasture in the English lowlands. Since the late 1960's it has sustained large losses due to drainage, ploughing and re-seeding and from the use of high rates of fertilisers. There is now less than 6,000 ha remaining in England. This technical note has been developed to explain the characteristics and value of MG5 grassland and to consider how further losses can be prevented.

What are MG5 grasslands?

The primary biological interest of MG5 grassland *Cynosurus cristatus – Centaurea nigra* or in English crested dog's-tail – common knapweed, is the rich assemblage of mostly widespread, unsown, native plants rather than the presence of rare species (Rodwell 1992). Herbaceous plants usually comprise a substantial proportion of the herbage and exceptionally may be as high as 95% cover (Cooper 1997). MG5 grasslands are species-rich ranging from around 12 to 38 plant species in a 4 m^2 quadrat with an average of around 23/species/4 m^2 (Rodwell 1992).

MG5 grassland in spring © Dave Mitchell

MG5 grassland in early summer © Stuart Smith/CCW

Characteristic herbs include:

- common knapweed *Centaurea nigra;*
- ox-eye daisy *Leucanthemum vulgare;*
- bird's-foot trefoil *Lotus corniculatus;*
- lady's bedstraw *Galium verum;*
- common sorrel *Rumex acetosa;*
- yellow meadow vetchling *Lathyrus pratensis;*
- meadow buttercup *Ranunculus acris;*
- ribwort plantain *Plantago lanceolata;*
- cowslip *Primula veris;*
- common cat's-ear *Hypochaeris radicata.*

Characteristic grasses include:

- crested dog's-tail *Cynosurus cristatus;*
- quaking grass *Briza media;*

First edition 2 April 2013

www.naturalengland.org.uk

- sweet vernal grass *Anthoxanthum odoratum;*
- yellow oat-grass *Trisetum flavescens*;
- red fescue *Festuca rubra;*
- common bent *Agrostis capillaris*.

Rare or scarce species that do occur in MG5 grassland include:

- sulphur clover *Trifolium ochroleucon;*
- meadow saffron *Colchicum autumnale;*
- green-winged orchid *Anacamptis morio;*
- greater butterfly orchid *Platanthera chlorantha;*
- French oat-grass, *Gaudinia fragilis;*
- whorled caraway *Carum verticillatum;*
- wood bitter vetch *Vicia orobus.*

Exceptionally, sites exceeding 40 species/4 m^2 have been documented (Gibson 1997, 1998) and these have probably had a long continuity of low-intensity 'traditional' grassland management and exhibit micro-scale spatial variation in soils (especially pH), slope, aspect and hydrology (Gibson 1998).

MG5 is now known to be more diverse in its floristic composition across its geographical range than the account in Rodwell (1992) indicates (Rodwell *et al* 2000). Although not listed in the published floristic table (Rodwell 1992), great burnet *Sanguisorba officinalis* can sometimes occur at high frequency and cover in MG5 grassland, especially in the east Midlands and eastern England. This has sometimes led to such swards being incorrectly labelled as MG4 (seasonally flooded unimproved neutral grassland). In the latter community great burnet is a constant species along with meadow foxtail *Alopecurus pratensis* and meadow sweet *Filipendula ulmaria,* which are generally much less frequent in MG5.

Species normally associated with woodlands that are sometimes found in MG5 grasslands include:

- wood anemone *Anemone nemorosa;*
- bluebell, *Hyacinthoides non-scripta;*
- wild daffodil *Narcissus pseudonarcissus;*
- goldilocks *Ranunculus auricomus;* and exceptionally
- oxlip *Primula elatior*.

MG5 grassland with greater butterfly and common spotted orchids © Stuart Smith/CCW

Some species are probable indicators of long continuity of 'traditional' management (ie no phase of land use change such as ploughing and conversion to crops, woodland establishment etc). These include:

- betony *Stachys officinalis;*
- devil's-bit scabious *Succisa pratensis;*
- dyer's greenweed *Genista tinctoria;*
- saw wort *Serratula tinctoria;*
- wood anemone *Anemone nemorosa;*
- pignut *Conopodium majus;*
- bitter vetch *Lathyrus linifolius;*
- meadow saxifrage *Saxifraga granulata;*
- burnet saxifrage *Pimpinella saxifraga;*
- pepper saxifrage *Silaum silaus*;
- small sedges, in particular, spring sedge *Carex carophyllea*.

However, this is not a universal rule and a few of these species (eg pignut) can tolerate a certain amount of *in situ* improvement through addition of fertilisers. Damper forms of MG5 may include some species more typical of purple moor grass and rush pasture communities (M22-26) (albeit at lower frequency), such as:

- rushes *Juncus spp*;
- greater bird's-foot trefoil *Lotus pedunculatus*;
- meadowsweet *Filipendula ulmaria*;
- carnation sedge *Carex panicea*;
- flea sedge *Carex pulicaris;*
- cuckoo flower *Cardamine pratensis*.

MG5 grasslands are not known for their richness of mosses, liverworts or lichens. Those species that do occur are widespread ubiquitous species such as the mosses:

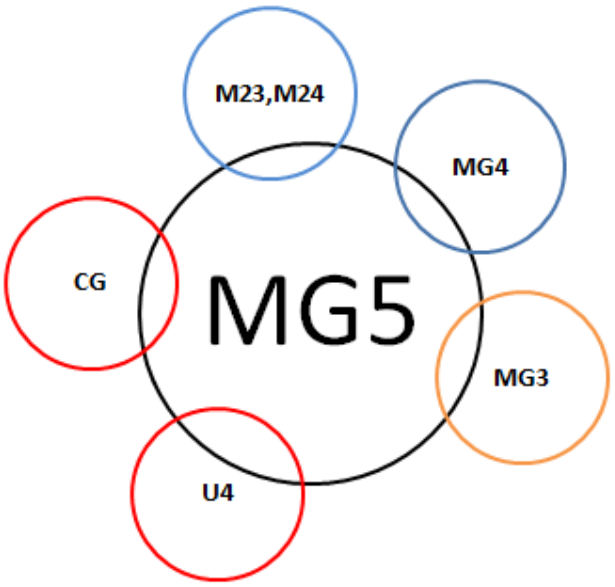
- *Brachythecium rutabulum;*
- *Kindbergia praelonga;*
- *Scleropodium purum; and*
- *Rhytidiadelphus squarrosus*

Transitions

MG5 can form transitions with other semi-natural vegetation communities. These may be related to changes in geology, soil type (notably pH), slope, topography and hydrology.

Common transitions are to:

- Various types of calcareous grassland (CG).
- Fen meadows/rush pastures eg M23 *Juncus effusus/acutiflorus-Galium palustre* rush-pasture and M24 *Molinia caerulea – Cirsium dissectum* purple moor-grass–meadow thistle fen meadow.
- Acid grassland especially U4 *Festuca ovina-Agrostis capillaris-Galium saxatile* grassland.
- Neutral grassland eg MG4 as discussed above and, in the northern uplands, MG3 *Anthoxanthum odoratum-Geranium sylvaticum*.



Possible vegetation transitions between MG5 and other semi-natural grasslands

Key to transition factors

- Blue = hydrology, topography;
- Red = soil type especially pH and nutrient status;
- Orange = altitude/latitude.

MG5 grassland for fungi

Along with other drier semi-natural grasslands, MG5 grasslands can provide a habitat for communities of macrofungi, including waxcaps and pinkgills and, indeed some may independently qualify as SSSI for their fungal interest. Further information on the importance of semi-natural grasslands for fungi can be found in Genney *et al* 2009 and Griffith *et al* 2004.

MG5 grassland for birds

A large proportion of bird species in Britain use grassland at some time during the year and many species show preferences for this habitat. However, few can be termed grassland specialists as most also make some use of arable habitat.

In general, the remaining small and fragmented individual areas of MG5 grassland are rarely important for their bird interest in a national context although the large losses of such grasslands since WWII have undoubtedly contributed to the declines in farmland bird populations across Great Britain (Vickery *et al* 2001). Nonetheless, existing areas of MG5 may support ‘generalist’ farmland birds for breeding and/or foraging in summer or winter such as meadow pipit, skylark, yellowhammer, starling, fieldfare, species of gulls and rook.

Hedgerows, where present, may also support a range of species for breeding, shelter and foraging throughout the year, including species of conservation concern such as blackbird, bullfinch, dunnock, marsh tit, mistle thrush, turtle dove and whitethroat.

MG5 grassland and mammals

The majority of native mammals are primarily adapted to woodland and few are grassland specialists. However, there are quite a few species that use grassland (including MG5) and associated hedgerows for shelter, breeding and feeding including mole, brown hare, badger and various species of bats may forage over grasslands (see Crofts & Jefferson 1999, Harris & Yalden 2008).

MG5 grassland and invertebrates

The invertebrate assemblages found on MG5 grassland have not been intensively studied but evidence suggests that MG5 pastures, in particular, may have significant invertebrate interest. There is some data available on invertebrates associated with MG5 from a research study undertaken for Defra and English Nature on a site in Somerset (Tallowin 2005).

In particular, plant-feeding species are well represented such as:

- grasshoppers and crickets;
- butterflies and moths;
- plant hoppers;
- plant bugs.

Common butterflies such as meadow brown *Maniola jurtina*, ringlet *Aphantopus hyperanthus*, common blue *Polyommatus icarus*, small copper *Lycaena phlaeas* and small heath *Coenonympha pamphilus* can often be found on these grasslands either breeding or utilising the nectar resource.

Various day-flying moths occur on MG5 and other unimproved grasslands. These include several widespread species whose larva feed on leguminous plants such as the 5-spot burnet *Zygaena trifollii*, burnet companion *Euclidia glyphica* and mother shipton *Callistege mi*. Others include chimney sweeper *Odezia atrata* and the endangered grass rivulet *Perizoma albulata* the larva feeding on pignut *Conopodium majus* and yellow rattle *Rhinanthus minor* respectively.

Flowers and seed heads of meadow plants, particularly in the families *Asteraceae* (yellow/white flowered daisies, hawkweeds etc), *Fabaceae* (legumes including clovers and trefoils), and *Umbelliferae* (carrot family), support specialist seed and gall forming insects, especially larvae of micro-moths, weevils and small flies. In addition, nectar and pollen feeding species such as bumblebees are well represented (see Dicks 2002).

In Wales, clusters of MG5 are important for invertebrates and, in particular, scarce and declining species such as the shrill carder bee *Bombus sylvarum* and the hornet robber fly *Asilus crabroniformis* (Stevens *et al* 2010).

The historic value of MG5 grassland

As a result of the long continuity of management, MG5 grassland can also contain some of the nation's best-preserved archaeological sites as ‘earthworks’ - visible 'humps and bumps'. These sites, which can include ancient ridge and furrow or deserted medieval villages, provide us with valuable information about how our ancestors lived and worked.

Maintaining them in grassland is their best form of management, as this ensures their long-term preservation and visibility. However, careful site management is still needed as these sites are susceptible to damage from livestock poaching, burrowing animals and the encroachment of vegetation, as well as more obvious issues such as new planting or fencing and land drainage.

All known sites are recorded on Historic Environment Records maintained by local authorities and some are nationally important sites – ‘Scheduled Monuments’; that are protected by law from damaging works.

It is thought that MG5 grassland is an artefact of post-Neolithic farming. However, if the prehistoric vegetation was more parkland than closed woodland (Vera 2000) then it is possible that vegetation analogous to MG5 and other neutral grassland types could be construed as being near natural vegetation (Peterken 2009).

MG5 grassland and ecosystem services

Ecosystem services are the benefits society gets from the natural environment. These include cultural services such as:

- the conservation of biodiversity and people's enjoyment of the countryside;
- regulating services, such as carbon storage, flood protection, clean air and water; and
- provisioning services such as the production of food, timber and other resources.

MG5 grasslands contribute to the provision of ecosystem services, for example, carbon storage, pollination and predator services and they are a source of seed/hay for grassland restoration - see Bullock *et al* 2011, for more information.

Where does MG5 grassland occur?

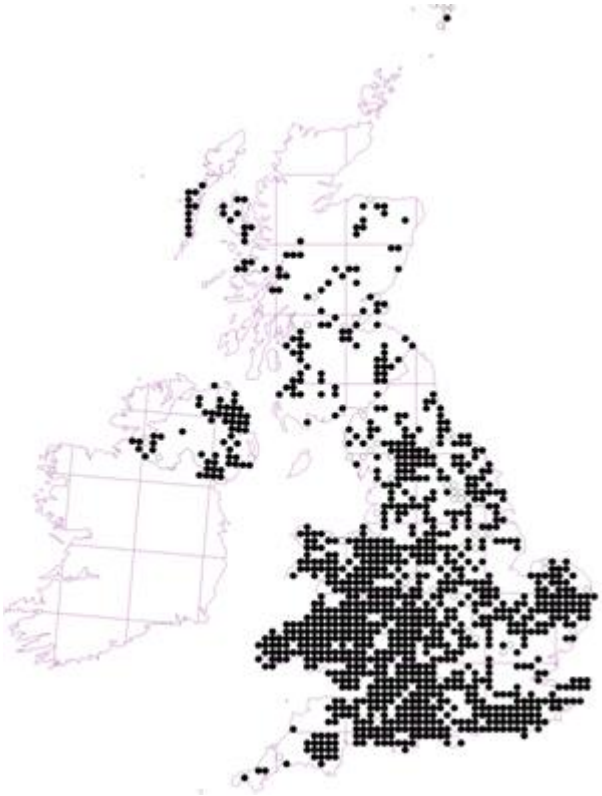
MG5 grasslands are largely confined to the UK and Ireland. Outside the British Isles, related grasslands only occur in the Atlantic/sub-Atlantic regions of Europe, in lowland and sub-montane areas, notably in northern France and Spain (Rodwell *et al* 2007).

MG5 old meadows and pastures occur on infertile/moderately fertile (phosphorus index of 0 or 1), well-drained or moist brown soils such as clay loams that are neither very acid nor very lime-rich (neutral) (Rodwell *et al* 2007), pH ranges from around 5.2 to 6.2 depending on the sub-community (see below, Rodwell 1992, Stevens *et al* 2010). The soils are often developed over superficial deposits (eg head deposits, drift, till or alluvium).

MG5 mostly occurs within enclosed field systems and as part of less enclosed limestone/chalk 'downland' landscapes in association with, and often transitional to, calcareous grassland throughout the lowlands (less than 300 m, Rodwell 1992).

A few sites occur in more upland situations where they can show floristic transitions to MG3 *Anthoxanthum odoratum-Geranium sylvaticum* grassland.

Fragmentary stands of MG5 can be found in churchyards, woodland rides or road and railway verges (Rodwell 1992).



 10 km square distribution map of MG5 grassland in the UK. Source Rodwell *et al* 2007.

MG5 grasslands vary in their plant species composition across England and Wales due to the nature of past grassland and land management, soil type (especially pH), hydrology, altitude and topography (Rodwell 1992, Stevens *et al* 2010).

The three sub-types of MG5 tend to pick out soil conditions, especially pH (Rodwell 1992).

- MG5a is the 'typical' MG5 grassland on soils with pH between 6.5 and 7.5.
- MG5b supports a range of species that prefer more lime-rich soils such as lady's bedstraw *Galium verum*, salad burnet *Sanguisorba minor*, upright brome *Bromopsis erecta* and hoary plantain *Plantago media.*
- On more acid soils, MG5c is typical, with heath grass *Danthonia decumbens*, tormentil *Potentilla erecta* and bitter vetch *Lathyrus linifolius* often prominent.

Conserving MG5 grasslands

Until the early 1970s, it seems that ecologists and conservation scientists had neglected the need to consider the conservation of neutral meadows and pastures (Ratcliffe 1977) despite the first accessible description of their botanical composition being published in 1939 (Tansley 1939). This is in contrast to other grassland types such as chalk and limestone grasslands whose botanical and conservation value was recognised much earlier.

This was possibly because neutral grasslands were seen as commonplace in the farmed landscape. For example, the list of 735 key nature conservation sites published in 1977 (Ratcliffe 1977) only lists 9 sites (1.2%) equivalent to MG5 (NCR neutral grassland groups 8 and 9).

Realisation that neutral grasslands were rapidly being improved for agriculture and that they had considerable nature conservation value led to increased conservation effort from the late 1970s onwards.

MG5 is one of three component unimproved grassland types of the UK BAP priority habitat known as Lowland Meadows (UK Biodiversity Group 1998), which is listed as a habitat of principal importance under section 41 of the Natural Environment and Rural Communities (NERC) Act 2006 (see Annex 1 on page 9 for more details).

MG5 covers less than 6,000 ha in England (Robertson & Jefferson 2000), 0.06% of non-urban land area of England. The total estimated resource of MG5 currently in Sites of Special Scientific Interest (SSSIs) is approximately 55%, and around 616 SSSIs have MG5 as an interest feature.

For the other UK countries, Scotland, Wales and Northern Ireland, the estimates are 1500, 1595 and 937 hectares respectively.

The site size profile for lowland meadows (MG4, MG5 & MG8) shows that 80% of sites are less than 5 hectares, and only 9% of sites are over 10 hectares (Bullock *et al* 2011 based on data from Natural England Priority Habitat Inventories).

The main mechanisms for conserving MG5 grassland include :

- notification as SSSI;
- purchase by conservation organisations and establishment of nature reserves;
- agreements under the Environmental Stewardship Higher Level Scheme (HLS).

As part of a priority habitat, listed under section 41 of the NERC Act, MG5 sites exceeding 2 hectares are within the scope of the Environmental Impact Assessment (Agriculture) Regulations, 2006, which seek to ensure that activities designed to increase agricultural productivity do not have significant negative impacts on uncultivated land and semi-natural areas including high-value grasslands. Unfortunately, there is evidence that the Regulations have been ineffective as a mechanism for the conservation of semi-natural grasslands (The Grasslands Trust 2011).

Creation of lowland meadows, including MG5, is an objective of the England Biodiversity Strategy (Biodiversity 2020) and precursor strategies. The Higher Level Scheme is the main delivery mechanism for funding grassland creation on farmland, although some County Wildlife Trusts and other non-governmental organisations have embarked on grassland creation projects (see Hewins & Wilson 2013, Critchley et al 2004).

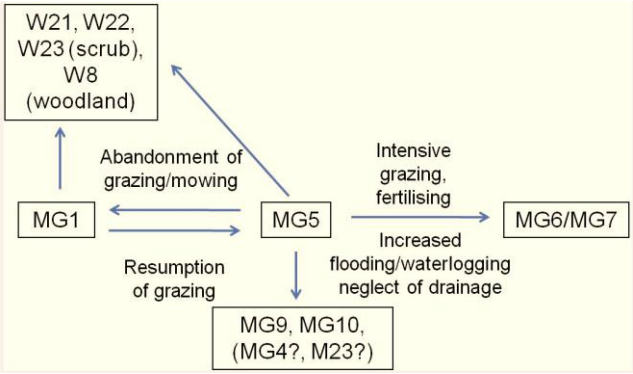
Vegetation that approximates to MG5 (and indeed some other types of dry calcareous and acid grassland) can be created on suitable arable soils using hay strewing or seed mixtures over timescales of 10-20 years (Hewins & Wilson 2013). However, such grasslands should not be confused with long-established grasslands including MG5 which are very different in character in terms of:

- species richness and diversity;
- presence of local or scarce species;
- presence of so-called species indicative of long continuity and/or species that are difficult to establish in new swards;
- soil structure and topographical heterogeneity;
- other components of the ecosystem including above and below ground biota.

Typically neutral and calcareous grasslands that closely resemble ancient semi-natural grassland take a minimum of 100 years to develop (Fagan et al, Gibson 1998, Gibson & Brown 1991, Morris *et al* 2006). However, the abiotic and biotic conditions under which such grasslands formed were very different to those pertaining today (Gibson 1998, Morris *et al* 2006).

Conservation management

Lack of cutting or grazing will initially result in an increase in coarser more competitive grasses and herbs and given time, ultimately scrub and woodland (Duffey *et al* 1974). In the absence of management, MG5 will undergo a succession often initially to MG1 *Arrhenatherum elatius* grassland followed by scrub (eg W21 *Crataegus monogyna- Hedera helix* scrub) and ultimately woodland (eg W8 *Fraxinus excelsior-Acer campestre-Mercurialis perennis* woodland).



Management relationships between MG5 and other vegetation types

The biodiversity value of MG5 grassland can only can be sustained by either

- hay meadow management (hay cut typically early July) and late summer/autumn aftermath grazing); or
- pasture management by sheep, cattle or horses.

Species composition may vary depending on the broad management type (Duffey *et al* 1974, Rodwell 1992, Gibson 1996, Crofts & Jefferson 1999, Robertson & Jefferson 2000, Rodwell *et al* 2007). For example, sustained overgrazing can also lead to a shift from MG5 to semi-improved MG6 grassland (Gibson 1997).

Further information on appropriate stocking rates and livestock management can be found in Crofts & Jefferson 1999, Kirkham *et al* 2003, Gibson 1996, 1997).

There is some evidence that, for at least some of the MG5 meadow resource, the botanical composition of MG5, which is now valued in the 21st Century, has been strongly influenced by historic traditional management involving the use of applications of farmyard manure (FYM) and lime. In some cases, MG5 may have been originally 'won' from different vegetation by enclosure, limited drainage, manuring and liming such as on Dartmoor and the Shropshire Hills from dwarf shrub- heath and acid grassland.

Generic guidance for hay meadow sites to maintain biodiversity is to allow applications of FYM up to 12 t/ha/year for sites with a history of manuring or 4 – 6 t/ha/year or 8 – 12t/ha every other year for sites with no recent history of manuring.

However, ideally, vegetation composition, conservation objectives, soil physical and chemical status, past nutrient management and other environmental variables such as rainfall and temperature should guide what level of FYM is likely to be ecologically sustainable at specific sites.

Higher rates of nutrient application to MG5 meadows or pastures (including from atmospheric deposition of nitrogen) will result in a decline in species-richness moving the community from MG5 towards MG6 and MG7 semi-improved and improved grasslands (Kirkham *et al* 2008, Kirkham *et al* submitted).

The maintenance and restoration of the biodiversity value of species-rich neutral grassland (including MG5) and some types of fen meadows on soils prone to acidity through leaching is dependent on the periodic application of lime. Further detailed guidance as to when and where this is appropriate can be found in Walsh *et al* 2012.

MG5 and agriculture

As mentioned above it is essential for the conservation of these biodiverse grasslands that they are managed by cutting and /or grazing.

This is most readily achieved when they form part of livestock farming enterprises. They are more readily integrated into beef or sheep rearing systems than dairying because of the requirement for high yields and digestibility of herbage for dairy cows. This is most easily satisfied by reseeded or improved pastures.

When MG5 is managed as pasture, not surprisingly, the growth rates of beef cattle tend to be below that expected for beef cattle on improved, fertilised pasture. However, the growth rates that can be achieved on MG5 can still be respectable and range from around 60% up to rates almost equivalent to growing beef cattle on agriculturally-improved grassland under comparable grazing management conditions. Indeed the legume component of MG5, the high mineral content and the relatively high herbage production in late spring and summer, means they can be a valuable complement to agriculturally-improved grassland.

However, there is some evidence that these grasslands may be less suitable for maintaining the performance and the health of growing or productive cattle in the late summer/autumn. At this time, they could be grazed by less productive stock such as dry suckler cows.

Sheep production systems generally tend to be compatible with the utilisation of MG5 although feed supplementation or movement onto more productive grassland may be necessary during mating and lambing.

For MG5 sites managed as meadows, the hay is used as winter feed for livestock. Yields range from around 40-80% of yields from intensively managed improved grasslands. Also, the energy value of the hay may be between 10 and 40% lower and they tend to have lower spring growth rates. From an agricultural perspective, the yield and quality (digestibility) of hay is likely to be maximised by cutting in late June or early July. After this, there is a decline in the digestibility of the hay crop. The utilized metabolizable energy (UME) output of unfertilised, semi-natural grasslands cut for hay and then grazed in autumn may be at best only 60% of that achieved on improved grasslands.

Adapting to climate change

The component plant species of MG5 grassland mostly belong to the southern temperate, widespread temperate and temperate biogeographical elements of the British flora (Preston & Hill 1997). This suggests it might be relatively resilient to climate change scenarios, especially those related to temperature.

Bird's-foot trefoil a component species of MG5 © Stuart Smith CCW

However, the situation is complex. Increased spring temperatures (and legacy of wetter winters) may boost total biomass and favour competitive species. Drier summers on the other hand will favour stress tolerant (eg deep-rooted species) and ruderal species but retard competitors/stress-tolerant competitors.

It is also possible that the phenology of characteristic lowland meadow plant species may change significantly in response to climatic prompts.

Conclusion

MG5 grassland is a valuable resource that needs continued management, monitoring, research and protection for it to survive. There is also a need to raise awareness of the value of this grassland type and the methods available to manage and protect it.

References

BLACKSTOCK, T. H., RIMES, C. A., STEVENS, D. P., JEFFERSON, R. G., ROBERTSON, H. J., MACKINTOSH, J. & HOPKINS, J. J. 1999. The extent of semi-natural grassland communities in lowland England and Wales: a review of

conservation surveys 1978-96. *Grass and Forage Science* 54, 1-18.

BULLOCK, J.M., JEFFERSON, R.G., BLACKSTOCK, T.H., PAKEMAN, R. J., EMMETT, B. A., PYWELL, R. J., GRIME, J. P. & SILVERTOWN, J. W. 2011. Chapter 6: Semi-natural grasslands. In: *The UK National Ecosystem Assessment Technical Report. UK National Ecosystem Assessment*, UNEP-WCMC, Cambridge.WCMC, Cambridge. URL: **uknea.unep-wcmc.org/Resources/tabid/82/Default.aspx**

COOPER, E.A. 1997. *Summary descriptions of National Vegetation Classification grassland and montane communities*.UK Nature Conservation, No. 14. JNCC, Peterborough.

CRITCHLEY C.N.R, BURKE M.J.W, STEVENS D.P 2004 Conservation of lowland semi-natural grasslands in the UK: a review of botanical monitoring results from agri-environment schemes. *Biological Conservation*, 115, 263–278.

CRITCHLEY, C. N. R., CHAMBERS, B. J., FOWBERT, J.A., SANDERSON, R. A., BHOGAL, A. & ROSE, S. C. 2002. Association between lowland grassland plant communities and soil properties. *Biological Conservation*, 105, 199-215.

CROFTS, A. & JEFFERSON, R.G. 1999. *The lowland grassland management handbook*. 2nd edition. English Nature & The Wildlife Trusts, Peterborough.

DICKS, L.V. 2002. *The structure and functioning of flower-visiting insect communities on hay meadows*. PhD thesis, University of Cambridge.

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

FAGAN, K.C., PYWELL, R.F., BULLOCK, J.M. & MARRS, R.H. 2008 Do restored calcareous grasslands on former arable fields resemble ancient targets? The effect of time, methods and environment on outcomes. *Journal of Applied Ecology*, 45, 1293–1303.

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.

GENNEY, D.R., HALE, A.D., WOODS, R.G. & WRIGHT, M. 2009. Chapter 20 Grassland fungi In: *Guidelines for the selection of biological SSSIs: detailed guidelines for habitats and species groups*. JNCC, Peterborough.

GIBSON, C.W.D. 1996. *The effects of horse grazing on species-rich grasslands*. English Nature Research Reports, No. 164. Peterborough.

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

GIBSON, C.W.D. 1998. South Somerset SSSIs: *A study of neutral grassland succession*. English Nature Research Reports, No. 266. Peterborough.

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

HARRIS, S. & YALDEN, D.W. 2008. *Mammals of the British Isles: Handbook*. 4th edition. Mammal Society, Southampton.

HEWINS, E. & WILSON, P.J. 2013 *A survey of selected agri- environment grassland and heathland creation and restoration sites* Parts 1& 2 - 2010 and 2011 surveys. Natural England Commissioned Report, NECR107. Natural England, Sheffield.

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

HOPKINS, J.J. 1990 British Meadows and pastures. *British Wildlife*, 1, 202 -213.

JEFFERSON, R.G., GIBSON, C.W.D., LEACH, S.J., PULTENEY, C.M., WOLTON, R. &

ROBERTSON, H.J. 1999. *Grassland habitat translocation: The case of Brocks Farm, Devon*. English Nature Research Reports, No. 304. English Nature, Peterborough.

KIRKHAM, F.W, 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. CCW, Bangor.

KIRKHAM, F.W., TALLOWIN, J.R.B., SANDERSON, R.A., BHOGAL, A., CHAMBERS, B.J. & STEVENS, D.P. 2008. The impact of organic and inorganic fertilizers and lime on the species-richness and plant functional characteristics of hay meadow communities. *Biological Conservation*, 141, 1411-1427.

KIRKHAM, F.W., TALLOWIN, J.R.B, DUNN, R.M., BHOGAL, A., CHAMBERS, B.J., & BARDGETT, R D. submitted *Ecologically-sustainable fertility management for the maintenance of species-rich hay meadows: a 12 year fertilizer and lime experiment*.

MARREN, P. 1995 Harvests of beauty: the conservation of hay meadows. *British Wildlife*, 6 235-243.

MORRIS, R.K.A., ALONSO, I., JEFFERSON, R. G. & KIRBY K.J. 2006 The creation of compensatory habitat – can it secure sustainable development? *Journal of Nature Conservation*, 14, 106-116.

Nature Conservancy Council 1989 Guidelines for selection of biological SSSIs. Nature Conservancy Council, Peterborough.

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

PETERKEN, G. 2009. Woodland origins of meadows. *British Wildlife*, 20, 161-170.

PRESTON, C.D. & HILL, M.O. 1997. The geographical relationships of British and Irish vascular plants. *Botanical Journal of the Linnean Society*, 124, 1-120.

RATCLIFFE, D . A. (ed) 1977. *A Nature Conservation Review. Volume 1*. Cambridge University Press, Cambridge.

ROBERTSON, H.J. & JEFFERSON, R.G., 2000. *Monitoring the condition of lowland grassland SSSIs. Volume I: English Nature's rapid assessment system*. English Nature Research Reports, No 315. English Nature, Peterborough.

RODWELL, J. S. ed. 1991a. *British Plant Communities Volume 2: Mires and heaths*. Cambridge: Cambridge University Press.

RODWELL, J. S. ed. 1991b. *British Plant Communities Volume 1: Woodlands and scrub*. Cambridge: Cambridge University Press.

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

RODWELL, J.S., DRING, J.C., AVERIS, A.B.V., PROCTOR, M.C.F., MALLOCH, A.J.C., SCHAMINÉE, J.H.J & DARGIE, T.C.D., 2000. *Review of Coverage of the National Vegetation Classification*. JNCC Report 302. Joint Nature Conservation Committee, Peterborough.

RODWELL, J.S., MORGAN, V., JEFFERSON, R.G. & MOSS, D., 2007. The European Context of British Lowland Grasslands. Joint Nature Conservation Committee Report 394. Joint Nature Conservation Committee, Peterborough.

STEVENS, D.P., SMITH, S.L.N., BLACKSTOCK, T.H., BOSANQUET, S.D.S. & STEVENS, J.P. 2010. *Grasslands of Wales: A survey of lowland species-rich grasslands*, 1987–2004. University of Wales Press, Cardiff.

TALLOWIN, J.R.B. 2005. *Ecologically sustainable grazing management of lowland neutral grassland and its effects on livestock performance*. BD 1440: Final Report to DEFRA, London.

TALLOWIN, J.R.B. 1997 *The agricultural productivity of lowland semi-natural grassland: a reveiw* . English Nature Research Reports, No. 233 English Nature, Peterborough.

TALLOWIN, J.R.B. & GRIFFITH, B.A. 2013 *Sustainable Management Systems for Unimproved Neutral Grassland*. BD 1460: Final Report to DEFRA, London.

TALLOWIN, J.R.B. & JEFFERSON, R.G. 1999 Hay production from lowland semi-natural grasslands: a review of implications for ruminant livestock systems. *Grass and Forage Science*, 54, 99–115.

TANSLEY, A.G. 1939. *The British Islands and their vegetation*. Cambridge University Press, Cambridge.

The Grasslands Trust 2011. *Nature's Tapestry: The story of England's grasslands and why not all grass is green.* The GrasslandsTrust, Eastleigh.

VERA, F.W.M 2000. *Grazing Ecology and Forest History*. CABI Publishing, Wallingford.

VICKERY, J.A., TALLOWIN, J.R.B., FEBER, R.E., ASTERAKI, E.J., ATKINSON, P.W., FULLER, R.J. & BROWN, V.K. 2001. The management of lowland neutral grasslands in Britain: effects of agricultural practices on birds and their food resources. *Journal of Applied Ecology*, 38, 647–664.

WALSH, G., PEEL, S. & JEFFERSON, R.G. 2012. *The use of lime on semi-natural grasslands in agri-environment schemes*. 3rd edition. Natural England Technical Information Note No. 045.

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

Further information

Natural England publications and English Nature Research Reports are available to download from the Natural England website: **www.naturalengland.org.uk**. In particular see:

- TIN045: *The use of lime on semi-natural grassland in agri-environment schemes*
- TIN060: *The use of yellow rattle to facilitate grassland diversification*
- TIN110: *Assessing whether created or restored grassland is a BAP Priority Habitat*

Natural England is currently undertaking a comprehensive review of the evidence regarding the management of a related hay meadow type, MG3, that occurs in the uplands. This will be published later in 2013.

For further information contact the Natural England Enquiry Service on 0300 060 0863 or e-mail **enquiries@naturalengland.org.uk**.

- Historic Environment Records maintained by local authorities **www.heritagegateway.org.uk/gateway/chr/default.aspx**
- Guide on how to manage archaeology under grass **www.english-heritage.org.uk/content/publications/publicationsNew/guidelines-standards/farming-the-historic-landscape-grassland/farming-the-historic-landscape.-caring-for-archaeological-sites-in-grassland2004.pdf**

Acknowledgements and copyright

Author Richard Jefferson with contributions from Ben Fraser, Audra Hurst, Pete Stevens, Vicky Gilson, Vicky Hunns, Adam Kwolek, Graham Walsh, Peter Holmes, Mark Beard, Alisa Swanson, Steve Peel, David Askew, Pete Brotherton Natural England, Stuart Smith (CCW), Jane MacKintosh (SNH). Photographs Stuart Smith and Dave Mitchell. Editor Susie Smith.

Annex 1: Classification and nomenclature of neutral grasslands

Name	NVC types	Notes
Unimproved neutral grassland (also Level 1 code B21 and Phase 1 code B2.1)	MG2-MG5, MG8, MG11-MG13	Some sub-types of MG1 could possibly be classed as unimproved/semi-natural. Also, some stands of MG11, MG12 and MG13 may possibly be semi-improved
Lowland meadows (s41 priority)	MG4, MG5, MG8	
Upland Meadows (s41 priority)	MG3, MG8	Upland forms of MG8 are now included in the upland meadows s41 priority type
Level 1 Unimproved Neutral Grassland, lowland	MG4, MG5, MG8	
Improved Grassland (also Phase 1 code B4)	MG7	
Semi-improved neutral grassland (also Phase 1 code B2.2)	MG1, MG6, MG7, MG9, MG10	Some vegetation that conforms to MG7 may be semi-improved where more botanically diverse
Neutral grassland	MG1- MG13	
Annex 1 Mountain hay meadows H6520	MG3	
Annex 1 Lowland hay meadows H6510	MG4	

Footnote: s41 priority habitats are those listed as of principal importance for the conservation of biological diversity in England under section 41 of the Natural Environment and Rural Communities Act 2006. These were also listed as BAP priority habitats under the UK Biodiversity Action Plan.