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The European context of British Lowland Grasslands

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Summary

This report assesses the significance of British Lowland Grasslands, occurring below the line of enclosure or moorland wall, within a wider European frame. There are five such priority habitats in the UK Biodiversity Action Plan and these are used as the framework for the report: Lowland Calcareous Grassland, Lowland Dry Acid Grassland, Lowland Meadows, Upland Hay Meadows and Purple Moorgrass/Rush-pasture. The report also includes Metallophyte Vegetation for which there is, as yet, no BAP equivalent.

The report describes the character and occurrence of the constituent plant communities of these habitats in terms of the National Vegetation Classification, with a separate section reviewing the situation for Northern Ireland. Using a phytosociological approach, it then outlines the wider occurrence of related vegetation types elsewhere in Europe, emphasising similarities and contrasts to the UK and indicating the various factors - climatic, edaphic, cultural or historical - that underlie these patterns. The study focuses on the 25 European Union states but, where relevant information is available for countries bordering on the EU, this has been included.

All the Lowland Grasslands include priority Habitats Directive habitats and the report describes how these have been defined in the countries where equivalents of the Lowland Grasslands occur and how well the habitats are covered within Natura 2000.

The report identifies gaps in coverage within the UK BAP, highlighting the need for further survey of open ephemeral-rich vegetation of Lowland Acid Grasslands and wetter Lowland Meadows. There is also an inadequate understanding of the full range of Metallophyte Vegetation and Serpentine swards. Within Natura 2000, the UK definitions of which Lowland Grasslands are included are somewhat narrower than in other EU member states, particularly for the Lowland Acid Grasslands and drier Lowland Meadows.

Important threats to Lowland Grasslands include continuing eutrophication from agricultural improvement and atmospheric deposition but neglect of management and abandonment are becoming increasingly important. Failure to manage at landscape-scale and in ways which accommodate dynamic ecological processes also threaten the sustainability of these habitats. The report also identifies some possible impacts of climate change. Conservation initiatives in Lowland Grasslands are diverse but unevenly spread across the full range of habitats and their approaches and achievements are inadequately disseminated. However, novel partnerships, community involvement and a local focus are striking features of some projects. Research is needed on the underlying environmental factors that influence the distribution and occurrence of lowland grasslands, relationships between biodiversity and productivity, the impacts of grazing, species recruitment and assembly rules and dynamic processes operating at landscape scale.

A European perspective will be vital to understanding and sustaining these habitats and the report outlines ways in which the UK could contribute to developing scientific networks and partnerships for software development.

The report includes a full bibliography, including all web sites referred to in the text. Appendices summarise the sources and quality of distribution data for UK Lowland Grasslands and list the Habitats Directive Interpretation Manuals used in the report.

1 Introduction

1.1 Rationale and scope of the work

The purpose of this work is to assess for Natural England and the Joint Nature Conservation Committee the character and significance of British lowland grasslands within a wider European frame. In particular, this report describes how widely similar vegetation types occur elsewhere in Europe and how the UK examples fit into this context in a phytosociological sense, precisely how and where our own lowland grasslands differ from those found elsewhere and what the causes of this variation are - whether climatic, edaphic, cultural or historical. In addition, the report considers how the policy and delivery of conservation of lowland grasslands in the UK differs from approaches elsewhere, what key gaps there are in knowledge and conservation action and what initiatives exist or could be undertaken in constructive partnerships.

Here, lowland grasslands are defined as all grassland within the line of farmland enclosure or below the moorland wall. There are five priority grassland habitats in the UK Biodiversity Action Plan (DETR 1995) that occur within such limits: Lowland Calcareous Grassland, Lowland Dry Acid Grassland, Lowland Meadows, Upland Hay Meadows and Purple Moorgrass & Rush-pasture. Natural England is a lead partner for two of these BAP habitats and a key participant in delivery of targets for all of them.

All of these BAP lowland grasslands include priority habitat types within Annex I of the Species and Habitats Directive (CEC 2003) and the relationship between the two classifications is shown in Table 1. The contract brief also included a further related Annex I habitat, the metallophyte Calaminarian grassland, for which there is as yet no BAP equivalent. Table 1 includes this habitat and indicates the plant communities of the National Vegetation Classification (hereafter NVC: Rodwell 1991, 1992, 2000) that are equivalent to all the BAP and Annex I types (Jackson & McLeod 2002).

1.2 Geographical limits of the study

The study is focused primarily on the 25 countries of the European Union, including the territory covered by the 10 states which joined in 2004, with a particular emphasis on the Atlantic Biogeographic region. Wherever analogues of our own lowland grasslands occur in EU candidate countries likely to join in 2007 or others bordering on the EU and relevant information of high quality has been available, this has been included, most notably for Switzerland, Norway, Romania, Bulgaria and some countries of the former Jugoslavia. Figure 1 shows the location of the countries included and Figure 2 the extent of the Biogeographic Zones across the EU.

Table 1 Relationships between BAP Priority Habitats, NVC communities and Habitats Directive habitats

NVC community code & name	Phytosociological alliance	Habitats Directive code & Name	BAP Priority Habitat
CG1 *Festuca-Carlina* grassland	Xerobromion	6210 Semi-natural dry Grasslands and scrubland facies On calcareous substrates (*Festuco-Brometalia*)	Lowland Calcareous Grassland
CG2 *Festuca-Avenula* grassland	Bromion erecti		
CG3 *Bromus* grassland	Bromion erecti		
CG4 *Brachypodium* grassland	Bromion erecti		
CG5 *Bromus-Brachypodium* grassland	Bromion erecti		
CG6 *Avenula pubescens* grassland	Bromion erecti		
CG7 *Festuca-Hieracium-Thymus* grassland	Koelerio-Phleion		
CG8 *Sesleria-Scabiosa* grassland	Bromion erecti		
CG9 *Sesleria-Galium* grassland *	Seslerion		
CG10 *Festuca-Agrostis-Thymus* grassland *	Violion		
U1 *Festuca-Agrostis-Rumex* grassland	Plantagini-Festucion	None	Lowland Dry Acid Grassland
U2 *Deschampsia flexuosa* grassland	Violion		
U3 *Agrostis curtisii* grassland	Violion		
U4 *Festuca-Agrostis-Galium* grassland *	Violion		
SD10 *Carex arenaria* grassland @	Ammophilion		
SD11 *Carex-Cornicularia* grassland @	Corynephorion	2330 Inland dunes with open *Corynephorus* and *Agrostis* grasslands	
SD12 *Carex-Festuca-Agrostis* grassland @	Corynephorion	2330 Inland dunes with open *Corynephorus* and *Agrostis* grasslands	None
MG4 *Alopecurus-Sanguisorba* flood meadow	Alopecurion	6510 Lowland hay meadows (*Alopecurus pratensis, Sanguisorba officinalis*)	Lowland Meadows
MG5 *Centaurea-Cynosurus* meadow	Cynosurion	None	
MG8 *Cynosurus-Caltha* flood pasture	Calthion		
MG3 *Anthoxanthum-Geranium* meadow	Triseto-Polygonion	6520 Mountain hay meadows	Upland Hay Meadows
M24 *Molinia-Cirsium* fen-meadow	Junco-Molinion	6410 *Molinia* meadows on calcareous, peaty or clayey-silt-laden soils (*Molinion caeruleae*)	Purple Moorgrass and Rush-pasture
M26 *Molinia-Crepis* fen-meadow	Molinion		
M22 *Juncus-Cirsium* fen-meadow	Calthion	None	
M23 *Juncus-Galium* rush-pasture	Juncion acutiflori		
M25 *Molinia-Potentilla* mire	Junco-Molinion		
OV37 *Festuca-Minuartia* grassland	Thlaspion calaminariae	6130 Calaminarian grasslands of the *Violetea calaminariae*	None

* lowland enclosed stands only
@ inland stands only

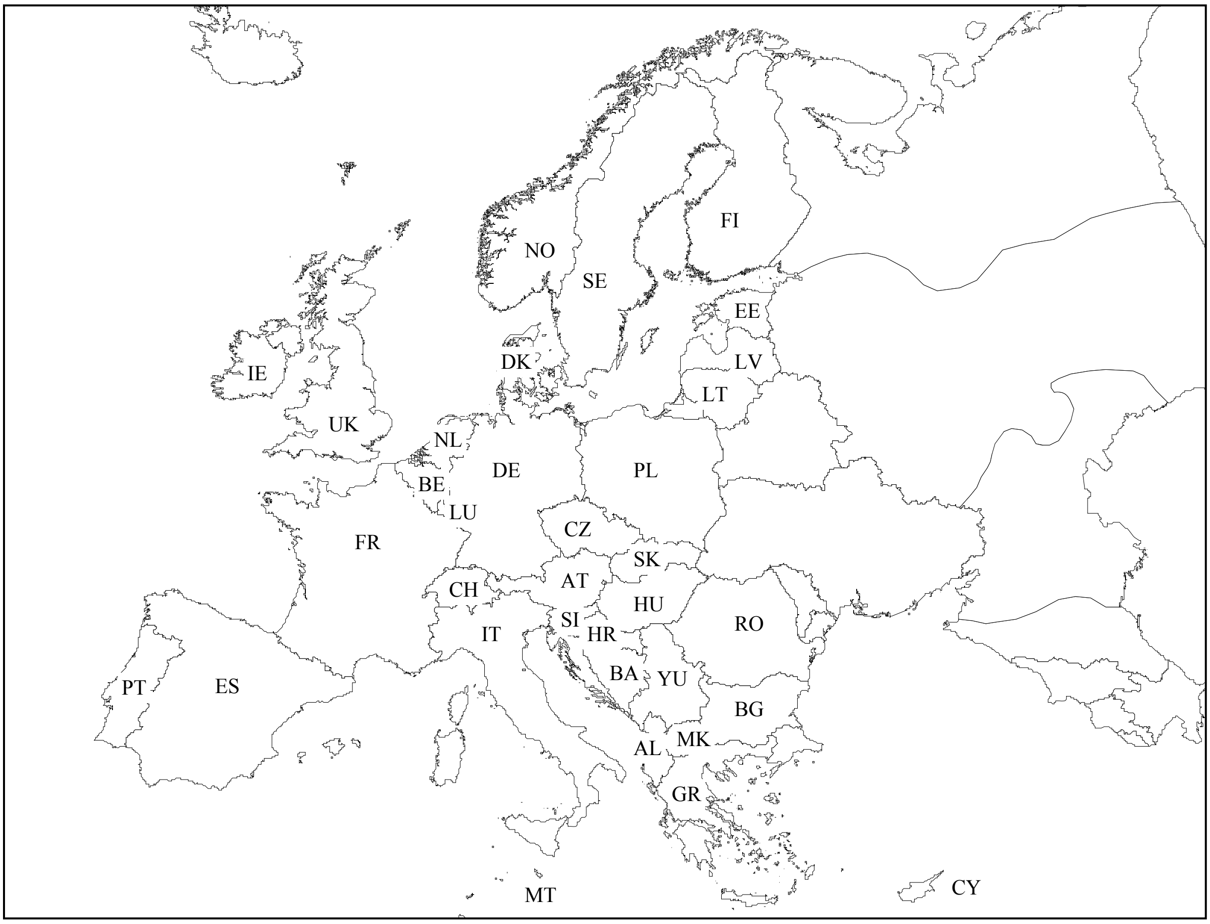

Figure 1 European countries

Figure 2 EU Biogeographic zones

1.3 The format of the accounts

The grasslands are considered under the five BAP priority habitat categories and in the following order: Lowland Calcareous Grassland, Lowland Dry Acid Grassland, Lowland Meadows, Upland Hay Meadows and Purple Moorgrass and Rush-pasture with the additional habitat Metallophyte Vegetation thereafter. The accounts are organised in a modular format and include information under the following headings:

- summary of the BAP (or major) habitat type;
- synonymy with the NVC, Annex I, the alliances of the European Vegetation Survey overview and EUNIS;
- character and distribution of the NVC constituents;
- the BAP type and its constituents in Northern Ireland;
- character and significance of the UK habitat in the wider European context;
- coverage in Natura 2000;
- key threats to the habitat;
- conservation initiatives;
- research needs.

1.4 The BAP Priority Habitat definitions

The details of the definition of the BAP Lowland Grassland habitats have been taken from the Habitat Action Plans of the UK BAP (www.ukbap.org.uk and www.ehsni.gov.uk for Northern Ireland). Where there is some uncertainty, awkwardness or inconsistency in such definitions, or in the relationship between these categories and either the NVC or the Annex I types, this has been made clear in the accounts.

1.5 The constituent NVC communities

The NVC communities referred to in the UK BAP are fully described in Rodwell (1991, 1992, 2000), where maps of their distributions at the time of publication can also be found. Updated maps have been prepared of the NVC communities included in the BAP habitats (Figures 4-13, 16-20, 23-25, 30-34) and these have been used to produce maps of the total extent of the 5 BAP habitats. These overall distributions have been used as a backdrop to each of the NVC community maps and have also been mapped separately (Figures 3, 15, 22, 27 & 29). Figures for the extent of the habitats are taken from the Lowland Grassland UK HAP Steering Group *Target Review 2005.* For Metallophyte Vegetation, for which there is no BAP category, a single map of the relevant NVC community and related vegetation is included (Figure 37) and this exceptionally includes data from upland stands beyond the limit of enclosure. Appendix 1 details the data sources for the maps and provides a critical note on some of the problems of accuracy and scale.

The *Review of Coverage of the NVC* (Rodwell *et al*. 2000) provides outline definitions of additional vegetation types that were not covered in *British Plant Communities* and some of these fall within certain of the BAP Lowland Grassland categories. The habitat accounts indicate what these plant communities are and what equivalents they have elsewhere in Europe, both within phytosociological schemes and within the interpretation other countries have made of the Habitats Directive categories. These additional communities ought to be fully described, mapped and considered for eventual inclusion within the habitats.

1.6 The wider phytosociological perspective

Table I indicates the phytosociological alliances[1] to which each of the NVC plant communities was allocated (Rodwell 2000, Rodwell *et al*. 1998) with the nomenclature of the alliances updated according to the overview of European vegetation provided by the European Vegetation Survey (Rodwell *et al*. 2002). It is this framework which has provided the basis for the discussion of the wider European affinities of the grasslands in each of the BAP habitats and whose alliances are listed in the synonymy for each of them. For this review, an extensive phytosociological literature survey has been undertaken both in the UK and in the library of the Orto Botanico in Rome in March 2006.

Like the UK, some other European countries have a national phytosociological classification (notably Austria, the Czech Republic, France, Hungary, Ireland, The Netherlands, Poland, Romania, Spain and, part-published, Lithuania and Slovakia). The amount of detail in these schemes varies considerably, some being little more than a conspectus, and the way in which the plant communities are classified within an overall hierarchy differs. Even where no such classification exists, there is in many countries a very substantial phytosociological tradition which has resulted in books, research reports and scientific papers, though the coverage of vegetation types in these is necessarily uneven and incomplete, and usually in the native language. Other countries have national vegetation or habitat classifications which are not organised phytosociologically (Ireland, Norway, the Nordic Countries). Much European literature has been incorporated among the references and a list of the country contacts whose comments on the work were requested has been included in Appendix 2. Tabular summaries of phytosociological relationships are included in the text where appropriate.

1.7 The Habitats Directive Annex I types

The definitions of the Annex I habitats have been taken from the Species & Habitats Directive Interpretation Manual (CEC 2003) with the UK interpretation provided from Jackson & McLeod (2002). Cross-reference is also made in the synonymy to the categories in the EUNIS habitat classification, the latest development of CORINE (Davies *et al.* 2004 on http://eunis.eea.europa.en/related-reports.jsp). Many other EU states have an interpretation manual of their own, in some cases a published book or books (Austria, France, Germany, The Netherlands, Latvia, Poland, Slovakia), sometimes with or alternatively as a CDrom (France, Germany, Spain), in others as an agency report (Denmark) or on an agency website (Belgium with separate sites for Flanders and Wallonia, Portugal and Spain). Other publications or reports on biotopes or vegetation types can provide a comprehensive cross-reference to the Habitats Directive (the Czech Republic) or to CORINE (Hungary) or briefer and more indirect references (Slovenia, Finland). In some countries, more detailed local interpretation manuals are available (as for about ten of the German Länder, for example).

[1] Phytosociology is a way of describing vegetation types that first developed in France and Germany in the early decades of the past century and which has become widely accepted (and more or less standardised) across much of Europe. Vegetation is sampled in a disciplined fashion, recording plant species in relevés from homogeneous stands and these samples are classified into associations which are formally named using an author citation. Associations are grouped into phytosociological hierarchies: first into alliances, then into orders, then classes, each of which is again formally named. Further details of the phytosociological approach and the way it was adapted in the NVC can be found in Rodwell (2006).

An interpretation manual or interpretive material is now also available for some EU candidate countries (Bulgaria, Romania, Croatia) or others outside the EU (Switzerland). Generally, all this interpretation material is in the native language of the country, only exceptionally in English (some for Bulgaria, Denmark, Finland, Slovakia, Slovenia).

Most interpretation manuals adopt some sort of modular format (the fullest being those for France, Germany and Poland) and many provide a summary definition of the habitat, a synonymy with the national classification, lists of indicator species, details of habitat factors and necessary management, of zonations and successions and of threats, with a bibliography. National distribution maps often figure, though these are not always of precise locations on dot maps, but sometimes use hatching to denote generalised ranges across part of a country or shading within defined regions (like the German Länder or Flanders eco-regions). Some accounts have photographs of the habitats. In some countries, a phytosociological framework is used for interpretation and, when this is explicit and detailed, comparisons from country to country are much more readily achieved. Overall, the most appealing publication in terms of quality of content, convenience of use and colourful appearance is that for the biotopes of the Czech Republic. As much as possible of this material has been reviewed for this report, in hard copy provided for the research, on the internet and at The European Topic Centre on Nature Protection and Biodiversity in Paris in January 2006.

The numbers of Special Areas of Conservation (hereafter SACs) for each of the six Annex I habitats in the EU countries and the proportional contribution of each country to the total site number (not extent) for each habitat are shown in Tables 2 and 3, which have been compiled from data kindly supplied by the European Topic Centre on Biological Diversity. It is important to remember that the disparity in numbers of SACs for a particular habitat in different member states sometimes reflects the different approach of the countries to defining the sites: in Germany, for example, very many SACs are small, in Spain, larger sites are the rule. SACs included in these totals have also often been declared for more than one Natura 2000 habitat. Distributions of the SACs (Figures 14, 20, 26, 28, 35 & 37) have been shown using a base map with the country boundaries, and with different symbols to distinguish SACs within each of the Biogeographic Zones. Where allocations to zone appear confusing, this is because sites span such zones or because individual countries have not accurately located the SACs on the spatial platform.

1.8 Key threats to the habitat

The report identifies and discusses what appear at the moment to be the key threats to each of the BAP Habitats. Much of this information is based on the expert opinion of the authors and those consulted during the preparation of the report, whose assistance is credited in the Acknowledgements. Where possible, however, we refer to the *Common Standards Monitoring of Designated Sites: First Six Year Report* (Williams 2006) which summarises the results of a survey of designated sites throughout the UK applying standard condition categories to the habitats (as well as species and geology) and characterising adverse activities contributing to unfavourable condition. The habitats defined do not coincide exactly with those of the UK BAP but are sufficiently close for the results to be generally applicable: Lowland Calcareous Grasslands, Lowland Acid Grasslands, Neutral Grasslands (including both Lowland Meadows and Upland Hay Meadows) and Fens & Marshes (including Purple Moor Grass & Rush Pastures but also flushes, tall-herb fens and swamps). Separate assessments were made for Flowering Plants & Ferns and Non-flowering Plants & Fungi.

For most of the BAP habitats included here (but not the Metallophyte swards), we have also been able to draw upon a report (Hewins *et al*. 2005) which summarises the results of a condition assessment of a random selection of non-statutory grassland sites in England and which discusses the reasons for condition assessment failure.

1.9 Conservation initiatives

The report provides as accurate an indication as possible of the extent of inclusion of each habitat within the SSSI/ASSI network and within Environmentally Sensitive Areas and then highlights particular UK projects which illustrate initiatives in statutory agencies and NGOs to the conservation, restoration and re-creation of the habitat. References are given to published or internet sources which provide further details of these projects.

1.10 Research needs

The report indicates any important gaps in knowledge and understanding of each of the habitats and indicates particular survey and research needs.

1.11 Conclusions

A final chapter summarises the general conclusions of the research and highlights some possible future directions for the conservation of lowland grasslands in Europe.

1.12 References and appendices

A full bibliography is included at the close of the report. Appendix 1 details the sources and quality of available grassland data. Appendix 2 provides a list of Habitats Directive Interpretation Manuals.

1.13 Glossary and abbreviations

This lists the abbreviations used in the report and explains some frequent technical terms.

Table 2 Numbers of SACs for each of the Lowland Grassland habitats in each EU country

	AT	BE	CY	CZ	DE	DK	EE	ES	FI	FR	GR	HU	IE
2330		23		7	187	10	2			36			
6130	4	6			35			1		3			2
6210	46	76		57	723	81	84	176	240	390	19	65	36
6410	48	66		32	501	48	48	59	3	211		90	17
6510	58	124		60	1166		52	150	39	228	2	118	10
6520	21	50		7	263			6	29	93		17	
Total	177	345		163	2875	139	186	392	95	961	21	290	65

	IT	LT	LU	LV	MT	NL	PL	PT	SE	SI	SK	UK	Total
2330	1	4		4		13	17	6	22			1	333
6130	6					1				1		23	82
6210	576	26	17	25		5	40	11	163	17	84	83	2807
6410	101	21	16	21		21	57	12	424	24	16	44	1880
6510	111	24	25	42		12	68	10	271	14	115	5	2704
6520	73						2		20	5	10	3	599
Tot	868	75	58	92		52	184	39	900	51	223	159	8405

AT Austria, BE Belgium, CY Cyprus, CZ Czech Republic, DE Germany, DK Denmark, EE Estonia, ES Spain, FI Finland, FR France, GR Greece, HU Hungary, IE Ireland, IT Italy, LT Lithuania, LU Luxembourg, LV Latvia, MT Malta, NL Netherlands, PL Poland, PT Portugal, SE Sweden, SI Slovenia, SK Slovakia

Table 3 Percentage of SACs for each of the Lowland Grassland habitats in each EU country.

	AT	BE	CY	CZ	DE	DK	EE	ES	FI	FR	GR	HU	IE
2330		7		2	56	3	1			11			
6130	5	8			45			3		4			
6210	2	3		2	26	3	3	6	1	14	1	2	1
6410	3	3		2	27	3	3	3	<<1	11		5	1
6510	2	5		2	43		2	6	1	8	<<1	4	<1
6520	3	8	1	44				1	5	15		3	
Total	3	4		2	34	2	2	5	1	11	<11	3	1

	IT	LT	LU	LV	MT	NL	PL	PT	SE	SI	SK	UK
2330	<1	1		1		4	5	2	7			<1
6130	8					1				1		29
6210	21	1	1	1		1	1	1	6	1	3	2
6410	5	1	1	1		1	3	1	23	1	1	2
6510	4	1	1	2		1	3	1	10	1	4	<<1
6520	12						1		3	1	2	<<1
Tot	10	1	1	1		1	2	1	11	1	3	2

AT Austria, BE Belgium, CY Cyprus, CZ Czech Republic, DE Germany, DK Denmark, EE Estonia, ES Spain, FI Finland, FR France, GR Greece, HU Hungary, IE Ireland, IT Italy, LT Lithuania, LU Luxembourg, LV Latvia, MT Malta, NL Netherlands, PL Poland, PT Portugal, SE Sweden, SI Slovenia, SK Slovakia

2 Lowland Calcareous Grassland

2.1 Summary of the BAP habitat type

Lowland Calcareous Grassland comprises a range of swards, generally maintained by stock and wild herbivore grazing, on thin, sharply-drained, infertile lime-rich soils that have developed from a variety of limestone bedrocks through the warmer and drier lowlands of Britain. Conspicuous suites of calcicole plants are a characteristic feature and variation in floristics and structure of the vegetation is related to contrasts in climate, both regional and more locally with differences in topography, in soil depth and fertility and in the kind of impacts of which stock and wild herbivores make. The habitat also includes related grasslands with a more modest representation of calcicoles along the fringes of the cooler and wetter uplands if these occur within enclosures, though this situation is not so straightforward in Northern Ireland. A total of eight main NVC communities are included here, many of them species-rich and some providing a locus for many rare plants. Transitions to scrub and mosaics with heath can be associated with the grasslands in this habitat and provide further floristic and structural diversity.

Comparable grasslands of the Bromion are widespread through western and central Europe, with the Xerobromion in sub-Mediterranean habitats, and the Koelerio-Phleion in more continental regions and Seslerion swards in the sub-alpine zone. Coverage under habitat 6210 Semi-natural dry grassland with scrubland facies on calcareous substrates in Natura 2000 is very extensive, though everywhere these swards are threatened by abandonment or inappropriate management and succession.

2.2 Synonymy

NVC CG1 *Festuca-Carlina* grassland, CG2 *Festuca-Avenula* grassland, CG3 *Bromus erectus* grassland, CG4 *Brachypodium pinnatum* grassland, CG5 *Bromus-Brachypodium* grassland, CG6 *Avenula pubescens* grassland, CG7 *Festuca-Hieracium-Thymus* grassland, CG8 *Sesleria-Scabiosa* grassland, with CG9 *Sesleria-Galium* grassland and CG10 *Festuca-Agrostis-Thymus* grassland on lowland/enclosed sites.

Annex I 6210 Semi-natural dry grasslands and scrubland facies on calcareous substrates (*Festuco-Brometalia*).

EVS 28C02 Bromion erecti, 28I02 Koelerio-Phleion phleoidis, 28M09 Xerobromion.

EUNIS E1.2 Perennial calcareous grassland and basic steppes, E1.9 Dry, open perennial and annual siliceous grassland, including inland dune grassland.

2.3 Character and distribution of the NVC constituents

Eight NVC communities, and parts of a two others, have been included within the Lowland Calcareous Grassland and their current known distributions, together with that of the BAP habitat as a whole, are shown in Figure 3-13. CG2 *Festuca-Avenula* grassland is the most widespread community across the warmer and drier lowlands and represents the core of the habitat (though it is not the most extensive, being estimated to occupy less than 8,000ha). CG3 *Bromus erectus* grassland (less than 19,000ha but the most extensive type of sward), CG4 *Brachypodium pinnatum* grassland (less than 3,000ha) and CG5 *Bromus-Brachypoium* grassland (less than 2,500ha) form a suite of often, though not always, impoverished derivatives largely related to relaxation of grazing over similar topographies across the same geographical range. CG6 *Avenula pubescens* grassland (less than 1,000ha) is more especially related to deeper, less droughty soils and represents one transition to ranker lowland meadows. More striking extremes of variation in relation to regional and local climatic conditions are seen in the CG7 *Festuca-Thymus-Hieracium* grassland (less than 3,000ha) which is especially well developed in the more continental east of the country and CG1 *Festuca-Carlina* grassland which is strikingly confined to hot, rocky slopes on hard limestones in the sunnier west of England and Wales (and has less than 300ha). Distinctive contingents of endangered and threatened plants characterise these swards, particularly the CG1, CG2 and CG7 types. Towards the hilly north of England, *Sesleria albicans* comes to play a part in Lowland Calcareous Grassland, in CG8 *Sesleria-Scabiosa* grassland which is more strictly confined to lower altitudes (occupying there less than 150ha) and essentially a mainstream type with *Sesleria*; and in CG9 *Sesleria-Galium* grassland, a more distinctively sub-montane community which occurs mostly beyond the limits of enclosure (and has less than 1,500ha in the lowlands). CG10 *Festuca-Agrostis-Thymus* grassland, a more species-rich though only slightly calcicolous counterpart to U4 *Festuca-Agrostis-Galium* grassland, and likewise essentially a community of the cooler and wetter north-west, though on somewhat more lime-rich soils, is also included within Lowland Calcareous Grassland where it occurs within enclosures.

2.4 The BAP type and its constituents in Northern Ireland

In the Northern Ireland lowlands proper, there are only very small pockets of grasslands that would be included in this BAP type. The stands are found mostly on the coast and are generally of CG10 *Festuca-Agrostis-Thymus* grassland. Some CG6 *Avenula pubescens* grassland has been reported from the coast (notably among the dunes at Killard NNR in County Down) but this has been treated as part of the Sand-Dune or Maritime Cliffs & Slopes habitats. The identification of CG1 *Festuca-Carlina* grassland in Northern Ireland by Cooper & McCann (1994) is questionable.

Calcareous grasslands are much more widespread in Northern Ireland within grazings that are unenclosed - at least not as part of complex field systems - and, even where these occur at low altitudes, they most closely resemble the extensive upland north-western types found on the mainland. Despite some mismatch (see, for example, Cooper & McCann 1994), CG9 *Sesleria-Galium* grassland has been extensively recorded on the West Fermanagh Scarplands (though there it lacks *Galium sterneri*) and CG10 *Festuca-Agrostis-Thymus* grassland more fragmentarily represented on the Tertiary Basalts of County Antrim (where *G. sterneri* does occur, but without *Sesleria*) and consolidated shell sands elsewhere. The NI Countryside Survey 1992 reported 268ha of calcareous grassland in lowland land-classes and 866ha in upland, a total of 1135ha, though this is virtually all unenclosed. The apparent decline to 936ha by NI Countryside Survey 2000 (Cooper & McCann 2002) results from substrates other than limestones being excluded.

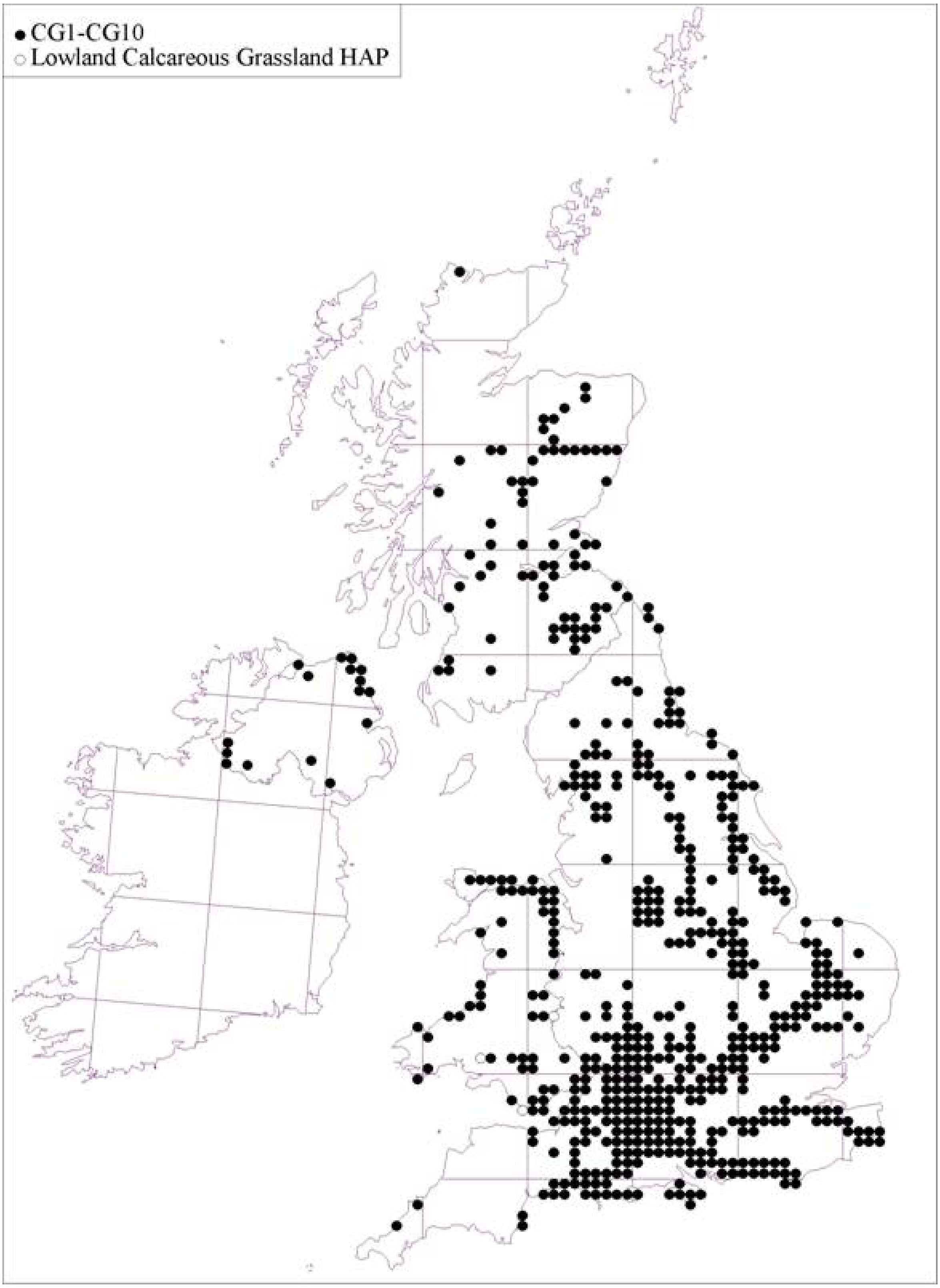

Figure 3 BAP Lowland Calcareous Grassland

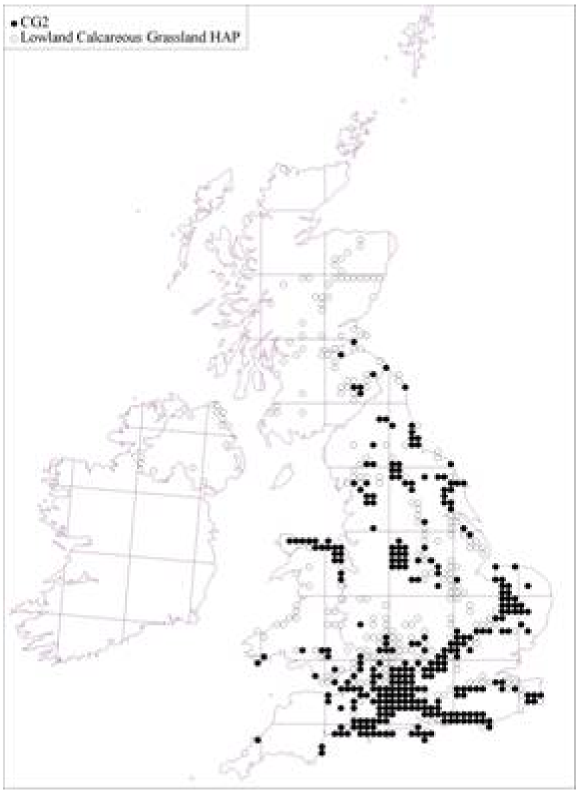

Figure 4 CG2 *Festuca-Avenula* grassland

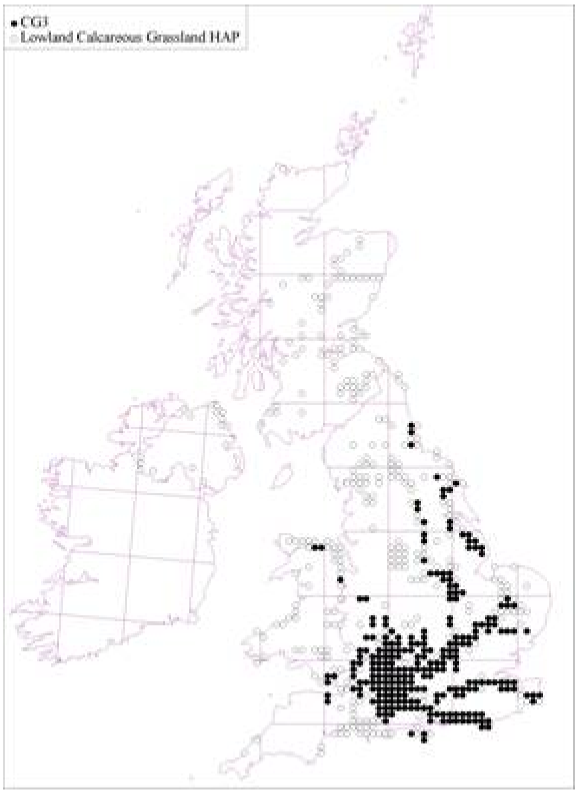

Figure 5 CG3 *Bromus erectus* grassland

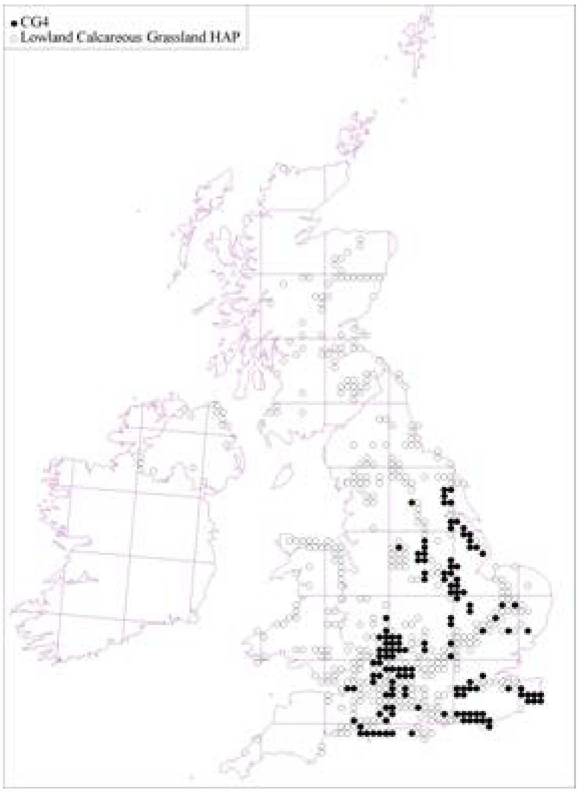

Figure 6 CG4 *Brachypodium pinnatum* grassland

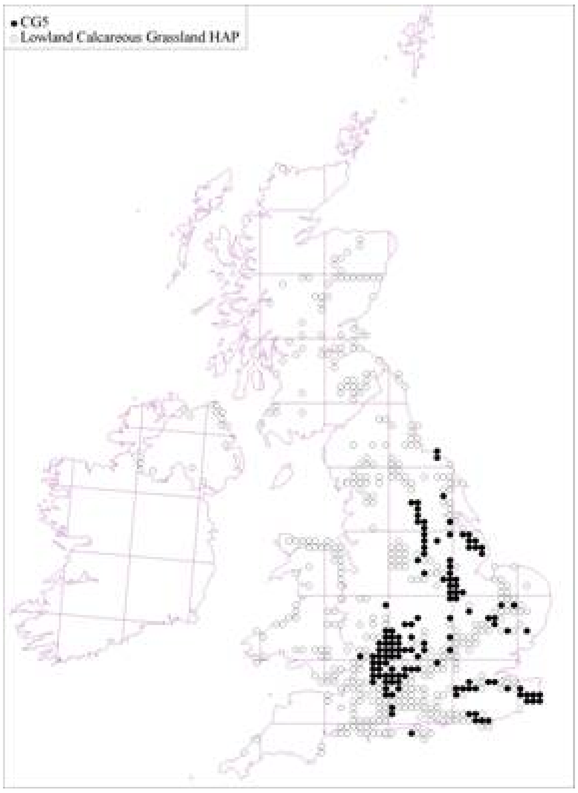

Figure 7 CG5 *Bromus-Brachypodium* grassland

The 10km grid records from which these maps were prepared date from 1980 onwards and include vegetation recorded as intermediate between NVC communities. The filtering has been inclusive, including all sites where the target community was recorded, even if only part of an intermediate with one or more other communities.

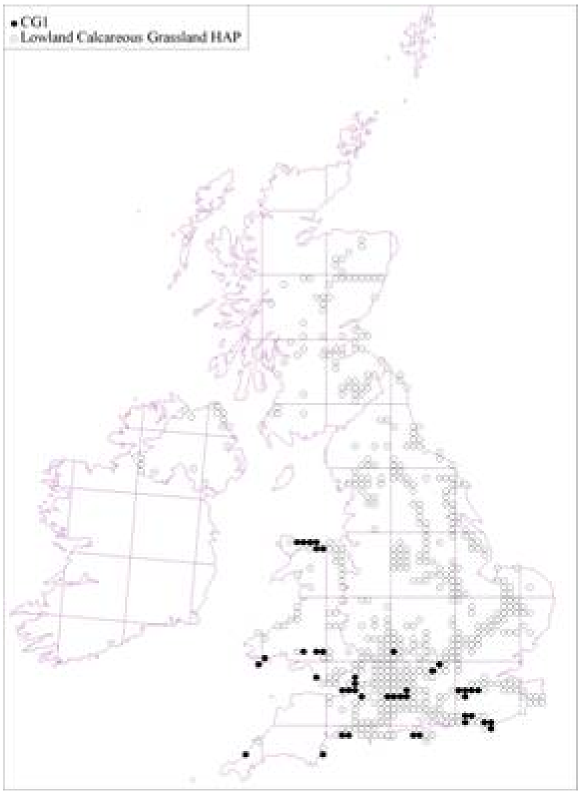

Figure 8 ***CG1 Festuca-Carlina*** **grassland**

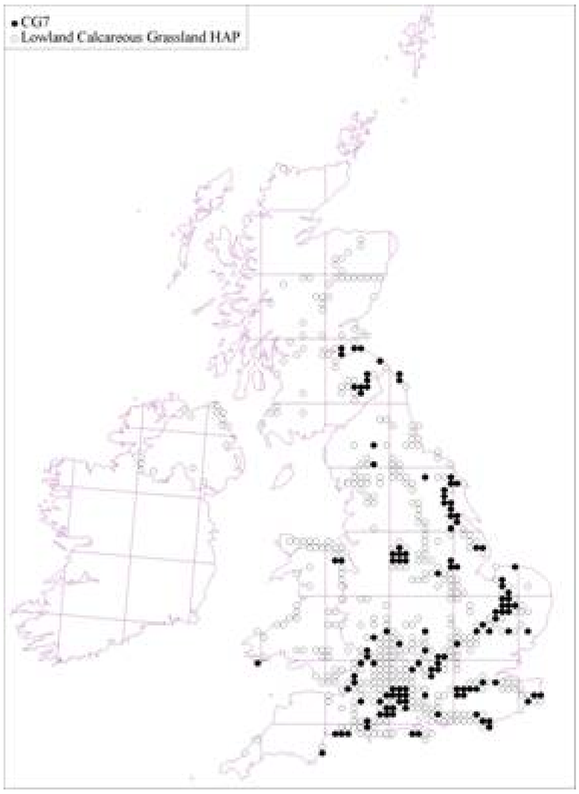

Figure 9 CG7 ***Festuca-Hieracium-Thymus*** **grassland**

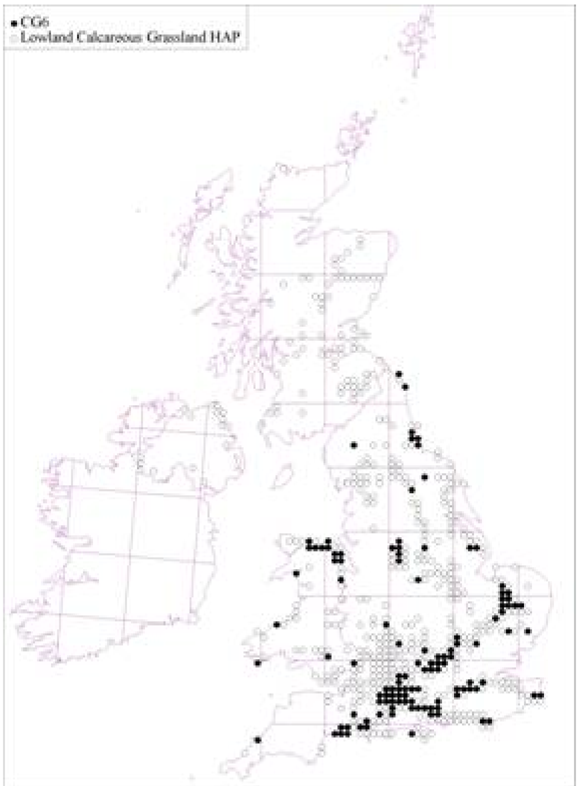

Figure 10 CG6 ***Avenula pubescens*** **grassland**

Figure 11 CG8 ***Sesleria-Scabiosa*** **grassland**

The 10km grid records from which these maps were prepared date from 1980 onwards and include vegetation recorded as intermediate between NVC communities. The filtering has been inclusive, including all sites where the target community was recorded, even if only part of an intermediate with one or more other communities.

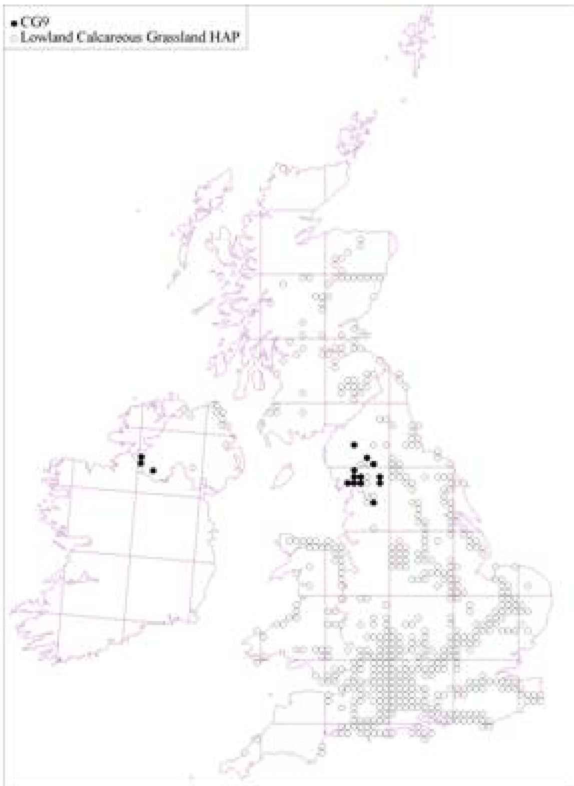

Figure 12 CG9 *Sesleria-Galium grassland* (lowland/enclosed)

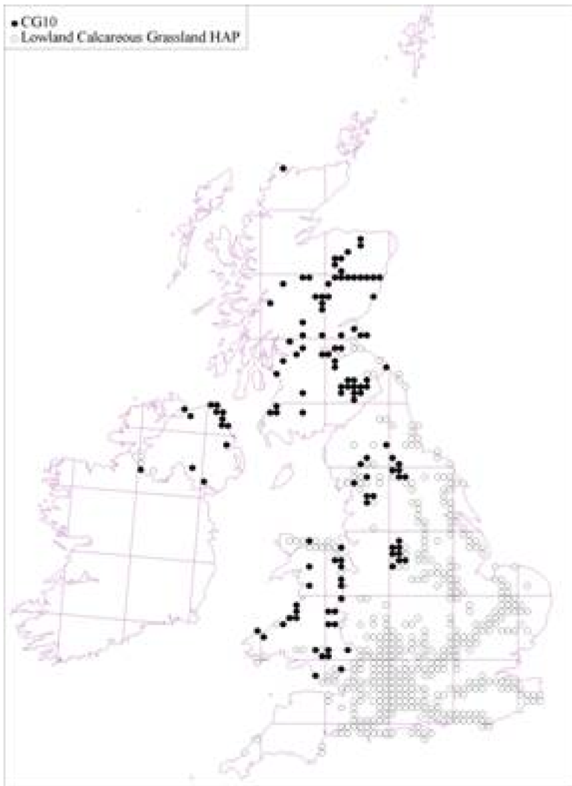

Figure 13 CG10 *Festuca-Agrostis-Thymus* grassland (lowland/enclosed)

The 10km grid records from which these maps were prepared date from 1980 onwards and include vegetation recorded as intermediate between NVC communities. The filtering has been inclusive, including all sites where the target community was recorded, even if only part of an intermediate with one or more other communities.

2.5 Character and significance of the UK habitat in the wider European context

Except where they occur on rocky outcrops with very fragmentary, shallow and drought-prone soils, the Lowland Calcareous Grasslands of Europe are anthropogenic vegetation types that have replaced various kinds of calcicolous forest on lime-rich bedrocks and more permeable superficials. Such parent materials are widespread and locally very extensive through the lowlands and upland fringes of Europe, particularly in the more continental climate zone. From a wider European perspective, the bulk of the Lowland Calcareous Grassland of the UK can be seen as part of the **Bromion**, or Mesobromion as it was called in Rodwell (1992) and by some authorities still. This is one of 10 alliances within the Brometalia erecti (or Festuco-Brometalia in the older usage retained in the Habitats Directive), itself one of 14 orders within the Festuco-Brometea, a class of grasslands and steppes occurring on free-draining, impoverished and calcareous to somewhat lime-poor soils right across the lowlands and foothills of Europe. Variation within the Festuco-Brometea is largely related to differences in climate and soils across this territory: the orders comprise a clear geographic sequence from more mesophytic 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. The current view on the status of these orders in the Festuco-Brometea is shown in Rodwell *et al*. (2002) and part of the floristic variation encompassed by the sequence is neatly summarised in table 89 in Ellenberg (1988). Table 4 summarises the relationships of those alliances referred to below.

The Brometalia is the order that includes the grasslands at the more Atlantic end of this sequence, swards that are broadly characterised by *Bromopsis erecta* (= *Bromus erectus*), *Koeleria pyramidata* (*K. macrantha* with us), *Helianthemum nummularium, Hippocrepis comosa, Centaurea scabiosa* and *Scabiosa columbaria.* The Bromion, the core alliance of semi-arid calcicolous grasslands in western Europe within the Brometalia, is additionally distinguished by *Helictotrichon pratense* (=*Avenula pratensis*)*, Brachypodium pinnatum*, *Carex flacca, Carlina vulgaris, Cirsium acaule, Gentianella ciliata, G. germanica, Sanguisorba minor* and the bryophytes *Fissidens cristatus, Homalothecium lutescens* and *Weissia* spp., together with a variety of orchids: *Aceras anthropophorum, Anacamptis pyramidalis, Herminium monorchis, Himantoglossum hircinum, Ophrys apifera, O. insectifera, O. sphegodes, Orchis mascula, O. militaris, O. morio, O. simia, O. tridentata, O. ustulata* and *Spiranthes spiralis.* Like many of the grasslands within the Festuco-Brometea, these are potentially species-rich and diverse swards, provided the more competitive grasses are held in check.

Among the Lowland Calcareous Grassland, CG2-CG6 are mainstream Bromion swards that would be very familiar to ecologists from elsewhere in western Europe. Similar grasslands have been described as the Gentiano-Koelerietum Knapp ex Bornkamm 1960, the Carlino-Brometum Oberdorfer 1957 or their equivalents from France (Julve 1993), Belgium (LeBrun *et al*.1949), The Netherlands (Schaminée *et al*.1996), Germany (Oberdorfer & Korneck in Oberdorfer 1978, Ellenberg 1988, Dierßen 1996), Austria (Mucina *et al.* 1993), Switzerland (Delarze *et al*. 1998), Poland (Herbicha 2004), Lithuania (Balevičienė *et al.* 1998), Latvia (Kabucis *et al*. 2000), the Czech Republic (Moravec 1995), Slovakia (Viceníková & Polák 2003) and Hungary (Borhidi & Sánta 1999). In Ireland, too, Bromion swards have been described, though from the rather particular habitats of eskers, moraines and stabilised calcareous dunes (Braun-Blanquet & Tüxen 1952, Ivimey-Cook & Proctor 1966, Shimwell 1971, White & Doyle 1982). Mainstream Bromion swards have also been described from more mesic soils in Denmark (Pihl *et al*. 2001).

With the shift from the sub-Atlantic to the sub-Continental zone, from Poland and Austria eastwards, the Bromion is replaced by the Cirsio-Brachypodion, and beyond there, the Brometalia gives way to the Festucetalia valesiacae, its counterpart in the truly continental parts of Europe. In the French and Spanish Pyrenees, the Brometalia is still represented, but the Bromion is replaced there by the Potentillo montanae-Brachypodion rupestris (Bensettiti *et al.* 2005) and, then in Spain and Portugal, also by the Teucrio pyrenaici-Bromion erecti (Rivas-Martínez *et al*. 2002), while in Italy, the Cytiso-Bromion caprini and Festuco-Bromion are the main Brometalia alliances. In the west and central Mediterranean, calcicolous meadows and abandoned fields on limey substrates are included in the Brachypodietalia phoenicoidis while, in the Balkans and Greece, the Brometalia is replaced by the dry steppic grasslands of the Astragalo-Potentilletalia (Dimopoulos 2006). Towards these southern latitudes, the Festuco-Brometea is a class of the submontane and montane zones, where altitude brings some relief from the summer heat and the prospect of droughting.

Table 4 A simplified phytosociological classification of the lowland and sub-montane calcicolous grasslands of western Europe.

Class	Order	Alliance
Festuco-brometea Grasslands and steppes on calcareous soils	***Brometalia erecti*** Semi-arid to arid grasslands on deeper calcareous soils	**Bromion erecti** Semi-arid grasslands in western Europe
		Cirsio-Brachypodion pinnati Semi-arid to arid grasslands in Sub-Continental regions
		Potentillo montanae-Brachypodion rupestris Steppic grasslands of northern Spain & the Pyrenees
		Teucrio pyrenaici-Bromion erecti Chamaephyte-rich grasslands of Cantabria
		Cytiso-Bromion caprini Sub-Mediterranean grasslands of Cantabria
		Festuco-Bromion Sub-Mediterranean grasslands of Provence & Ligurian Alps
	Koelerio-Phleetalia phleoidis Steppic grasslands of western and central Europe	**Koelerio-Phleion phleioidis** Grasslands of somewhat lime-poor sands in western and central Europe
	Stipo pulcherimae-Festucetalia pallentis Open arid rocky grasslands of central and south-east Europe	**Xerobromion** Open rocky grasslands of south-west central Europe
Elyno-seslerietea Sub-alpine & alpine calcicolous grasslands	***Seslerietalia albicantis*** Sub-alpine and alpine calcicolous grasslands	**Seslerion albicantis** Grasslands dominated by *Sesleria albicans*

The number and diversity of other grassland types described from within the Bromion alliance varies considerably across Europe with, for example, 30 associations recognised from France (Julve 1993) and 15 associations from the Czech Republic (Chytrý *et al*. 2001). This probably reflects different approaches to syntaxonomy as well as the variations in soil type, regional climate and intensity of grazing which, there as well as in this country, influence floristic composition and structure among the swards, though countries like France with a broad range of climatic variation naturally encompass more diversity than here. However, one aspect of British Bromion grasslands that is distinctive in this respect is the fading of the more strictly Continental contingent of herbs towards the north of England where the Bromion reaches its north-western European limit. Here, among the foothills of the Derbyshire dales and the Pennines, with scattered stands in Southern Scotland, CG2d *Dicranum* sub-community of *Festuca-Avenula* grassland represents a transition to the **Violion**. This alliance of the Nardo-Callunetea is probably the best location for the CG10 *Festuca-Agrostis-Thymus* grassland, a community with scarcely any representation of calcicoles of drier swards and no real affiliation with the Festuco-Brometea at all.

In Britain, this northern transition is complicated by the appearance of *Sesleria albicans* (=*S. caerulea*) in calcicolous swards, some of which, like the CG8 *Sesleria-Scabiosa* grassland, still preserve some floristic features of the Bromion, a situation that is seen elsewhere in Europe. In France, too, (Julve 1993) and in Ireland (White & Doyle 1982), a Bromion sub-alliance, the Seslerio-Mesobromenion has been characterised to contain such swards (Oberdorfer 1957). In his pioneer study of British calcicolous grasslands, Shimwell (1968) saw the Asperulo-Seslerietum (Br.-Bl. & Tx. 1952) described in detail from the Burren by Ivimey-Cook & Proctor (1966), as essentially identical to the most xeric of the sub-associations within the CG9 *Sesleria-Galium sterneri* grassland (see also White & Doyle 1982). As defined in the NVC, this community is actually a fairly compendious vegetation type that, at its opposite extreme, beyond the limits of enclosure in the very harsh montane conditions of Upper Teesdale, approaches the Carici-Kobresietea, the class of sub-alpine and alpine grasslands that replaces the Festuco-Brometea in Scandinavia (Fremstad 1997) and to which the British CG13 and CG14 *Dryas* heaths probably belong. In Rodwell (2000), the CG9 *Sesleria-Galium* grassland was also, along with CG8 *Sesleria-Scabiosa* grassland, included within the Bromion, but this is really an inadequate solution, even for many of the lowland stands of the Typical sub-community and certainly for the vegetation at present included within CG9c-e. The **Seslerion albicantis,** an alliance that includes sub-alpine *Sesleria* swards within the Elyno-Seslerietea, a class transitional in composition and ecology between the Festuco-Brometea and Carici-Kobresietea, might be a better affiliation for such grasslands. Grasslands in other alliances of this class are widespread and common through the pre-Alps and Alps of central Europe, with the Carici-Kobresietea occurring more locally at high altitudes, and dominated by arctic-alpine species, through central Europe and the Balkans.

Two other climate-related trends can be seen among the British Lowland Calcareous Grassland. First, in CG1 *Festuca-Carlina* grassland, a community of steep and stable rocky slopes on hard limestones around the south and west coasts of Britain with immature rendziniform soils experiencing a hot and sunny summer topoclimate, there is the closest approach we have to the more arid swards of the **Xerobromion.** This alliance contains open grasslands with a real sub-Mediterranean feel, where such Continental Southern or Oceanic Southern species as *Carex humilis, Helianthemum apenninum, H. canum, Koeleria vallesiana* and *Trinia glauca* find a locus. Comparable vegetation has been reported from similar habitats in Belgium (LeBrun *et al.* 1949), France (Julve 1993) Germany (Korneck 1974, Oberdorfer & Korneck in Oberdorfer 1978) and Switzerland (Delarze *et al*. 1998), with associations like the Koelerio-Helianthemetum apennini Luquet 1937 looking very similar to some of our own vegetation in this community. However, though once seen as part of the Brometalia, a stricter interpretation of the Xerobromion has now developed, placing these grasslands among the more xerophilous grasslands of the Stipo pulcherrimae-Festucetalia pallentis, an order whose central area of distribution is in rocky habitats in central and south-eastern Europe. From this perspective, our own CG1 grasslands would be best seen as an extreme part of the Bromion.

The second climatic trend is represented by the CG7 *Festuca-Hieracium-Thymus* grassland which extends the Lowland Calcareous Grassland on to skeletal and sometimes sandy soils in the most continental parts of Britain. Rodwell (1992, 2000) suggested this vegetation had affinities with the **Koelerio-Phleion**, an alliance of grasslands in more continental climates centred on central and western Europe. Grasslands of this type have been described from Germany (Korneck 1974, Oberdorfer & Korneck in Oberdorfer 1978), Austria (Mucina *et al.* 1993, under the somewhat unhelpful alliance name of Euphorbio-Callunion) and Czechia

(Moravec 1995, Chytrý *et al*. 2001) and, in a more poorly differentiated form, from Switzerland (Delarze *et al*. 1998). Strictly speaking, however, these swards occur on somewhat lime-poor soils derived from siliceous parent materials like sands, a distinction recognised in shifting the Koelerio-Phleion from the Brometalia (as in Ellenberg 1988) to the Koelerio-Phleetalia. They come close in floristics to the Plantagini-Festucion swards that are included in the UK in the U1 *Festuca-Agrostis-Rumex* grassland and ecologists from elsewhere in Europe have expressed some scepticism that we could have vegetation of this kind. Nonetheless, especially in CG7b (the Breckland Grassland B of Watt 1940) which provides a locus for the more calcifuge *Thymus serpyllum* and some Continental rarities, the Koelerio-Phleion is approached quite closely.

2.6 Coverage in Natura 2000

In England, Scotland and Wales, the Natura 2000 Habitat 6210 Semi-natural dry grasslands and scrubland facies on calcareous substrates Festuco-Brometalia (CEC 2003) includes all the Lowland Calcareous Grassland as defined within the BAP; in Northern Ireland, only CG9 Sesleria-Galium grassland is included, CG10 being included with the 6230 Species-rich *Nardus* grasslands. The bracketed term (Festuco-Brometalia) is unhelpful because, as the fuller definition explains, this Habitat is intended to include vegetation of two orders of the Festuco-Brometea, the Brometalia and the Festucetalia vallesiacae, though the species list of the Annex I habitat actually focuses on plants of the Mesobromion and Xerobromion. Further confusion comes in the list of corresponding categories where vegetation of the Koelerio-Phleion is also included. More explicit in the basic definition is the fact that the habitat should be interpreted as including scrub and the intermediate thermophilous fringe vegetation of the Trifolio-Geranietea, which results from abandonment. The distribution of SACs for this habitat is shown in Figure 14 and the proportions of the total site numbers represented in each country are: Austria (2%), Belgium (3%), Denmark (3%), Finland (1%), France (14%), Germany (26%), Greece (1%), Ireland (1%), Italy (21%), Luxembourg (1%), The Netherlands (1%), Portugal (1%), Spain (6%), Sweden (6%), United Kingdom (2%), Czech Republic (2%), Estonia (3%), Hungary (2%), Latvia (1%), Lithuania (1%), Poland (1%), Slovakia (3%) and Slovenia (1%).

Subdivision of the habitat recognises the particular importance of sites with rich suites of orchids, important populations of more uncommon orchids or the occurrence of one or several nationally rare orchids (CEC 2003). Alone among the EU states, the UK has used sub-habitat 6211 to include such sites based on the occurrence of *Aceras anthropophorum, Herminium monorchis, Himantoglossum hircinum, Ophrys fuciflora, O. sphegodes. Orchis militaris, O. purpurea, O. simia* and *O. ustulata* (Jackson & McLeod 2002). These are good Bromion indicators, all threatened or endangered plants in the UK, though widespread on the Continent and not always so vulnerable there. Elsewhere in Europe, only France and Germany have designated SACs for 6211 and their rationale for doing so is quite different: in these countries, this sub-division of 6210 covers Sub-Continental Steppic Grasslands, mostly of the Festucetalia vallesiacae, the Stipo-Poion carniolicae in France (Bensettiti *et al*. 2005), the Stipo-Poion xerophilae in Austria (Ellmauer & Traxler 2000), the Festucion vallesiacae in Germany (Ssymank *et al*. 1998), and also there the Cirsio-Brachypodion, now regarded as the more continental part of the Brometalia (Rodwell *et al.* 2002).

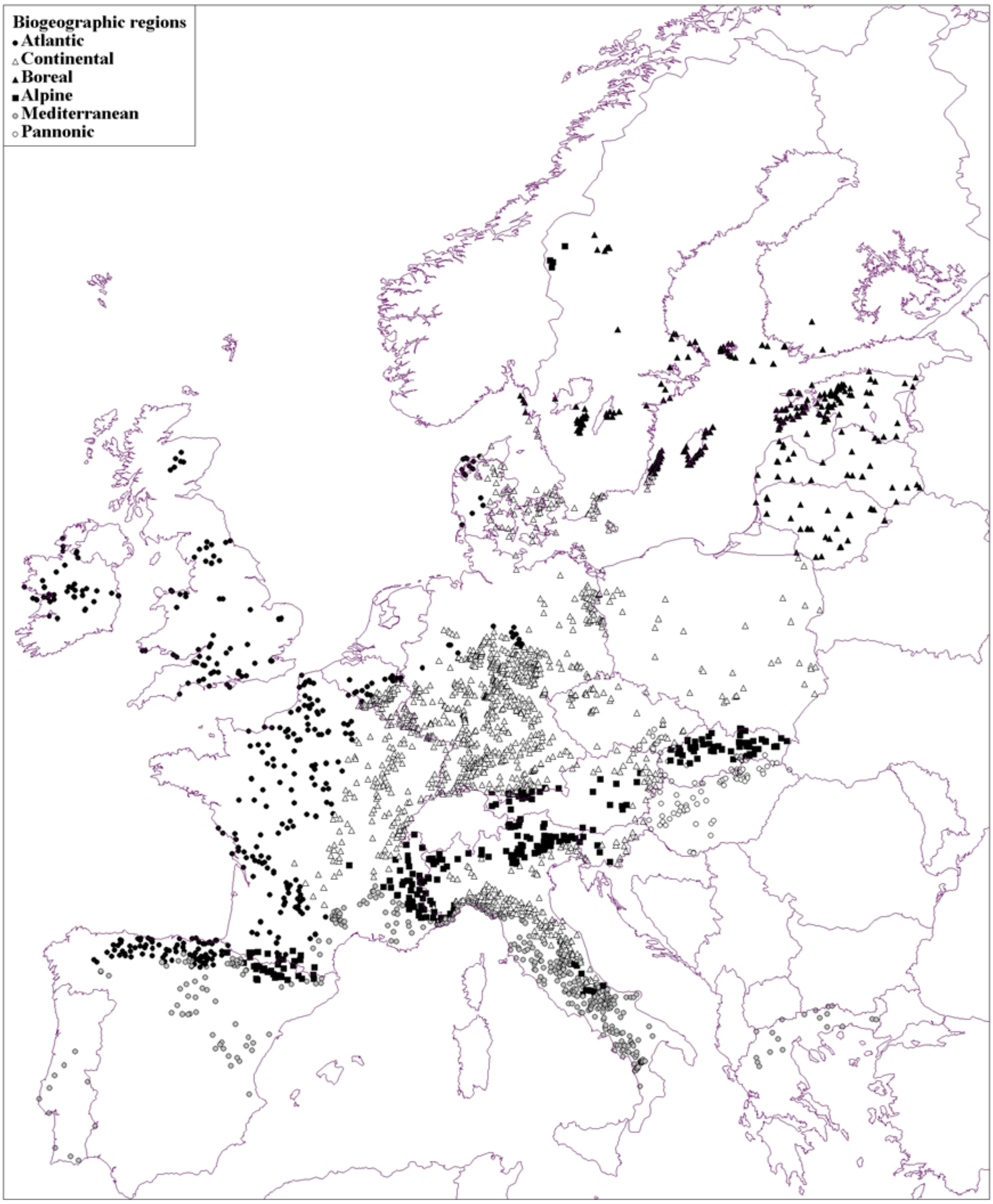

Figure 14 Annex I 6210 Semi-natural dry grasslands and scrubland facies on calcareous substrates

Within the Atlantic zone, the EU countries have designated their own equivalents of our core Lowland Calcareous Grassland as Habitat 6210. These are mostly Brometalia swards, particularly of the Bromion, as in the Netherlands (Jansen & Schaminée 2003) and Denmark (Pihl *et al*. 2002, Bruun & Ejrnaes 2000) but Germany (Ssymank *et al*. 1998) and France (Bensettiti *et al*.), like the UK, have also included grasslands of the Xerobromion and the first two countries also of the Koelerio-Phleion, along with those of the Bromion. In the Boreal lowlands of Lithuania (Rašomavičius *et al*. 2001), Latvia (Kabucis *et al*. 2000) and Estonia (Paal 2004), the designated grasslands are also of a fairly mainstream Bromion type. With the shift into the sub-Atlantic zone, other Brometalia alliances make an appearance within the designations and, in the Continental zone, in Austria (Ellmauer & Traxler 2000), Poland (Herbicha 2004), Czechia (Chytrý *et al.* 2001), Slovakia (Viceníková & Polák 2003), Hungary

(Borhidi 2003), the prominence in the SACs of grasslands of the Cirsio-Brachypodion and Festucion vallesiacae marks a shift towards the Festucetalia vallesiacae. Countries towards the very limits of the Brometalia and Festucetalia vallesiacae have been imaginative in ensuring designation of other kinds of Festuco-Brometea associations to include their valuable calcicolous grasslands within Habitat 6210. In Portugal, for example, vegetation of the Brachypodietalia phoenicoidis has been included (Instituto da Conservação da Natureza 2005), while in Greece, it is the Astragalo-Potentilletalia that figures (Dimopoulos *et al.* 2006). Elsewhere, the Festucetalia valesiacae has been included in other habitats such as 6240 Sub-pannonic Steppe Grasslands and 62A0 Pannonic Loess Steppic Grasslands.

It is the Dutch who have been most explicit and detailed in their interpretation of Habitat 6210 as including not only calcicolous swards themselves but also transitions to woody vegetation that develop with relaxation of treatments, usually abandonment of grazing. In the Netherlands, this habitat therefore also includes associations of calcicolous fringe vegetation of the Trifolion medii in the Trifolio-Geranietea and Berberidion scrubs of the Rhamno-Prunetea (Jansen & Schaminée 2003). Transitions to scrub are also included as part of this habitat in Denmark (Pihl *et al.* 2001) and Lithuania (Rašomavičius *et al*. 2001) or they find mention in the literature as part of mosaics or dynamic transitions, as in France (Bensettiti *et al.* 2003) and Germany (Ssymank *et al*. 1998). Grassland-scrub transitions are mentioned in the British interpretation manual as being of particular interest as a habitat for certain rare and local plants, and some SACs especially significant in this respect are listed there (Jackson & Mcleod 2002). The NVC (Rodwell 1992) also makes particular mention of species such as *Himantoglossum hircinum* (Good 1936) and *Orchis militaris* which are especially associated with transitional habitats of this kind. W21 *Crataegus-Hedera* scrub is the usual invader of Bromion grasslands in Britain, with the W21d *Viburnum lantana* sub-community particularly associated with this habitat though, where juniper is a local pioneer, this vegetation can be included within the Natura 2000 Habitat 5130 *Juniperus communis* formations on heaths or calcareous grasslands. *Saum* or fringe vegetation was poorly covered in the NVC but Rodwell *et al*. (2000) suggested the likely existence in Britain of two Geranion sanguinei assemblages, an *Agrimonia eupatoria-Origanum vulgare* community (for which some data exist in Willems 1978) and the *Geranio-Coryletum* first described by Shimwell (1968) and swallowed up in the W21 scrub in Rodwell (1991). These could be more explicitly included within Habitat 6210 in Britain, though their management poses particular problems which are detailed below.

2.7 Key threats to the habitat

The *Common Standards Monitoring of Designated Sites: First Six Year Report* (Williams 2006) showed that 29% of SSSI features and 27% Natura 2000 features were in Favourable condition, figures well below the average for all habitats taken together, with 40% and 54% respectively in Unfavourable Recovering and 30% and 17% respectively in Unfavourable. Among the random sample of non-statutory English sites for the BAP Lowland Calcareous Grassland habitat included by Hewins *et al.* (2005), mostly CG2 *Festuca-Avenula*, CG3 *Bromus* and CG5 *Bromus-Brachypodium* grasslands, 28% were Favourable.

Grazing by domesticated farm animals was, and in many places remains, a key factor in sustaining Lowland Calcareous Grasslands in many parts of Europe, so **reductions or changes in stock grazing** will always affect this habitat (Rodwell 1992, Smith 1980) and was the major reason for unfavourable condition of this habitat in the UK reported by Williams (2006). However, even in a relatively small country like ours, it would be rash to make assumptions about the pastoral practice of former times as a basis for understanding currents threats and best management now since, as elsewhere in Europe climate, physiography, cultural history and social structure all affected pastoral practice (Wells 1969, 1971). Even today, the choices of grazing stock for management can be very flexible (Bacon 1990) and some important regional differences also persist: in Northern Ireland, for example, cattle have always been important grazers of this habitat, particularly before the impact of headage payments. It is clear, too, from studies of the effects of grazing on particular species (for example, Pigott 1955, Proctor 1956, Smith 1979, Bishop & Davy 1984) and experiments on particular grassland types (Duffey & Watt 1971, Duffey *et al*. 1974) that the responses of different swards and their plants to changes in the kind and intensity of grazing can be diverse and complex, so specifiying more than generic threats for the whole of Lowland Calcareous Grassland can be misleading. And it is also important to realise that, though the BAP and Annex I habitats are defined mainly on their vascular plant interest, grazing has important impacts on less conspicuous elements of the habitats like bryophytes (During 1990) and invertebrates (Morris 1990, Jones-Walters 1990), such that optimal management for vascular plants may be itself threatening to the welfare of other important plants and associated fauna.

Of especial consequence among the Lowland Calcicolous Grasslands is the fact that grazing to some extent mediates shifts between the more close-cropped CG2 *Festuca-Avenula* grassland and those swards dominated by bulky grasses such as *Bromopsis erecta* (in CG3 and CG5), *Brachypodium pinnatum* (in CG4 and CG5), *Helictotrichon* (=*Avenula*) *pubescens* and *Arrhenatherum elatius* (in CG6). An intensity and quality of grazing that is generally threatening to the first kind of community can therefore be beneficial for the others, and vice versa (Wells 1968, 1971, Austin 1968, Green 1973), though some associated species survive the shift from close to ranker swards more readily than others (eg. Wells 1968 on *Pulsatilla vulgaris*). Moreover, these successional shifts are not always entirely predictable nor easily reversible, particularly where *Brachypodium* is concerned, and they show quite complex interactions with soil variations which can favour this or that successional development. On the more northerly limestones, grazing also mediates a shift between species-rich and more impoverished tussocky swards with *Sesleria albicans* (in CG8 and CG9).

Rabbits have played an important auxiliary role in sustaining the distinctive character of much of our Lowland Calcareous Grassland, probably for centuries, and it is clear from the aftermath of the myxomatosis epidemic of 1954/55 (Lockley 1964, Sheail 1971) and enclosure experiments (eg. Watt 1957, 1974) that **reductions in wild herbivore grazing** can pose a substantial threat to this habitat. It is especially in the CG7 *Festuca-Hieracium-Thymus* component of the Lowland Calcareous Grassland, vegetation which, in the more continental eastern England, most closely approaches the Koelerio-Phleion, that rabbits have played a crucial part in sustaining this vegetation and its mosaics there with Lowland Acid Grasslands, by the cropping of the sward, the preferential character of the predation, the general run-down of nutrients and by the disturbance that grazing involves (Rodwell 1992).

In habitats like Lowland Calcareous Grassland which is dependent on the maintenance of impoverished soil conditions for the particularly striking richness of species, the **manuring impacts of herbivores** like stock and rabbits whose cropping of the herbage is essential to sustain the vegetation can pose a threat where the dunging is localised, as in sheep lie-ups or rabbit latrines (Watt 1981). In other cases, modest manuring can be beneficial, as with the more mesophytic CG2b *Succisa-Leucanthemum* and CG2c *Holcus-Trifolium* swards of the Wiltshire cow-downs, where grazing by cattle augments what is probably a naturally higher level of nutrients in loess-derived soils, producing Lowland Calcareous Grassland swards which are 'as different as chalk and cheese', as the local saying goes (Rodwell 1992). In The Netherlands, this kind of vegetation, classified as the Galio-Trifolietum within the Cynosurion, is also specifically included within the Annex I 6210 habitat (Jansen & Schaminée 2003).

More drastic eutrophication has often come from **agricultural improvement** of Lowland Calcareous Grassland by the application of chemical fertilisers, together with ploughing and reseeding on soils sufficiently deep for cultivation, though in Northern Ireland the impact of these changes was later, as part of the general increase in rural development in the 1980s, and it has been discontinued in some places. Ultimately (and quite readily with sufficient upgrade), Lowland Calcareous Grassland is then converted to various kinds of Cynosurion sward (Smith *et al*. 1971) with a rise in herbage productivity but a consequent reduction in species richness and a convergence from locally distinctive swards into the sort of improved mesotrophic grassland that is ubiquitous (see Rodwell 1992, Figure 9).

In the UK, until recently, there has been little interest in **mowing** Lowland Calcareous Grassland except as an experimental substitute for grazing (Wells 1971, Wells & Cox 1993), but this method of management is now attracting increasing interest, particularly in isolated or steep sites. Elsewhere in Europe, mowing for hay has been more often practiced, though, as in southern Germany and Switzerland, this may not be a very ancient tradition: stall-feeding of cattle began there only 150 years or so ago with a demise of sheep-rearing some 70 or so years later (Ellenberg 1988). In the Swiss Jura and Rhineland, the Mesobromion grasslands are generally mown once a year, though more mesic and productive swards can stand two cuts, the general effect being to favour the dominance of *Bromopsis erecta*.

Although **neglect and the succession to woodland**, with its eclipse of many of the shade-sensitive herbs, is seen as threatening to Lowland Calcareous Grassland, certain rarer plants, including some specified within Annex I definitions like *Himantoglossum hircinum* (Good 1936) and *Orchis militaris* are actually associated with scrub margins and the Annex I habitat 6210 includes such transitional vegetation within its definition. Moreover, it is likely that maximum benefit of such mosaics occurs where they are dynamic and represented at a landscape scale rather than where they are maintained as static spatial pattern on small and fragmentary sites (Rosenberg & Freedman 1984, Ward 1990). Such ironies pose a particular challenge and the **lack of a spacious imagination** among conservation managers might itself pose a threat to the sustainability of this habitat in its full richness. This is an especial problem elsewhere in Europe where EU member states have proposed many small SACs, as in Germany.

The particular vulnerability of certain calcicolous grasslands to **atmospheric acid and nitrogen deposition** led to their inclusion within the then DoE's Air Quality research programme in the 1990s. A national monitoring network was established to include all 14 communities recognised in the NVC (Rodwell 1992) with baseline recording of detailed floristic data from over 120 permanently marked quadrats in over 50 sites, all chosen to ensure in so far as possible stable ownership and management, and many on SSSIs (Rich *et al.* 1993). Site reports were provided to the DoE and site managers and contributions made to the mapping of critical load exceedance maps (Rodwell *et al.* 1993) and the subsequent INDITE programme. The recent resurgence of interest in such data records includes a summary of this monitoring framework (Morecroft *et al.* 2005).

For habitats such as Lowland Calcareous Grassland, part of whose character comes from drought-resistance or, in some cases, dependence on the shortage of water to maintain the distinctive floristics and structure of the vegetation, the prospect of **climate change** with more severe drought episodes is a threat. This is particularly so for those plant communities sustained in regions or on topographies which already have a highly xeric character, as with the CG7 *Festuca-Hieracium-Thymus* grassland of East Anglia (tending to Koelerio-Phleion) and the CG1 *Festuca-Carlina* and CG9a *Sesleria-Galium* grasslands of south and west-facing rocky slopes around the western seaboard of the British lowlands (our nearest approach to the Xerobromion). Here, more dramatic losses of perennials and the spread in the UK of drought-tolerantt ephemerals, including perhaps more Continental plants not yet recorded here, might be in prospect. Milder winters might also affect the phenology of growth in Lowland Calcareous Grasslands.

It is particularly in the rocky habitat favoured by vegetation like the CG1 *Festuca-Carlina* and CG9a *Sesleria-Galium* that **invading alien plants** have already proved a threat to this habitat. Here, bird-sown *Cotoneaster* and *Berberis* species can root in crevices and spread extensively over the ground, shading out the native flora. On the coastal limestones of southern England and North Wales, *Quercus ilex* is also spreading into swards on sunny aspects (Crofts & Jefferson 1999).

2.8 Conservation initiatives

In the UK, Lowland Calcareous Grassland is well represented within the SSSI network with 616 sites in England and 22 in Wales where this habitat is the main purpose of designation, and this probably accounts for 60-70% of the total resource (UK Biodiversity Group 1998). Estimates of the extent of the Annex I habitat 6210 give the areas as 38,687ha for England, 1146ha for Wales, 761ha for Scotland, with 20 SACs for which this is the primary reason for designation, 2% of the EU site total. The extent of habitat 6211, the category used in this country for orchid rich sites, is unknown but 16 SACs have been declared (Jackson & McLeod 2002). Environmentally Sensitive Areas with a significant proportion of Lowland Calcareous Grassland include Breckland, the South Downs, the South Wessex Downs and the Cotswold Hills. Tir Gofal also include this habitat as eligible for funding and Rural Stewardship in Scotland targets lowland semi-natural grassland which includes Lowland Calcareous Grassland. Very many conservation initiatives focus on this habitat and the following is a small selection.

The Ministry of Defence owns the biggest proportion of Lowland Calcareous Grassland in the UK with extensive holdings on Salisbury Plain, Porton Down in Wiltshire and the Stanford Training Area in East Anglia, places where military occupation and some forms of disturbance have been essential to preserving the extent and character of large-scale landscapes. On the first sites, the MoD and the Defence Science and Technology Laboratories worked in partnership with Natural England, the Royal Society for the Protection of Birds, the Centre for Ecology and Hydrology and Butterfly Conservation in the **Salisbury Plain EU Life Project** aimed at enhancing the grassland by scrub and plantation clearance and shepherding of livestock and encouraging the regeneration of juniper by exclosure (http://www.rspb.org.uk/ england/ southwest/ conservation/ salisbury_life_project.asp) . Rare types of CG7 *Festuca-Hieracium-Thymus* grassland figure among the Calcareous Grasslands and there are 13 nationally rare and scarce plants on the sites. Stone curlew and the marsh fritillary were two particular targets among the fauna but Salisbury Plain also hosts 67 rare and scarce moths, butterflies, bees and flies, as well as the

Red Data Book Fairy Shrimp. In the RSPB's ongoing **Manor Farm Project** (http://rspb.org.uk/supporting/campaigns/wildplaces/manorfarm/index.asp), the Stone Curlew is a particular target in the restoration of 296ha of Lowland Calcareous Grassland between Salisbury Plain and Porton Down.

Porton Down itself has 200 species of spider, 66 species of breeding birds and 220 fungi. CEH includes the site in the **Environmental Change Network** (http://www.ecn.ac.uk) with an extensive suite of monitoring including vegetation, birds, invertebrates - notably the carabid beetles - and rabbits (especially important as grazers of the swards). Porton is a valuable research site with two projects looking at the relationships between butterfly abundance and habitat availability and the role of mycorrhizae in orchid abundance.

An integrated landscape-scale approach to a fragmented Lowland Calcareous Grasslands resource is part of the vision of CCW's **Gwella'r Olygfa: Improving the View** project. This will include 12 SSSIs on the North Wales Carboniferous Limestone, totalling 775 ha, which have over one third of this habitat in Wales, 90% of the CG1 *Festuca-Carlina* grassland and important populations of nationally scarce vascular plants. Scrub encroachment, the spread of bracken and invasion of non-native plants are all problems on these sites which, by virtue of their unproductive soils and rocky terrain, have become increasingly unappealing for grazing livestock. Attention has so far focused on scrub clearance, but ensuring appropriate grazing (or short-rotation mowing in some places) will be crucial for long-term sustainability of the swards. As prominent features of their local landscapes, these places are appealing for recreation and there is the prospect of improving panoramic views in some situations, with the challenge for interpretation and limiting damage by trampling.

An emphasis on the physiographic foundation for this kind of habitat is also a feature of the **Lincolnshire & Rutland Limestone** project (www.lincstrust.org.uk), a partnership between Natural England, Leicestershire & Rutland Wildlife Trust and the Lincolnshire Wildlife Trust. This aims to work with land managers, local authorities and quarry owners to protect and extend the 100ha of calcareous grasslands, now much fragmented, to safeguard the geological history in quarry exposures and celebrate the landscape of the Oolitic Limestone that stretches across three counties.

Emphasising the value of Lowland Calcareous Grasslands within reach of the urban fringe is the **Downlands Project** established in 1988 to cover the greenbelt of north-east Surrey and adjacent parts of south London. Its objectives include not only biodiversity but also access and community involvement and the project relies heavily on dedicated volunteers (www.countryside-management.org.uk).

2.9 Research needs

A review of existing research into the conservation and restoration management of Lowland Calcareous Grassland is needed, particularly in relation to the integration of these activities with agriculture, and at a landscape scale, so that gaps in existing knowledge can be identified.

Further research is needed on arable reversion and the management of successions in this habitat, particularly in relation to valuable Saum and scrub such as those with juniper. The possible impacts of climate change and atmospheric nitrogen deposition are, as in other habitats, poorly understood here.

3 Lowland Dry Acid Grassland

3.1 Summary of the BAP Habitat Type

Lowland Dry Acid Grassland comprises open and closed swards, usually managed as pasture, dominated by calcifuge grasses and herbs, sometimes with a contingent of cryptogams. These grasslands are characteristic of acidic, impoverished and free-draining soils derived from sands and siliceous bedrocks throughout the lowlands, where they often, though not invariably, occur in mosaics with heaths, and within managed upland fringe landscapes up to the limits of functional enclosure, generally below 300m. Six NVC grassland and inland dune types are included here, with the likelihood of further definition of more ephemeral-rich assemblages from disturbed places. Similar vegetation of the Koelerio-Corynephoretea and the grassier Calluno-Ulicetea occurs widely across the northern European lowlands but is everywhere subject to the threats of continuing habitat loss, fragmentation and the abandonment of traditional pastoral management. In the UK, only the inland dune grasslands have been included within Natura 2000, in contrast to elsewhere in Europe where other equivalents of our Lowland Dry Acid Grasslands have been included within other Annex 1 habitats.

3.2 Synonymy

NVC U1 *Festuca-Agrostis-Rumex* grassland, U2 *Deschampsia flexuosa* grassland, U3 *Agrostis curtisii* grassland, U4 *Festuca-Agrostis-Galium* grassland (up to the limits of enclosure in the upland fringes); SD10b *Carex arenaria* dune community, *Festuca* sub-community & SD11b *Carex-Cornicularia* dune community, *Festuca* sub-community (all inland examples only).

Annex I 2330 Inland dunes with open *Corynephorus* and *Agrostis* grasslands (and elsewhere in the EU 6230 Species-rich *Nardus* grasslands, on siliceous substrates in mountain areas, and submountain areas in continental Europe).

EVS 29C02 Corynephorion canescentis, 29C03 Thero-Airion, 29D02 Plantagini-Festucion, 30A08 Violion.

EUNIS E1.7 Non-Mediterranean dry acid and neutral, closed grassland & E1.9 Dry, open perennial and annual siliceous grassland, including inland dune grassland.

3.3 Character and distribution of the NVC constituents

Six NVC communities have been included within Lowland Dry Acid Grasslands and their known distributions, and that of the BAP habitat as a whole, are shown in Figures 15-20. The U1 *Festuca-Agrostis-Rumex* grassland is the most widespread constituent of the habitat through the drier and warmer south-east of Britain: though its occurrence has always been local because of the relative scarcity of suitable substrates, it is now much more restricted and fragmentary. Within its range, the SD10 *Carex arenaria* and SD11 *Carex-Cornicularia* communities are more specialised and restricted vegetation types of mobile and fixed inland sands in a few localities in East Anglia and Lincolnshire.

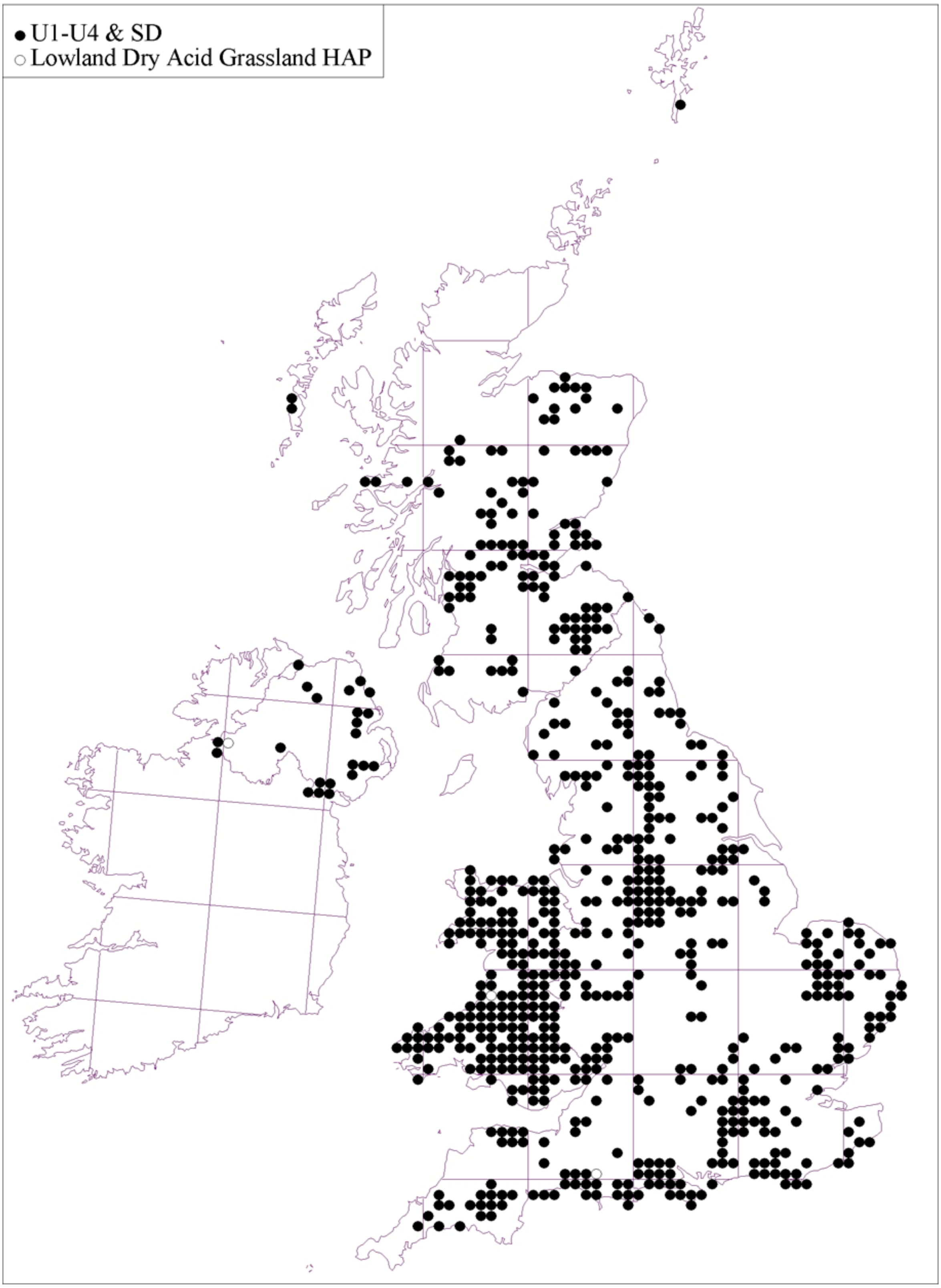

Figure 15 BAP Lowland Dry Acid Grassland

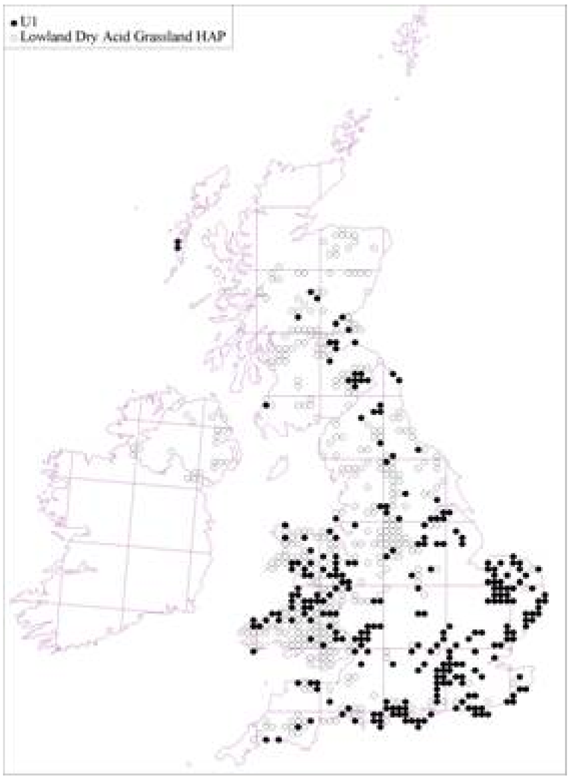

Figure 16 U1 *Festuca-Agrostis-Rumex* grassland

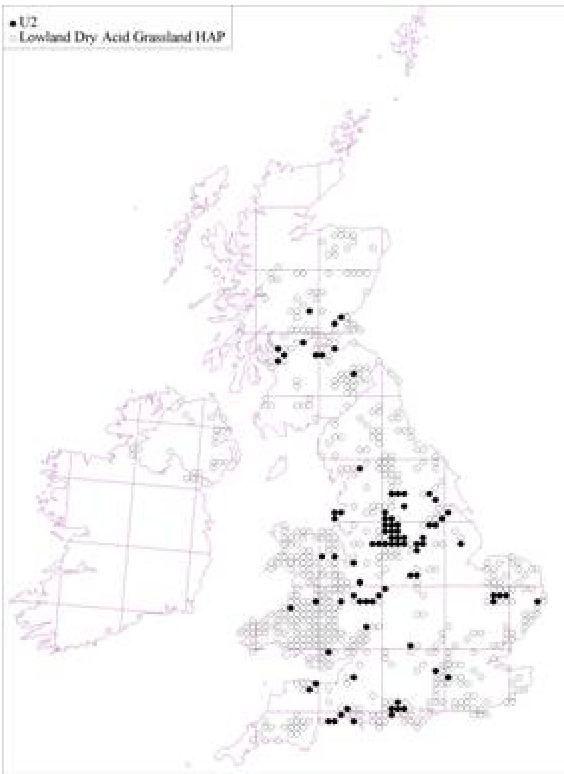

Figure 17 U2 *Deschampsia flexuosa* grassland

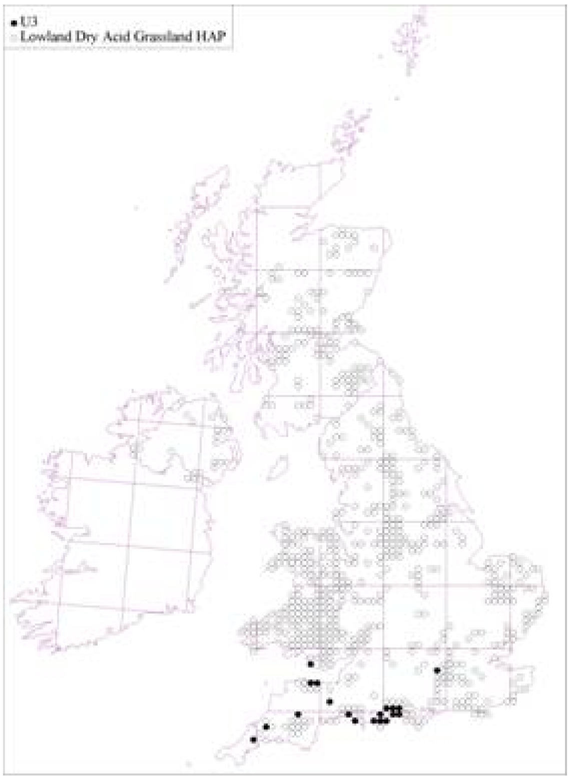

Figure 18 U3 *Agrostis curtisii* grassland

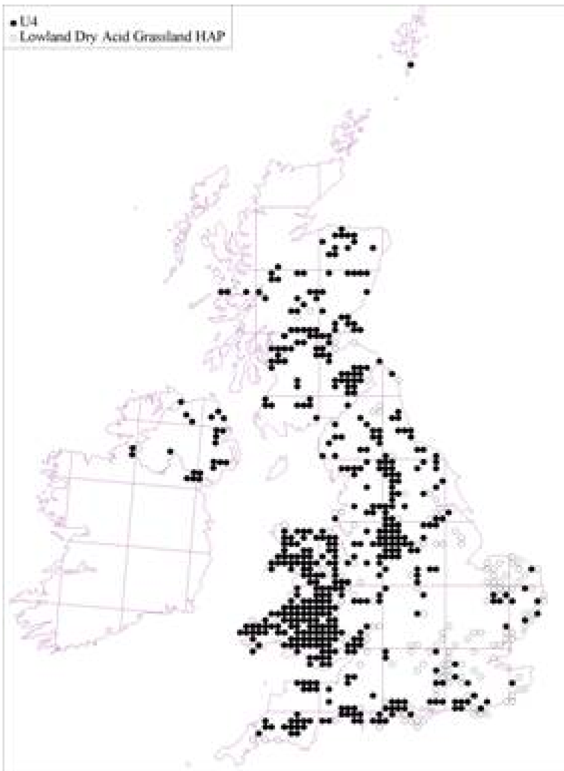

Figure 19 U4 *Festuca-Agrostis-Galium* grassland

The 10km grid records from which these maps were prepared date from 1980 onwards and include vegetation recorded as intermediate between NVC communities. The filtering has been inclusive, including all sites where the target community was recorded, even if only part of an intermediate with one or more other communities.

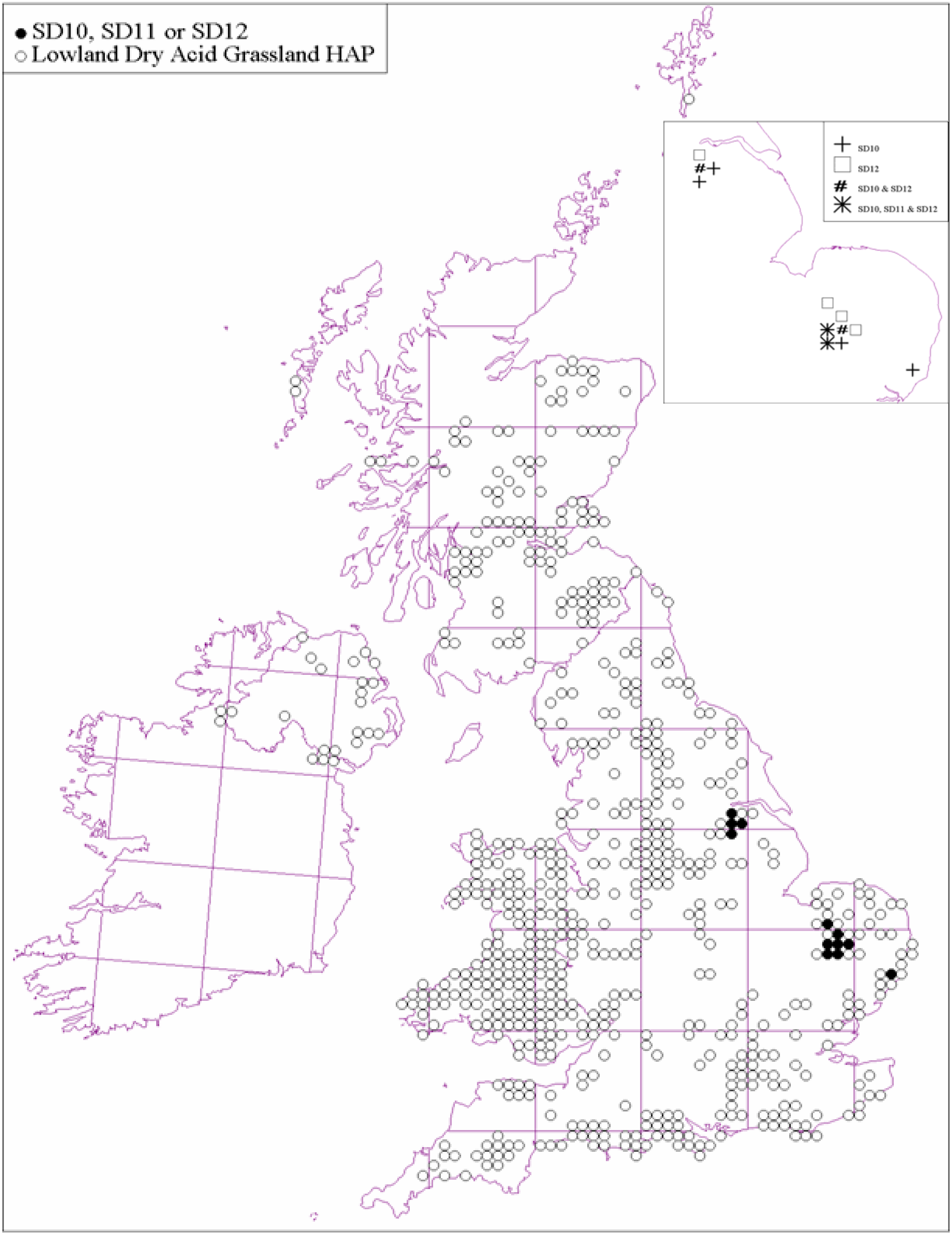

Figure 20 SD10 Carex arenaria, SD11 Carex-Cornicularia and SD12 Carex-Festuca- Agrostis grasslands (inland occurrences only)

The 10km grid records from which these maps were prepared date from 1980 onwards and include vegetation recorded as intermediate between NVC communities. The filtering has been inclusive, including all sites where the target community was recorded, even if only part of an intermediate with one or more other communities.

Two other grassland types occur within the lowlands proper: the U3 *Agrostis curtisii* grassland is a distinctly oceanic community in the milder Atlantic climate of the south-west, while the U2 *Deschampsia flexuosa* grassland is largely limited to the more humid upland fringes, in association not just with acidophilous heaths and woodlands, but also on drying peat surfaces on raised bogs and, at higher altitudes, blanket bogs. Throughout the cooler and wetter north-west, the U1 grassland gives way on less drought-prone acid soils to the U4 *Festuca-Agrostis-Galium* grassland, a very widespread pasture of the unenclosed uplands but included among the Lowland Dry Acid Grasslands where it occurs within the limit of enclosure. The most recent estimates for the extent of this BAP habitat (UK HAP Targets Review (Lowland Grasslands) 2005 on http://www.ukbap.org.uk/BAPGroupPage.aspx?id=98) are 20,142 ha in England, 36,473 ha in Wales and 4537 ha in Scotland. More precise figures for the various NVC communities were collated by Sanderson (1998) as: U1 8,000-12,000 ha, U2 3,000-5,500 ha, U3 2,000-3,000 ha, U4 3,000-5,000 ha, SD10 150-450ha and SD11 60-300ha.

A further vegetation type, part of SD12 *Carex-Festuca-Agrostis* grassland, is included within the Annex I 2330 Inland dunes but is not covered by the BAP Habitat. In addition, Rodwell *et al.* (1998) noted the omission from the NVC of inland Thero-Airion communities, more open and richer in ephemerals than the acid grasslands proper, and characteristic of stable but disturbed acid sands and siliceous rock outcrops away from any maritime influence. These should certainly also be considered as an integral part of this habitat and further sampling is needed to characterise and map them and ensure that they are not neglected in any conservation measures. Their general distribution pattern will be much as the U1 *Festuca-Agrostis-Rumex* grassland among stretches of which and among related heaths, they often occur as a disturbed trackside element, with some localities on artificial substrates like pervious shale waste which replicates the habitat requirements (see, for example, Lunn 2000).

3.4 The BAP Habitat and its constituents in Northern Ireland

Lowland Dry Acid Grasslands are scarce and very fragmentary in Northern Ireland. More open calcifuge swards with species such as *Sedum acre* and *Umbilicaria rupestris* can be found on outcrops and walls but most sites are coastal and the vegetation has been thought best grouped within maritime grasslands like the MC5 *Armeria-Cerastium* community. More closed calcifuge swards do occur in the province below 300m, but mostly as unenclosed rough grazings, often associated with the marginal land of the upland fringes, so strictly speaking these do not qualify as part of the BAP habitat type. Elsewhere, such grasslands form a small and fragmentary part of mosaics with lowland heath, meadow and pasture or maritime cliffs and are best included within the BAP habitats for these vegetation types. In terms of the NVC, the commonest grassland seems to be of the U4 *Festuca-Agrostis-Galium* type, with richer examples being of the semi-improved U4b *Holcus-Trifolium* sub-community (eg. Cooper & McCann 1994). As elsewhere in the UK, there is sometimes a transition between U4 grassland and more calcifuge examples of MG5 *Cynosurus-Centaurea* grassland. The UK HAP Targets Review (Lowland Grasslands) (2005) estimated the total of such grasslands in Northern Ireland as 674 ha.

3.5 Character and significance of the UK habitat in the wider European context

In floristic terms, the definition of this BAP habitat is somewhat awkward: it includes vegetation types that occur widely through the north and west of Europe but which are of two rather different kinds, characteristic of different habitats and landscapes and raising different questions for protection and management. The U1 *Festuca-Agrostis-Rumex* grassland and the SD10 *Carex arenaria* and SD11 *Carex-Cornicularia* communities (and the SD12 *Carex-Festuca-Agrostis* grassland which figures in the Annex I type) are generally rather open vegetation types with a pioneer ephemeral element. Though it does not say so explicity, these seem to correspond with what the UK BAP calls 'parched acid grassland'. They are part of the Koelerio-Corynephoretea, a class of more strictly lowland vegetation of drought-prone and infertile sands of the sub-Atlantic north European plain whose alliances each show floristic transitions towards the Pannonian zone in east central Europe and to the Lusitanian towards the south-west (See table 5). The U2 *Deschampsia*, U3 *Agrostis curtisii* and U4 *Festuca-Agrostis-Galium* grasslands, on the other hand, are part of the Calluno-Ulicetea, a class of heaths and grasslands with closed swards dominated by perennials on often humic mineral soils occurring on siliceous rocks right up into the cooler and moister upland fringes of the Atlantic zone. Here, within the limit of enclosure, they are often part of the sporadically improved farmland devoted to pastoral agriculture, a very different landscape in its physical character and cultural associations from the lowland heaths of the Koelerio-Corynephoretea. The U3 *Agrostis curtisii* grassland shows affinities with the Lusitanian south-west of Europe, but the main floristic transition among this latter group of grasslands is to the montane *Nardus* grasslands.

Among the Koelerio-Corynephoretea grasslands, the SD10b *Carex* and SD11 *Carex-Cornicularia* communities (together with SD12 *Carex-Festuca-Agrostis* grassland) are the British representatives of the **Corynephorion** alliance, which comprises colonising vegetation and open grasslands of more mobile acid sands on both inland and coastal dunes. Although, in Britain, the alliance character species *Corynephorus canescens* is mostly coastal in occurrence and a scarce plant (Stewart *et al*. 1994) and *Spergula morisonii* is an introduction that occurs only as a naturalised plant on open sandy ground in East Sussex (Stace 2005), these vegetation types can be seen as our equivalent of the Spergulo-Corynephoretum Libbert 1932. This association is characterised throughout its range by such companions as *Teesdalia nudicaulis, Jasione montana, Agrostis vinealis* (and sometimes *A. capillaris*), *Carex arenaria, Polytrichum piliferum, Cladonia* spp. and *Cornicularia* (=*Cetraria*) *aculeata,* many of these of frequent occurrence with us. The association is synonymous with the Corynephoretum canescentis R.Tx. 1935 and also includes the Teesdalio-Sperguletum (R.Tx. 1937) Passarge 1964 and part of the Agrostietum coarctatae (Kobendza 1930 em R.Tx) and has been described under one name or another from France (Julve 1993), Belgium (LeBrun *et al*. 1949), The Netherlands (Schaminée *et al*. 1996, Weeda *et al*. 2002), Germany (Oberdorfer 1978, Ellenberg 1978, Dierßen 1996) and Poland (Matuszkiewicz 1984). Essentially similar vegetation also occurs in Latvia (Kabucis 2000) and Estonia (Paal 2004).

Table 5 A simplified phytosociological classification of the lowland and sub-montane dry acid grasslands of western and central Europe.

Class	Order	Alliance
Koelerio-Corynephoretea Grasslands of drought-prone & infertile sands in the Sub-Atlantic biogeographic zone	***Corynephoretealia*** More open grasslands of sands	**Corynephorion canescentis** Colonising vegetation of mobile acid sands on coastal & inland dunes
		Thero-Airion Ephemeral vegetation of bare but stable acid sands and rock outcrops
		Plantagini-Festucion ovinaae Less open swards of acidic to neutral sandy soils
	Festuco-Sedetalia Dry grasslands of less acid sandy soils	**Hyperico perforati-Scleranthion perennis** Open grasslands of shallow acid soils in Central Europe
	Sedo-Scleranthetalia Pioneer grasslands on immature soils	
Calluno-Ulicetea Heaths and acid grasslands on acidic soils from the lowlands to the montane zone	***Nardetalia strictae*** Mat-grass swards on infertile soils at moderate altitudes	**Agrostion curtisii** Lowland grasslands of the Atlantic zone
		Violion caninae Infertile mat-grass pastures at lower altitudes

Further south and east, the Corynephorion is represented in the Czech Republic, Slovakia and Hungary by the Thymo angustifolii-Corynephoretum Krippel 1954 and the Jurinea cyanoidis-Koelerietum Klika 1931 where species such as *Dianthus arenarius* ssp. *bohemicus*, *Artemisia campestris*, *Gypsophila fastigiata*, *Jurinea cynaoides*, *Koeleria glauca* and *Veronica dillenii* add a distinctive central European feel (Chytry *et al.* 2001). With the shift to Hungary, the alliance gains a more distinctly Pannonian character in the Festuco dominii-Corynephoretum Borhidi (1958) 1996 and the Thymo serpylli-Festucetum pseudovinae Borhidi 1958 (Borhidi & Santa 1999), with species such as *Festuca vaginati, Dianthus armeriastrum, Spergula pentandra, Alyssum montanum* and *Peucedanum arenarium*. In Portugal, the Corynephorion acquires an Oceanic South European character with the appearance of *Corrigiola telephiifolia* and *Jasione lusitanica* (Rivas-Martínez *et al.* 2002, Instituto da Conservacao da Natureza 2005).

The rather open, ephemeral-rich swards of the second Koelerio-Corynephoretea alliance, the **Thero-Airion**, certainly occur in this country though are not included in the NVC and are the British equivalent of vegetation types of more stable but locally disturbed acid sands and siliceous rock outcrops across the European lowlands. Diagnostic species of the alliance include *Aira caryophyllea*, *A. praecox*, *Ornithopus perpusillus*, *Scleranthus annuus* ssp. *polycarpos*, *Teesdalia nudicalis*, *Trifolium striatum*, *Vulpia bromoides* and *V. myuros* with more rarely *Filago minima, F. lutescens* and *F. gallica.* In this country, we probably have vegetation like the Ornithopodo-Corynephoretum passarge 1960 (which is now thought synonymous with the Airo caryophylleae-Festucetum ovinae R.Tx. 1955 and the Airetum praecocis (Schwickerath 1944) Krausch 1967) and the Filagini-Vulpietum myuros Oberdorfer 1938, associations which have been variously recorded with a general consistency of composition from Ireland (White & Doyle 1982), The Netherlands (Schaminée *et al*. 1996, Weeda *et al*. 2002), Germany (Dierßen 1996), Poland (Matuszkiewicz (1984), the Czech Republic (Moravec 1995), Slovakia (Valachovič 1995) and Hungary (Borhidi 2003). Again, towards the south-east, a Pannonian element becomes more prominent with species such as *Aira elegans* and *A. elegantissima* (Borhidi 2003) while in Spain and Portugal, species such as *Veronica dillenii, Silene scabriflora* and *Apera interrupta* give an Oceanic West European feel (Rivas-Martínez *et al.* 2002, Instituto da Conservacao da Natureza 2005).

The U1 *Festuca-Agrostis-Rumex* grassland is the inland British representative of the third alliance of calcifuge swards within the Koelerio-Corynephoretea, the **Plantagini-Festucion** (Rodwell 2000), not part of the Thero-Airion, as originally suggested by Rodwell (1992). This alliance (which now includes parts of the Koelerion albescentis and Armerion elongatae) comprises more mature, less open swards on drought-prone soils of less strikingly acidic character found on fixed inland dunes and heaths. Floristically, the vegetation is defined rather loosely by the high frequency of species generally characteristic of the class, such as *Koeleria macrantha, Galium verum, Pilosella officinarum* (=*Hieracium pilosella*) and *Rumex acetosella* but it provides a major locus for Continental plants that are scarce or rare with us, such as *Thymus serpyllum, Dianthus deltoides, Silene otites, S. conica, Crassula tillaea, Lychnis viscaria* and *Armeria elongata* (*A. maritima* spp. *elongata* according to Stace 2005). Very similar to the British U1 grassland is the Festuco-Thymetum serpylli R.Tx.(1928) 1937, an association which has been described from The Netherlands (Schaminee *et al.* 1996, Weeda *et al.* 2002), north-west Germany (Tüxen 1937) and the Czech Republic (Chytry *et al.* 2001). With a somewhat more continental character are the Diantho-Armerietum elongatae Pötsch 1962 described from Germany (Dierßen 1996), Poland (Matuszkiewucz 1984) and Czechia (Moravec 1995), the Sileno otitis-Festucetum from Poland (Matuszkiewicz 1984) and the Jasiono-Dianthetum deltoidis Oberdorfer ex Mucina in Mucina & Kolbec 1993 from Austria (Mucina *et al*. 1993). The more decisive shift towards the Pannonian zone is marked for some authors by the replacement of the Plantagini-Festucion by another alliance, the Hyperico perforati-Scleranthion (Mucina *et al*. 1993, Borhidi 2003). Towards the south-west of Europe, in Spain and Portugal, Koelerio-Corynephoretea grasslands of this more closed type have been classified in the Koelerion arenariae, with the Oceanic West European *Asparagus prostratus* becoming a characteristic plant (Rivas-Martínez *et al.* 2002).

In Britain, as elsewhere in Europe, the more closed swards of the Plantagini-Festucion show some floristic gradation to the second section of the Dry Acid Grasslands which includes the U2 *Deschampsia*, U3 *Agrostis curtisii* and U4 *Festuca-Agrostis-Galium* communities. Among such grasslands, which occur widely through the moister and more equable Atlantic and Sub-Atlantic lowlands and upland fringes of Europe, there is a denser turf of grasses such as *Festuca ovina, Agrostis capillaris, Anthoxanthum odoratum* and *Danthonia decumbens,* more frequent records for such calcifuge associates like *Potentilla erecta* and *Galium saxatile* and a locus for species such as *Euphrasia nemorosa, Polygala vulgaris* and *Hypericum maculatum* . *Viola canina* is the character species that gives its name to the **Violion** alliance of such grasslands within the order Nardetalia of the class Calluno-Ulicetea, though this plant is distinctly patchy in its occurrence and the older name of Nardo-Galion is really more sensible and still retained by some workers, as in the Netherlands. In Eire, White & Doyle (1982) reported the Achilleo-Festucetum Birse & Robertson 1976, essentially the same vegetation type as U4 *Festuca-Agrostis-Galium* grassland, but the most widespread association of this type across western Europe, and very similar to our own Violion, has been named the Polygalo-Nardetum (Preising 1953) Oberdorfer 1957 which has been recorded from The Netherlands (under the prior name Botrychio-Polygaletum Preising 1950 *emend* Swertz *et al*. 1996 in Schaminee *et al.* 1996), Germany (Oberdorfer 1978, Peppler 1992, Dierßen 1996, Peppler-Lisbach & Petersen 2001), Poland (Matuszkiewicz 1984), Lithuania (Balevičienė 1998) and Austria (Mucina *et al.* 1993). In Scandinavia, essentially similar grasslands have been described in the Nordic Classification as 5.1.3.1 *Deschampsia flexuosa-Galium saxatile* and 5.1.3.2 *Agrostis capillaris-Galium saxatile* types from the lowlands of Denmark, Norway and Sweden (Påhlsson 1994). In the more mountainous parts of Europe, such as Switzerland, Violion grasslands occur only fragmentarily among foothill Calluno-Ulicetea heaths (Delarze *et al*.1998) and, at higher altitudes throughout the range, there is a shift from the Violion to the grasslands of the Nardion. Though often dominated by *Nardus stricta*, these swards can be quite species-rich where grazing and mowing has continued, particularly in more continental mountains. Within the frame of Annex I, this represents a shift to 6230 Species-rich *Nardus* grasslands.

On moving to the drier, more continental climate in the centre of Europe, the distinction between the Violion and the various Koelerio-Corynephoretea grasslands becomes harder to tell and, in associations like the Nardo-Festucetum Klika & Smarda 1944 which was recorded in the former alliance from Czechia (Moravec 1995, Chytry et al. 2001) and Hungary (Borhidi 2003), there is a similar increase in Continental and Pannonian species with *Scorzonera humilis, Centaurea pannonica* and *Hieracium lactucella.* In France, grasslands like our U3 *Agrostis curtisii* community have been placed in a separate alliance, the Agrostion curtisii where, in an association like the Carici binervis-Agrostietum de Foucault & Géhu in Clément 1981, *Scilla verna* adds to the Oceanic West European feel of the sward.

3.6 Coverage in Natura 2000

Only one small element of Lowland Dry Acid Grassland as defined in the UK BAP is included by the UK within Natura 2000 and that falls within just a single Annex I habitat, the 2330 Inland dunes. This is described (CEC 2003) as comprising open formations found on inland dunes with dry siliceous soils of Atlantic, sub-Atlantic and Mediterraneo-montane distribution, often species-poor and with a strong representation of annuals. It includes formations of unstable Germano-Baltic fluvio-glacial sands with *Corynephorus canescens, Carex arenaria, Spergula morisonii, Teesdalia nudicaulis* and carpets of fruticose lichens (*Cladonia, Cetraria*) (64.11) and other grasslands of more stabilised Germano-Baltic fluvio-glacial inland dune systems with *Agrostis* spp. and *Corynephorus canescens* or other acidophilous grasses (64.12). Elsewhere in the EU, member states have decided to include lowland acid grasslands with *Nardus* within Natura 2000 as the Annex 1 habitat 6230 which, in the UK, is considered exclusively montane. The Fennoscandian habitat 6270 is also close to some kinds of British Lowland Dry Acidic Grasslands.

2330 Inland Dunes is a habitat strictly confined to areas of more acid sediments among superficial sands inherited from Glacial or early post-Glacial times, the material often of fluvio-glacial origin but frequently re-deposited through wind action into sand plains. Post-Glacial warming favoured the development of acidophilous grasslands and then oak-birch forest over this kind of landscape but clearance and grazing from prehistoric times, and probably particularly in the Middle Ages, opened up the systems again and re-initiated sand mobility and dune formation (Ellenberg 1988, Jentsch & Beyschlag 2003). The distribution of 2330 Inland Dune habitat SACs is shown in Figure 21. They have been designated in Belgium (7% of the total sites for the habitat), Denmark (3%), France (11%), Germany (56%), Italy (<1%), Netherlands (4%), Portugal (2%), Sweden (7%), United Kingdom (<1%), Czech Republic (2%), Estonia (<1%), Latvia (1%), Lithuania (1%) and Poland (5%).

In Britain, this Annex I habitat is interpreted (Jackson & McLeod 2002) as corresponding to NVC SD11 *Carex arenaria-Cornicularia aculeata* dune community and the SD12 *Carex arenaria-Festuca ovina-Agrostis capillaris* grassland, where the vegetation includes stands of *Corynephorus canescens* occurring inland. SD12 is not included within the BAP Lowland Dry Acid Grassland and SD10b *Carex* vegetation is not included within the UK 2330 definition although equivalent vegetation elsewhere in Europe is regarded as part of the Annex I habitat and this assemblage also falls within the BAP Lowland Dry Acid Grassland.

It is the Spergulo-Corynephoretum Libbert 1932 that forms the core of the 2330 Inland Dune as it has been defined in France (Bensettiti *et al.* 2005), Belgium, The Netherlands (Jansen & Schaminée 2003), Germany (Ssymank *et al*. 1998) and Poland (Herbicha 2004). Elsewhere in Europe, as in Britain, variation included within the 2330 Inland Dune habitat partly reflects successional processes in the vegetation as the sand surface is stabilised. In fact, in Britain, open dune vegetation with *Corynephorus* now occurs only on the coast (in the SD10 *Carex arenaria* community) and most of the British swards of 2330 Inland Dune are of the post-pioneer grassier type, vegetation such as is placed in the SD12a *Anthoxanthum* sub-community of *Carex-Festuca-Agrostis* grassland. The French Cahiers d'habitats (Bensettiti *et al*. 2005) specifically mentions this kind of successional trend within the 2330 Inland Dune and a range of grassier swards figure within the German (Ssymank *et al.* 1998) and Czech definitions (Chytry *et al*. 2001). Indeed, the interpretations of the habitat there are generous enough to also take in grasslands of the Thero-Airion and, in Czechia, of the Plantagini-Festucion.

More striking is the stabilised lichen-rich 2330 Inland Dune vegetation such as is included in Britain in the SD11b *Festuca* sub-community of the *Carex-Cornicularia* dune, where *Cetraria* (=*Cornicularia*) *aculeata* and a variety of fruticose *Cladonia* spp. establish as an extensive and sometimes quite diverse carpet, colouring the vegetation grey. Bryophytes can also be frequent, particularly *Polytrichum piliferum*, the patches of which may be crucial for establishment of the lichens (Ellenberg 1988). Such vegetation figures specifically in the description of the 2330 Inland Dune habitat in France (Bensettiti *et al.* 2005), The Netherlands (Jansen & Schaminée 2003), Germany (Ssymank *et al*. 1998), Poland (Herbicha 2004), Estonia (Paal 2004) and Latvia (Kabucis 2000).

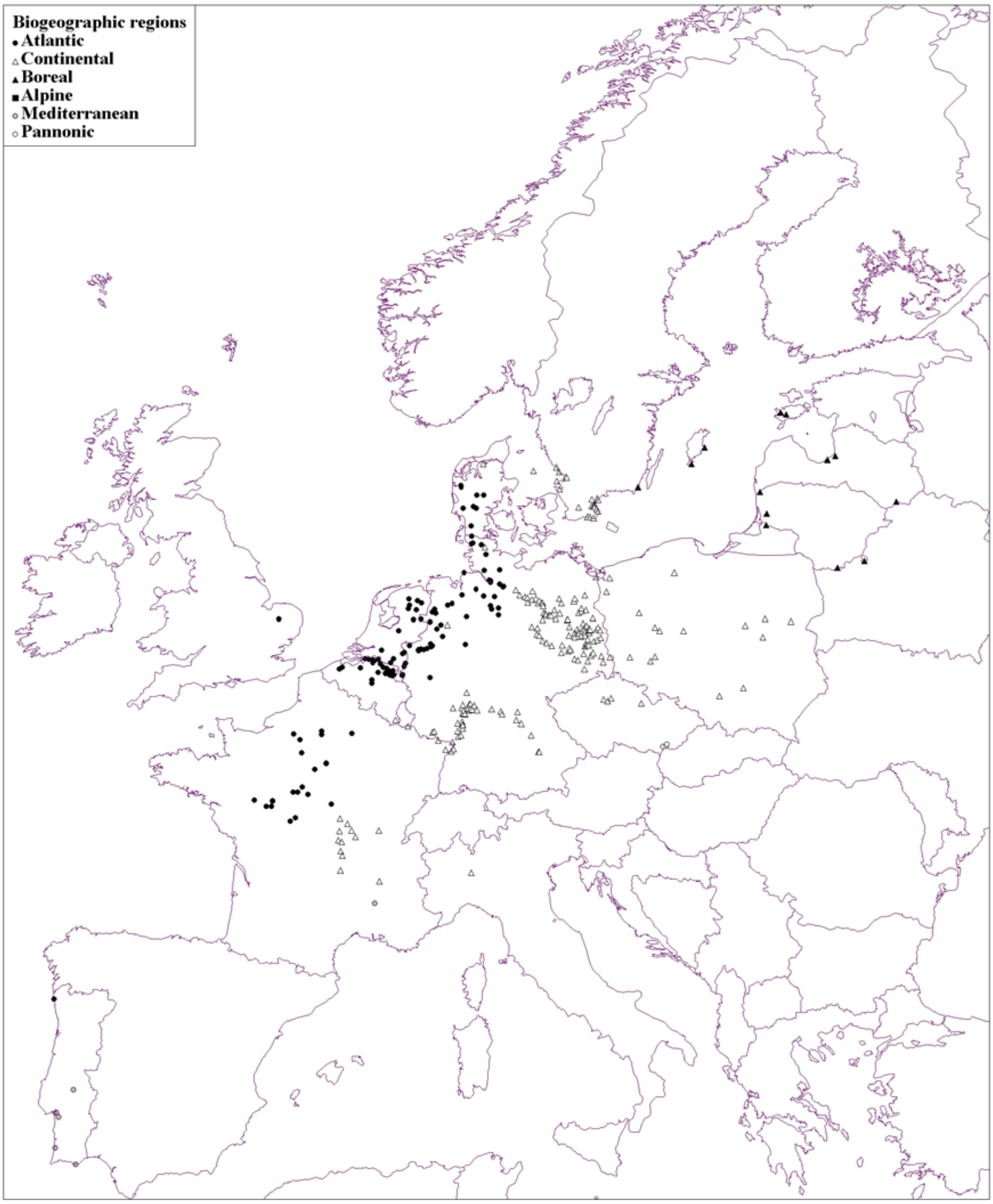

Figure 21 Annex I 2330 Inland dunes with open Corynephorus and Agrostis grasslands

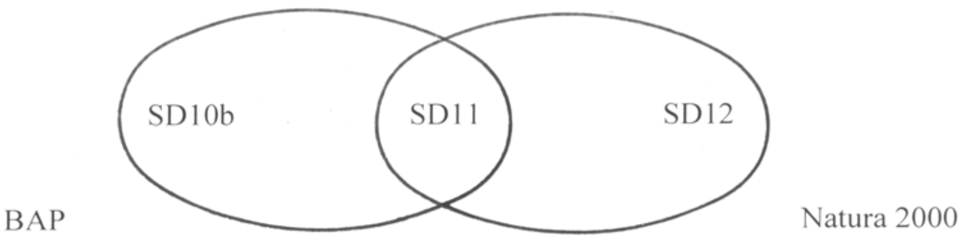

Figure 21a Inclusion of NVC Sand-dune communities within BAP and Natura 2000 habitats

Two other kinds of variation are sometimes included within the 2330 Inland Dune habitat as it is defined across Europe. First, small-scale patchy variation in the character of the sands that make up inland dune systems is characteristic in some areas, so stretches of ground that are more base-rich often occur in intimate contact with more acid sands. Such mosaics are sometimes included, as in Germany where associations of the Koelerion arenariae, the basiphilous counterpart to the Corynephorion, figure within the definition, and even of the more calcicolous Koelerio-Phleion (previously within the Armerion elongatae) (Ssymank *et al.*1998). In Britain, the nearest equivalents to such swards are grouped within the U1c *Erodium-Teesdalia* sub-community of the *Festuca-Agrostis-Rumex* grassland, vegetation that can indeed occur in Breckland in close association with the SD11 *Carex-Cornicularia* and SD12 *Carex-Festuca-Agrostis* communities.

Second, there is some floristic variation on a larger scale that is related to climatic differences where inland acid sands occur towards the margins of Central and western Europe, more particularly with the shift southwards to a Mediterranean climate and eastwards to the Pannonian zone. The effect of this is obvious even within France, for example, where the range of SACs spans three biogeographic zones so sub-Atlantic, Continental and Meridional variants of the Spergulo-Corynephoretum are recognised, each with distinctive suites of species and transitions to other associations (Bensettiti et al.). Towards southern France, for example, the 2330 Inland Dune habitat begins to acquire a contingent of Mediterranean plants that is more clearly seen in Portugal (Instituto da Conservacao da Natureza 2005). Beyond the Czech Republic, where a small contingent of steppe plants begins to appear towards the south-east border of the country, the inland dunes are of the 2340 Pannonic type (Viceníková & Polák 2003).

3.7 Key threats to the habitat

Except where they are locally maintained by very droughty conditions, the grasslands of the Koelerio-Corynephoretea are essentially replacements for the Quercion oak-birch forests that developed on acid, sandy soils in the Atlantic and Sub-Atlantic lowlands of Europe during the post-Glacial period and which were cleared from prehistoric times onwards. The resulting dry heath and grassland mosaics were maintained by grazing, burning and the harvesting of litter for fertilising arable land, the swards being especially important as forage for stock in landscapes that were relatively unproductive. The extent and make-up of this kind of landscape have fluctuated during historical time in relation to economic and social changes but particularly in the past two or three centuries very striking losses of these habitats have occurred with **conversion to intensive agriculture and forestry** and the **encroachment of settlements**. Contrasting maps, like those of the Dorset heaths (Moore 1962), the Hoge Veluwe in The Netherlands (Weeda *et al*. 2002) and Jutland (Dierßen 1996) demonstrate just how vast such changes have been right across the European lowlands. In such landscapes in the UK, the sometimes rich flora of the grasslands has suffered disproportionately serious declines (Byfield & Pearman 1996). In the *Common Standards Monitoring of Designated Sites: First Six Year Report* (Williams 2006), only 38% of SSSI features for this habitat were in Favourable condition, with 32% Unfavourable Recovering and 27% Unfavourable. The single SAC for 2330 Inland Dunes was found to be Unfavourable Recovering. Among the random sample of non-statutory English sites for Lowland Dry Acid Grasslands included in Hewins *et al*. (2005), 23% of stands (of which 75% were U4, 25% U1) were in Favourable condition.

By far the biggest current threat to Lowland Dry Acid Grasslands is under-management, particular **too little grazing**, close cropping being essential for maintaining the short sward typical of these grasslands, and local disturbance of the surface being needed to maintain opportunities for the ephemeral vascular component and less competitive cryptogams that are frequent elements of the richer vegetation types included here. Such deficiency is especially severe in the south and east which is where much of the more species-rich grasslands are concentrated in what were striking historic landscapes (Sanderson 1998). Without grazing, there is a quick return to a ranker structure dominated by the more competitive grasses and the appearance of bracken and woody species, especially oak and birch. In the past, a diversity of local pastoral traditions probably maintained these landscapes with cattle, sheep and ponies, as well as deer and rabbits (eg. Tubbs 1986, 1991, Sanderson 1998) playing various parts, but there has been an increasing reluctance in recent decades to keep stock, particularly larger animals, in such habitats, a situation exacerbated by the BSE and Foot & Mouth crises (Williams 2006).

Fragmentation of the dwindling resource has further added to the problems of integrated landscape-scale management which is essential to maintain the dynamic characteristic of this habitat and the full range of vegetation types with which it is associated, as well as for birds such as the stone curlew and woodlark which favour the short turf here (Dolman 1992) and the smooth snake, sand lizard and natterjack toad for which these grasslands form an essential part of their habitat mosaic (Sanderson 1998).

Even where management in these landscapes is active, **an emphasis on the higher value of heath** can leave Lowland Dry Acid Grasslands in short supply. Where the grassland component is a very minor and fragmentary one, as in Northern Ireland, it is likely that heathland restoration will take precedence, but the UK BAP rightly emphasises that the management of these two habitats ought to be undertaken in concert. The open vegetation of the Corynephorion and Thero-Airion, with the more closed swards of the Plantagini-Festucion and Violion, represent a suite of vegetation types that is related to the progress of colonisation and stabilisation of the substrate but, in sufficiently roomy and dynamic landscapes, with a confident and imaginative management programme, many of these could be represented, together with the lowland heaths, gorse scrub and birch thickets which constitute the next steps in secondary succession and which need to be themselves maintained by various regimes of grazing, burning and cutting. The German approach to designating Annex I 2330 reflects this more generous perspective.

Along with repeated intervention to halt succession, sharp drainage and poverty of nutrients in lime-poor soils are essential features required to sustain the habitat, so any factor which compromises these will threaten the establishment and maintenance of the range of vegetation types. Low-input stock rearing is probably the best management regime, though natural herbivores like rabbits can produce essentially similar effects, provided their populations are not too dense and **eutrophication** is not too intense. **Atmospheric nitrogen deposition** also needs to be recognised as a threat to this habitat.

The impacts of sharp drainage are most strikingly felt in the drier east of the British lowlands where the approach to continental climatic conditions gives these vegetation types an especially distinctive look and provides a locus for a suite of nationally scarce and rare plants (Stewart *et al.*1994, Sanderson 1998, Wigginton 1999). If there were to be **a shift towards a drier climate**, the incidence of drought episodes would be most keenly felt in this region, with maybe a greater instability of substrate as more susceptible perennials in the swards perished. More Continental species might also invade. Warmer winter temperatures in this region might also reduce the frost-heaving which is a striking feature of some Breckland stands of Lowland Dry Acid Grasslands.

With the more particular situation of the Corynephorion core of Annex I 2330 Inland Dunes, this is a much scarcer kind of Lowland Dry Acid Grassland with *Corynephorus* itself now 'Near Threatened' according to Cheffings & Farrell (2005). Conditions should be such as to maintain the vigour of newly colonising cohorts of the grass on shifting sands, to create niches for the accompanying ephemerals and allow only low-density recruitment of competitive perennials (Jentsch & Beyschlag 2003). The wind-dispersed seeds of *Corynephorus* are able to germinate after spring and summer rains and plants quickly establish as tussocks which encourage accretion. In the early stages, shallow-rooted ephemerals can quickly establish on remaining areas of open ground but increased stability of the sand surface allows more competitive perennials to invade and causes the grass to senesce. Appropriate disturbance comes from more natural elements of the biota such as ants and small burrowing mammals, particularly rabbits, but can also be anthropogenic - wear from walkers and cyclists, for example, or even light military traffic, an important feature of these sandy landscapes in Britain as elsewhere, since they still provide some extensive stretches of open lowland terrain for the training of troops. Any tendency to **limit necessary disturbance** will be a threat to such a dynamic habitat.

The more one moves into the Dry Acid Grasslands of the upland fringes of Britain, in which kind of landscape most of the western and northern records for this habitat occur, the more the threats and management questions are of a different kind. Here, where the grasslands can still contribute to relatively unproductive grazing land within enclosures, among Ulicion and Myrtillion heath or gorse scrub, the main threat is from **agricultural improvement** with the application of slurry or chemical fertilisers, and shifts in grazing intensity, converting the grasslands first to semi-improved swards (of the U4b *Holcus-Trifolium* sub-community of the *Festuca-Agrostis-Galium* grassland), then to ryegrass and clover pastures or leys (of the MG6 Lolio-Cynosuretum), particularly where there is the prospect of ploughing and reseeding. Such changes are difficult to reverse.

3.8 Conservation initiatives

The UK BAP for Lowland Dry Acid Grasslands shows that there are 271 SSSIs in England where this habitat is the principle reason for designation, 22 in Wales with a further 150 there where the habitat contributes to the interest and 40 with the habitat in Scotland. Nine English and Welsh NNRs have significant amounts of Lowland Dry Acid Grassland, much of it in Breckland, while Rhum NNR in Scotland has a considerable area. In addition to the single SAC for the Inland Dune habitat, several SPAs declared under the Birds Directive include the habitat among landscapes important for threatened birds. Several ESAs have a significant amount of these grasslands, particularly Breckland, the Shropshire Hills, Radnor, the Cambrian Mountains, Argyll Islands and Stewartry, and 24% of SSSIs for the habitat are in some form of agri-environment scheme. Hewins *et al*. (2005) showed that non-statutory sites receiving such subventions were twice as likely to be in Favourable condition.

Tomorrow's Heathland Heritage is a large-scale programme supported by the Heritage Lottery Fund with a target of restoring 58,000 ha of heath, acid grassland and other associated habitats, and recreating a further 6,000 ha across the whole of the UK (http://www.natural-england.org.uk/thh). The first five year phase of the work is focused on the Stiperstones Area of Outstanding Natural Beauty in Shropshire, the Sandlings in Suffolk where a long-distance footpath will include access for the disabled, Cornwall where restoration is centred in the china clay landscape and on the Lincolnshire Coversands.

The advantages of substantial land-holdings for developing a landscape-scale approach to the conservation of this habitat are demonstrated by the **Forestry Commission programme of heathland restoration** (Spencer & Haworth 2005). Across lowland England, clearfell of plantations, particularly focused on former heath or among existing heath landscapes, together with restructuring of rectilinear blocks and the widening and softening of edges is creating tracts of grassland, heath, mire, bracken brakes and small wet woodlands. Notable concentrations of such new landscapes have been created in Sherwood and Lincolnshire (200ha), Dorset (480ha), Breckland (400ha) and the New Forest (250ha).

Recreation of Lowland Dry Acid Grassland on former arable is underway at **RSPB Minsmere** on the Suffolk Sandlings, where over 80% of the Lowland Dry Acid Grassland and heath disappeared between 1932 and 1983. Though effective elsewhere, arable cropping for six years without fertilising has proved ineffective there in reducing fertility and pH, but additions of sulphur and reseeding with a grass mix appears more successful in establishing an open sward, and sulphur, bracken litter and heather cuttings in creating a grass/heath mosaic. However, the richest grassland has been produced by natural regeneration on the more sandy substrates (Marrs *et al*. 1998, Owen & Marrs 2000, 2001, Ausden *et al*. 2006). For the first time in over 35 years, stone curlew have nested on the site and the grassland is also used by woodlarks nesting in adjacent heath.

Defra is funding a 3-year programme of **assessment of sustainability and dynamics in restored Lowland Dry Acid Grassland** (BD1507 http://www.defra.gov.uk/research) which is focused in particular on monitoring the colonisation and dispersal of characteristic species under typical ESA management, the colonisation of the habitat by bryophtes and invertebrates and the possibility of establishing links between fragments.

3.9 Research needs

Despite the various vegetation types within this habitat being familiar, and the locus of some classic ecological studies, detailed survey of many areas has been very limited and it was not until the comprehensive review of Sanderson (1998) that the full extent of the habitat and its potential were appreciated. He identified the major remaining survey needs as determining the location, extent and character of Lowland Dry Acid Grassland, particularly U1 *Festuca-Agrostis-Rumex* grassland, and assessing their floristic quality, especially the occurrence of those scarce and rare species for which these swards provide the main locus. Rodwell *et al*. (2000) also highlighted the need for further survey of Thero-Airion vegetation of sandy tracks and rock outcrops. With a more thorough picture of the whole resource, research priorities can be more clearly indicated.

For the moment, although Crofts and Jefferson (1999) include Lowland Dry Acid Grassland within their comprehensive review of the management of lowland swards, much still needs to be understood about the intensity and kind of grazing needed to manage these vegetation types, particularly within the mosaics which are a frequent locus, so that varied dynamic landscapes can be sustained. Long-term trials of different disturbance techniques – rotovation, ploughing, turf-burying – are also needed to maintain the dynamism of the more open swards (Sanderson 1998) and further work is required into the feasibility of arable reversion.

4 Lowland Meadows

4.1 Summary of BAP Habitat Type

In the UK BAP, Lowland Meadows are generously defined as including most unimproved mesotrophic grasslands across the inland lowlands of England, Scotland and Wales and, despite the name, these vegetation types can be maintained by low-input pasturing as well as by a traditional mowing regime. In addition to farm fields, such grasslands can also be found on road verges, churchyards, recreation areas and other situations where the same combination of environmental factors and treatments occur. Despite the impression given in the definition that these grasslands are distinguished mainly by a group of rare and declining species, most of the characteristic plants are of wide distribution though their occurrence together in these kinds of vegetation is increasingly rare and the association with distinctive agriculture and landscapes now very fragile.

Three main grassland communities are included here, though these are more variable than defined by the NVC and should rightly be accompanied by other less well-known swards, particularly in wetter situations like flood-plains. Similar vegetation occurs widely right across the temperate lowlands of north-west Europe and has been grouped in three or four alliances of the Molinio-Arrhenatheretea. Coverage of the grasslands in Natura 2000 varies considerably from country to country because the interpretation of the Priority Habitat 6510 Lowland Hay Meadows is very different - sometimes strict, as with the UK, in other cases more generous. As in this country, such grasslands have suffered enormous losses, degradation and fragmentation through agricultural improvement and now face the widespread threats of abandonment, nitrogen deposition and climatic change.

4.2 Synonymy

NVC MG4 *Alopecurus-Sanguisorba* flood meadow, MG5 *Centaurea-Cynosurus* grassland, MG8 *Caltha-Cynosurus* flood-pasture.

Annex 1 6510 Lowland hay meadows (*Alopecurus pratensis, Sanguisorba officinalis*).

EVS 26B01 Arrhenatherion, 26B02 Cynosurion cristati, 26F01 Alopecurion, 26F02 Calthion palustris.

EUNIS E2.1 Permanent mesotrophic pastures and aftermath-grazed meadows, E2.2 Coarse permanent grassland and tall herbs, usually mown but little grazed, E. 3.3 Sub-Mediterranean humic meadows, E3.4 Moist or wet eutrophic and mesotrophic grassland.

4.3 Character and distribution of the NVC constituents

The Lowland Meadows are defined as ‘primarily embracing’ 3 NVC communities: MG4 *Alopecurus pratensis-Sanguisorba officinalis,* MG5 *Centaurea nigra-Cynosurus cristatus* and MG8 *Cynosurus cristatus-Caltha palustris* grasslands (Rodwell 1992) and the known distributions of these vegetation types, together with the overall range of the BAP Habitat are shown in Figure 22-25. The total extent of Lowland Meadows is estimated as 10,521ha, with 7,282ha in England, 980ha in Scotland, 1,322ha in Wales and 937ha in Northern Ireland (UK HAP Targets Review (Lowland Grasslands) 2005).

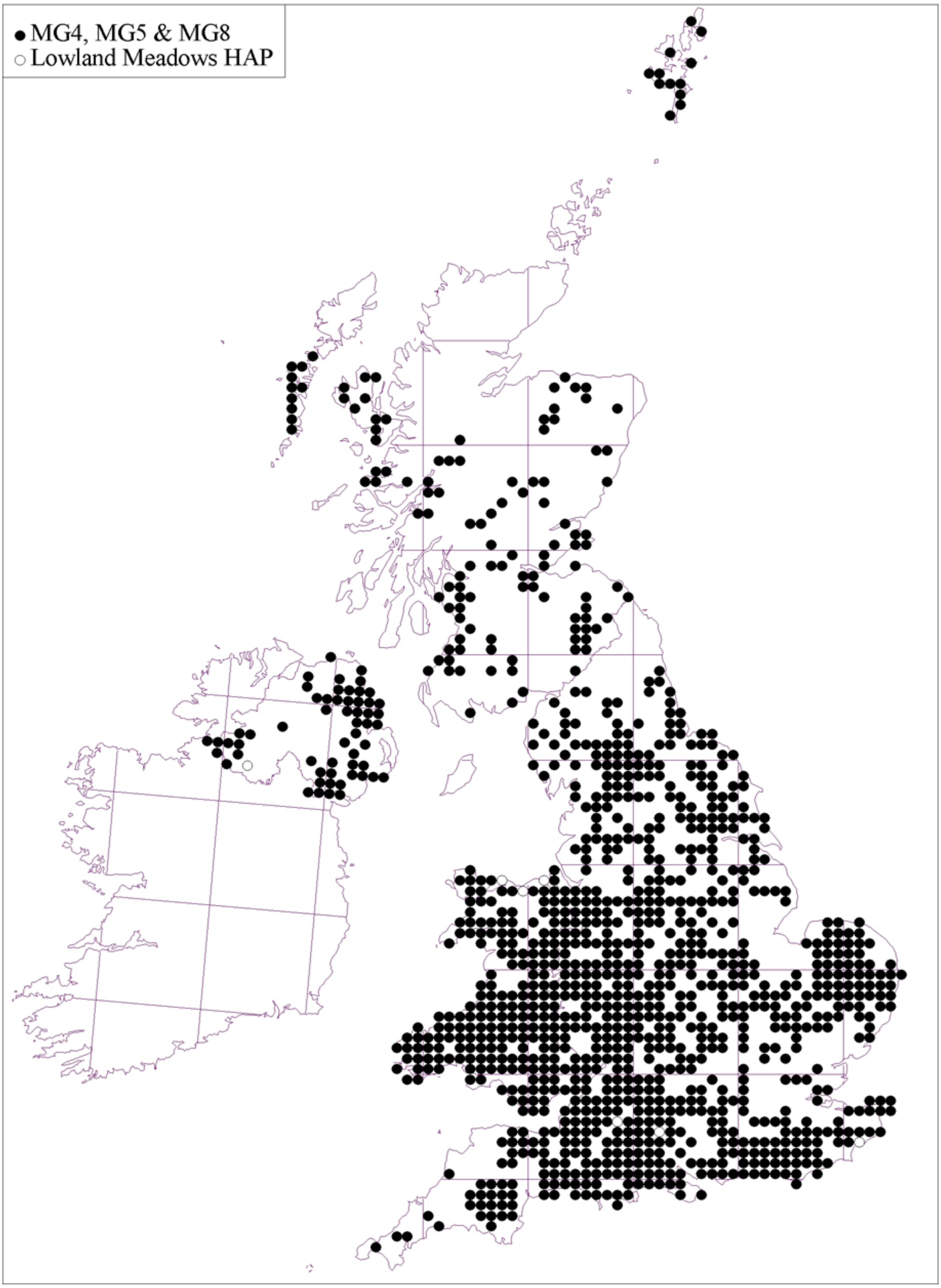

Figure 22 BAP Lowland Meadows

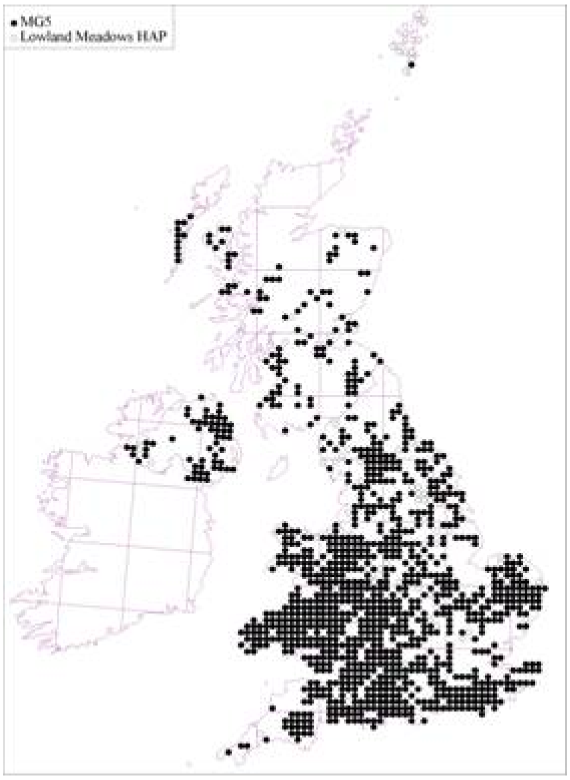

Figure 23 MG5 *Centaurea-Cynosurus* grassland

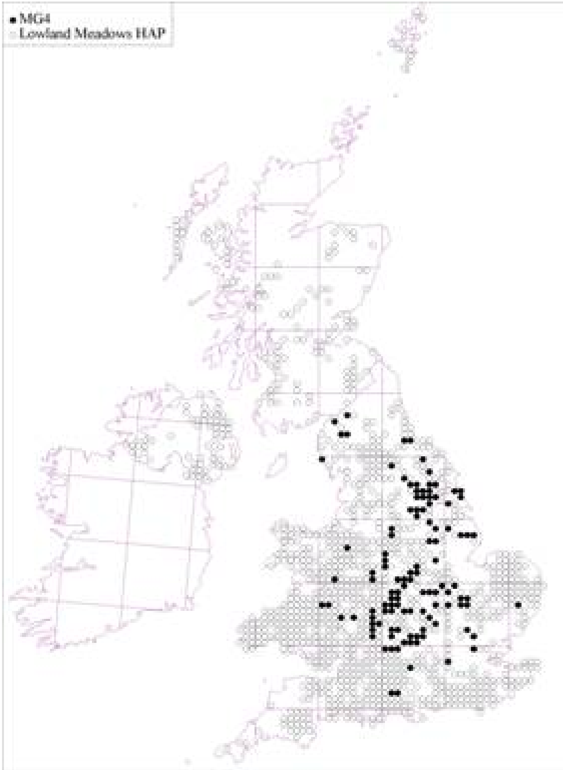

Figure 24 MG4 *Alopecurus-Sanguisorba* grassland

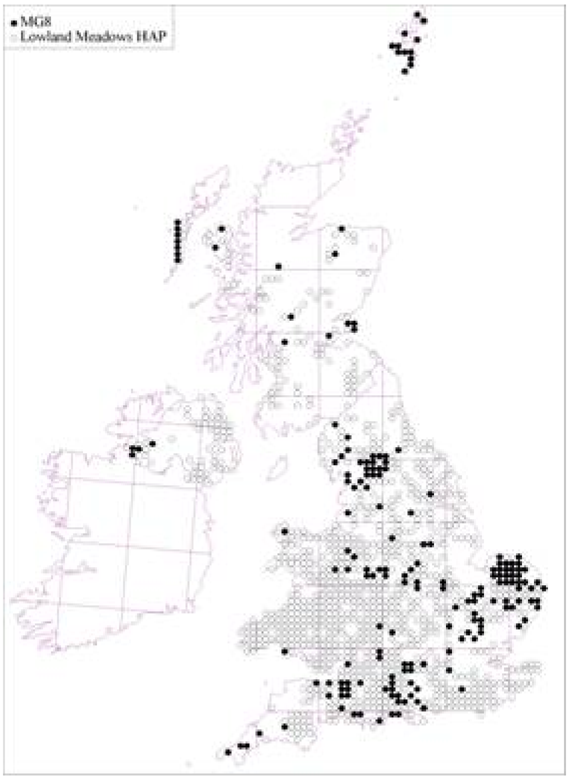

Figure 25 MG8 *Cynosurus-Caltha* grassland

The 10km grid records from which these maps were prepared date from 1980 onwards and include vegetation recorded as intermediate between NVC communities. The filtering has been inclusive, including all sites where the target community was recorded, even if only part of an intermediate with one or more other communities.

MG5 *Centaurea-Cynosurus* grassland is the most widespread of the three communities, typical of circumneutral and moderately fertile soils throughout the lowlands where traditional low-input agriculture has treated the vegetation as hay meadow or unimproved pasture. Though found in most parts of the English and Welsh lowlands and especially to the wetter west, less extensively in Scotland, its distribution is highly fragmented, generally now comprising isolated and small stands in highly intensified pastoral landscapes: a map resolved at a scale of a 10km grid, like Figure 23, gives an optimistic impression of extent. Recent estimates put the overall total area as between 5,000 and 10,000ha for England and Wales, where there are particularly important concentrations in South-west England, Worcestershire, the East Midlands, East Anglia and Brecon, with an additional 2000-3000ha in Scotland where the traditional crofting areas of Lochaber, Skye and the Western Isles have good extents.

MG4 *Alopecurus-Sanguisorba* grassland is a much more localised community of fertile, moist but free-draining floodplain alluvium, being dependent on inundation by winter floodwaters and treatment as hay-meadow with aftermath grazing. It occurs very locally in England and Wales, with important stands along the Thames and elsewhere in the Midlands and Welsh Borders and on the Yorkshire Derwent and Ouse, its total extent being less than 1,500ha. As defined in the NVC, MG8 *Cynosurus-Caltha* grassland is also dependent on seasonally high groundwater levels but it is not so strictly associated with flood-plain or streamside inundation, being found also around flushes, springs and seepage lines on naturally fertile, circumneutral soils generally treated as manured pasture, with only occasional cropping for hay. It is a scarce and locally distributed community of lowland flood pastures and spring-heads through the English lowlands, East Anglia and the Pennine valley sides with scattered localities in Scotland, the total extent being probably 300-800ha.

In fact, as Rodwell *et al*. (1998) make clear, MG8 *Cynosurus-Caltha* grassland was, even then, seen as one of the most poorly defined communities in the whole of the NVC (see, for example Prosser & Wallace 1992, 1993, 1995*a, b*, Cox 1995, Cox & Leach 1995, Benyon 1998). Since that time, further data (Gowing *et al*. 2002*a*) on this kind of vegetation, MG4 *Alopecurus-Sanguisorba* and MG7c *Lolium-Alpoecurus-Festuca* grasslands and some previously undescribed sward types have made a thorough review of wetter meadows and pastures essential. Furthermore, Rodwell *et al.* (1998) identified a need to review new data and possible further variation within MG5 *Cynosurus-Centaurea* grassland. It is clear, therefore, that other vegetation types could be defined within the BAP Lowland Meadow category that are dependent on different environmental conditions and management for their sustainability.

The BAP UK Habitat Action Plan for Lowland Meadows notes that the periodically- flooded grasslands occurring here also need to be taken into account in dealing with another BAP habitat, Coastal and Floodplain Grazing Marsh. This is defined primarily on physiographic grounds and the vegetation types represented in that habitat are not detailed in its Action Plan, but they include MG11 *Festuca-Agrostis-Potentilla* grassland, MG13 *Agrostis-Alopecurus* grassland (Rodwell 1992), and an unusual kind of MG6 *Lolium-Cynosurus* grassland (Rodwell *et al*. 1998), along with various salt-marsh and swamp communities.

4.4 The BAP type and its constituents in Northern Ireland

Of the NVC grasslands included within this BAP habitat, MG4 *Alopecurus-Sanguisorba* grassland has not been recorded from Northern Ireland but MG5 *Cynosurus-Centaurea* grassland is widespread. Some swards fit the published profile of this grassland well (Cooper & McCann 1994), but the distinctive rushy form of this meadow vegetation (Zuidhoff *et al*. 1996) also certainly occurs in the province (Rodwell 2004). Vegetation very similar to MG8 *Cynosurus-Caltha* grassland is known to occur within complexes of Purple Moor Grass and Rush Pasture in the province and has been included on Figure 25. Lowland Meadow occurs largely in the south, particularly in South Armagh, and is managed either as meadow or for a big-bale silage crop or as pasture. Estimates of extent are over 5,000ha (NI Countryside Survey 1992, Burke & Critchley 2000) but a tighter definition of more species-rich grassland of this type puts the figure below 1,000ha (Cooper unpublished). Various sources (NI Countryside Survey 1992, 2000; Cooper & McCann 1994) suggest that there has been a substantial decline over the past 15-20 years. Moreover, this habitat is very dispersed and often found in mosaics and transitions, grading to U4 *Festuca-Agrostis-Galium* or CG10 *Festuca-Agrostis-Thymus* grasslands depending on the substrate. Also, towards the rainier west, there is a gradual shift towards the wetter grasslands of Purple Moor Grass and Rush Pasture.

4.5 Character and significance of the UK habitat in the wider European context

As understood in the UK BAP, Lowland Meadows include what, within a wider European perspective, would be three or maybe four alliances within the Molinio-Arrhenatheretea, the class of anthropogenic pastures and meadows on deeper, more fertile soils across the European lowlands. A very helpful syntaxonomic survey of this big and varied group of plant communities within central Europe has been provided by Dierschke (1995) who in many respects follows the earlier surveys of Tüxen (1937) and Tüxen & Preising (1951). As a whole, the class within this region is characterised by such species as *Festuca pratensis, Holcus lanatus, Poa trivialis, Poa pratensis, Ranunculus acris, Trifolium pratense, Plantago lanceolata, Prunella vulgaris, Rumex acetosa* and, less so overall, by *Taraxacum officinale, Trifolium repens* and *Cerastium fontanum.* As understood in the overview of all of Europe, from the Canaries to the Urals, provided by Rodwell *et al*. (2002), this class contains 11 orders, but much of the anthropogenic pastures and meadows of the Continent can be understood as falling within the two major orders, the Arrhenatheretalia of generally drier mineral soils and the Molinietalia of moister and often peaty soils. Table 6 summarises relationships within these orders.

Unhelpfully, despite the names of the two orders, *Arrhenatherum elatius* is not consistent through the first nor is *Molinia caerulea* in the second, though each is more or less confined to one or the other and both orders have a suite of species that, in the UK, provides a broad distinction between mesotrophic grasslands and herb-rich poor fens. Plant communities in the Arrhenatheretalia are distinguished by the preferential occurrence of *Dactylis glomerata*, *Phleum pratense, Cynosurus cristatus, Agrostis capillaris, Trisetum flavescens, Centaurea jacea, C. nigra, Leucanthemum vulgare, Leontodon hispidus, Achillea millefolium, Bellis perennis* and *Lotus corniculatus* and, in many communities, also by *Heracleum sphondylium, Anthriscus sylvestris* and *Lathyrus pratensis.* By contrast, the Molinietalia is distinguished by *Deschampsia cespitosa, Filipendula ulmaria, Galium uliginosum, Lychnis flos-cuculi, Achillea ptarmica, Cirsium palustre, Equisetum palustre* and *Sanguisorba officinalis.*

Table 6 A simplified phytosociological classification of lowland meadows and pastures in western and central Europe.

Class	Order	Alliance
Molinio-Arrhenatheretea Anthropogenic pastures & meadows on deep fertile soils in the lowlands	***Arrhenatheretalia*** Pastures & meadows of better-drained fertile mineral soils	**Arrhenatherion** Ungrazed meadows of well-drained fertile mineral soils **Cynosurion cristati** Pastures & grazed meadows of fertile mineral soils
	(or in a separate order, the ***Poo Alpinae-Trisetetalia*** with high-altitude pastures & meadows)	**Triseto-Polygonion** Meadows of well-drained fertile soils in sub-montane & montane regions
	Molinietalia Meadows and pastures of moist soils, often peaty	**Alopecurion** Meadows of free-draining winter-flooded alluvium **Calthion** Wet meadows and pastures of fertile, often manured, soils
(or in a separate class, the **Plantaginetea** or **Polygono-poetea** with vegetation of trampled & disturbed habitats)	***Plantaginetalia*** Grasslands & weed vegetation of intensive farmland and waysides	**Lolio-Plantaginion** Heavily-fertilised grass crops cut for silage

Below this level, there is considerable argument about how best to understand the various plant communities included within the Molinio-Arrhenatheretea, but Dierschke's (1995) conservative view is a useful starting point. One of the earliest and most stable of the alliances to be recognised within the Arrhenatheretalia was the **Arrhenatherion**, a group of meadows and neglected grasslands, only lightly-grazed if at all, from well-drained and relatively fertile mineral soils in the European lowlands (Koch 1926). This alliance is distinguished by such species as *Arrhenatherum elatius, Bromus hordeaceus, Heracleum sphondylium, Crepis biennis, Campanula patula, Daucus carota, Galium mollugo, Geranium pratense, Vicia cracca* and *Knautia arvensis.* In the UK, this vegetation is familiar to many as the kind of ranker eutrophicated swards that were included within MG1 *Arrhenatherum* grassland, cut for amenity purposes on road verges or developing as a phase in the neglect of pastures (Rodwell 1992). Elsewhere in Europe, not so richly blessed with the moist climate that has so favoured the abundant hay crops of other kinds of unimproved grassland in the UK, the Arrhenatherion has been widely mown as an important source of herbage and shows considerable variety and species-richness.

In fact, even in this country, MG1 *Arrhenatherum* grassland is quite diverse, something which is rather masked by the broad view taken of the community in the NVC in which, in contrast to Page (1980) where this grassland was first described in detail, the differences are relegated to the level of sub-communities. The core of our Arrhenatherion vegetation is nonetheless clearly recognisable throughout the temperate European lowlands as the Arrhenatheretum elatioris Br.-Bl. 1919 and a similar broad view of this association has been taken in Belgium (LeBrun *et al*. 1949), Poland (Matuszkiewicz (1984), the Czech Republic (Moravec 1995), The Netherlands (Schaminée *et al* 1996), Germany (Oberdorfer 1983, Dierschke 1997, Wilmanns 1998, Dierschke & Bremler 2002, Nowak & Schulz 2002, Berg *et al*. 2004) and Lithuania (Balevičienė *et al*. 1998). Arrhenatherion vegetation has also been listed from Switzerland (Delarze *et al*. 1998) and Latvia (Kabucis *et al*. 2000). Even within such a single more compendious association, floristic differences usually relate, as with us, to variations in soil moisture, trophic state or base-richness and in other countries, where a variety of different Arrhenatherion associations has been recognised on this basis, some of these show an obvious similarity to different British Arrhenatheretum swards.

Most interesting in this present context is, first, what was called the MG1e *Centaurea nigra* sub-community in the NVC, an ungrazed grassland of moderately rich soils first described from Ireland as the Centaureo-Arrhenatheretum Br.-Bl. & Tx. 1952, expanded and ultimately renamed as the Vicio-Arrhenatheretum by O'Sullivan (1965, 1982) to avoid confusion with another different association already with that name. Quite what other Arrhenatheretum occurs in Ireland, if any, remains unclear (White & Doyle 1982) but this more species-rich grassland is clearly a particular feature of this Atlantic zone of Europe. Interestingly, rather similar vegetation seems to occur in Norway where it has been described as G10 Hestehavre-eng (Fremstad 1997). Second, there is the MG1d *Pastinaca sativa* sub-community which, with its more calcicolous character, is apparently synonymous with the Pastinaco-Arrhenatheretum (Knapp 1954) Passarge 1964 recorded from Germany (Dierßen 1996), Austria (Mucina *et al*. 1993), Hungary (Borhidi 2003) and Slovenia (Carni 2003). More eutrophic Arrhenathereta similar to our MG1b *Urtica* sub-community have also been described from elsewhere but a thorough review of other more species-rich types described from France (Julve 1993), Germany (Pott 1995), Austria (Mucina *et al*. 1993) and Hungary (Borhidi 2003) is needed to assess the overall variation. And, in the UK, as has happened elsewhere, more thought needs to be given to including these valuable components of Lowland Meadows, were they to be mown for nature management.

The second important alliance of lowland Arrhenatheretalia grasslands, which includes pastures and those meadows where grazing plays some part in the agricultural management, is the **Cynosurion**. Here, the more grazing-sensitive plants of the Arrhenatherion fade in importance and indeed much of the definition of the alliance comes from this negative characterisation. Across the whole of Europe, however, the most obvious preferentials are *Lolium perenne, Cynosurus cristatus* and *Trifolium repens,* perhaps also *Phleum bertolonii* and *Crepis capillaris* and, except in Spain and Portugal, *Leontodon autumnalis.* This is a widespread alliance, recorded from throughout the European lowlands and, towards southern latitudes, reaching up to 1,300m in Italy (Ubaldi 1978, Cortini Pedrotti 1973, Corbetta & Pirone 1981), Spain (Tüxen & Oberdorfer 1958), Austria and Switzerland (Smettan 1981), beyond which altitudes it is replaced by the mountain pastures of the Poion alpinae.

Within the Cynosurion, floristic variation across Europe is related mainly to differences in soil base status, moisture content and fertility, differences which, elsewhere in Europe, as in the UK, are compounded by the contrast between more fertile lowlands and less fertile uplands. Classifications of communities differ from country to country as to which of these gradients of floristic variation is given primacy in helping distinguish associations and sub-associations and the situation is complicated by the recognition of syntaxa on the basis of local species (Tüxen & Oberdorfer 1952, Seliskar 1993, Teles 1970, Bruno & Covarelli 1968, Ubaldi 1978, Cortini Pedrotti 1973). Unusually, however, this is one of the groups of plant communities where a large-scale analysis of original relevés has helped clarify Europe-wide patterns of variation (Zuidhoff *et al*. 1995).

Among the Cynosurion vegetation of the UK, the MG6 *Lolium-Cynosurus* grassland is clearly the Lolio-Cynosuretum (Br.-Bl. & De Leeuw 1936) R.Tx 1937, a virtually ubiquitous association throughout Europe, derived from a wide range of precursors by agricultural improvement and yielding heavy grass crops often sustained by liberal inputs of chemical fertilisers. Among UK Lowland Meadows, this community finds only a brief and disparaging mention (UK Biodiversity Group 1998), but, in its more calcicolous and calcifuge forms, it can, in fact offer considerable floristic interest that finds a parallel elsewhere in Europe. The MG6b *Anthoxanthum* sub-community, for example, is rather like the Festuco-Cynosuretum Tx. in Büker 1942 (now properly renamed as the Anthoxantho-Agrostietum Sillinger 1933) and the Festuco-Agrostietum Horvat 1951, all names which acknowledge the co-dominance of *Lolium perenne* with *Festuca rubra, Agrostis capillaris* and *Anthoxanthum odoratum* and the occurrence of calcifuge Violion companions. These are the equivalents of the semi-improved grasslands of the siliceous upland fringes of the UK, occurring in France (Julve 1993), Germany (Schubert *et al*. 1995, Wilmanns 1998, Berg *et al.* 2004), Switzerland (Delarze *et al*. 1998), Italy, Austria (Mucina *et al*. 1993), Poland (Matuszkiewicz 1981), the Czech Republic (Moravec 1995), Slovakia (Jurko 1969), Hungary (Borhidi 2003) and Romania (Boscaiu 1970, Coldea 1977, 1991) where, at higher altitudes, they acquire a more distinctly montane character. The Merendero-Cynosuretum Tx & Oberdorfer 1958 of the Pyrenees and Cantabrian mountains of Spain appears to be a south-western analogue of such vegetation types.

There are also distinctive forms of MG6 *Lolium-Cynosurus* grassland rich in *Iris pseudacorus* that are characteristic of less-improved pastures towards the oceanic west coast of England and Wales (Page 1980) and in Northern Ireland, and swards with frequent *Ranunculus sardous*, *Hordeum secalinum* and *Trifolium fragiferum* have been reported from the reclaimed coastal marshes of the Thames estuary and on the Severn (Rodwell *et al.* 1998). For their floristics and their landscape context, such grasslands are worthy of inclusion within some BAP habitat.

More usually valued among the grazed UK Lowland Meadows is the MG5 *Centaurea-Cynosurus* grassland which is clearly identical to the Centaureo-Cynosuretum Br-Bl. & Tx.1952, first described from the Republic of Ireland and since refined there in greater detail by O'Sullivan (1965). In the large-scale analysis of Zuidhoff *et al.* 1995, this type of Cynosurion grassland emerged very clearly as an Atlantic and Sub-Atlantic lowland and sub-montane component of the alliance characteristic of less fertile soils under more traditional meadow with a single mowing each year. It seems clearly identical to the Luzulo-Cynosuretum Meisel 1966 described from the the Landes de Gascogne and Hautes Pyrenees in France and the Basque Country by de Foucault (1981, 1986*b*, 1986*c,* Julve 1993) and the Lino-Cynosuretum Oberd. & Tx. 1954 of northern Spain (Tüxen & Oberdorfer 1958). These grasslands are all characterised by the preferential occurrence of *Centaurea nigra, C. jacea* or

C. thuillieri and *Luzula campestris* and, in Eire and France, as in the UK, show transitions to both Mesobromion and Violion vegetation.

A more striking transition to calcicole grasslands was recognised among the European Cynosurion by Zuidhoff *et al*. 1995 as the Galio-Trifolietum Sougnez 1957 in which plants like *Helictotrichon pubescens, Carex flacca, C. caryophyllea, Cirsium acaule* and *Sanguisorba minor* are preferential on fertile calcareous brown earths in cattle pastures. In fact, very similar swards do occur in the UK in just such situations but they were classified in the NVC among the calcicolous grasslands as the CG2b *Succisa-Leucanthemum* sub-community of *Festuca-Avenula* grassland. This kind of vegetation has been described from France, Belgium (Sougnez 1957, Sougnez & Limbourg 1963), The Netherlands (Schaminée *et al.* 1996), Germany (as part of the Festuco-Cynosuretum Tx. in Büker 1942) and Switzerland.

Another important element of the European Cynosurion, not recognised very clearly in the NVC, but characterised by O'Sullivan (1965) and Page (1980) as sub-communities of the Centaureo-Cynosuretum and outlined in Rodwell *et al*. (1998), is what was described originally from Belgium (Sougnez 1957, Sougnez & Limbourg 1963), later also from France (de Foucault 1981) as the Junco-Cynosuretum Sougnez 1957. In the data analysed by Zuidhoff *et al.* (1995), such Cynosurion grasslands were characterised by *Juncus effusus, J. acutiflorus*, *J. articulatus, Filipendula ulmaria, Cirsium palustre, Lychnis flos-cuculi* and *Lotus pedunculatus* (=*uliginosus*), giving a feel of the Molinietalia to the tussocky swards, characteristically occurring as pastures on mesotrophic brown earths kept moist by ground or surface water. As well as occurring towards the west of the British mainland, this kind of rushy meadow is common in Northern Ireland. Grasslands included within the Lolio-Cynosuretum lotetosum from The Netherlands (Schaminée *et al*. 1996), Germany (Pott 1995) and Poland (Matuszkiewicz 1981) are essentially similar to this community.

There is a Molinietalia element, too, in the flora of certain wetter Cynosurion meadows in the Anthemido-Cynosuretum (Teles 1963) Teles 1966 and Bromo-Cynosuretum (Telse 1963) Teles 1966, which have been described from higher altitudes in northern Portugal (Teles 1970), though *Agrostis castellana, Leontodon saxatilis, Orchis sesquipedalis* and *Gaudinia fragilis* give a south Atlantic feel to the flora there (Zuidhoff *et al*. 1995).

The widespread favouring, all across the European lowlands, of more intensive, heavily-fertilised grass crops on well-drained neutral soils, often with sown cultivars of rye grass and clover and cut as silage, like the leys that were included along with recreational swards within the compendious MG7 *Lolium* grasslands (Rodwell 1992), led to the creation of a separate alliance, the **Lolio-Plantaginion** (Sissingh 1969). This alliance has sometimes been placed in a different class altogether, the Plantaginetea (Tüxen & Preising 1951, more recently revised to the Polygono-Poetea by Rivas-Martinez 1975), which also includes vegetation of trampled or otherwise disturbed, sometimes seasonally wet, habitats where species such as *Plantago major, Potentilla anserina* and *Carex hirta* occur commonly alongside Cynosurion plants. This was the solution favoured in the NVC (Rodwell 2000). Tüxen (1970), however, embraced all of this vegetation within the Molinio-Arrhenatheretea as a distinct order, the Plantaginetalia, a proposal which has been followed in Germany by Pott (1995) and in Austria by Mucina *et al*. (1993). Schaminée *et al*. (1996) for the Netherlands retain a separate class but have subsumed the Lolio-Plantaginion into a Polygonion alliance.

As far as the BAP Lowland Meadows are concerned, much of this vegetation is too impoverished to be of nature conservation interest in its existing form, though MG7c, the *Lolium-Alopecurus-Festuca* grassland, is now known to be often richer than the NVC suggests and part of a continuum in the UK of vegetation representing degrees of impoverishment of MG4 *Alopecurus-Sanguisorba* flood meadow (Gowing *et al*. 2002b), a situation that has already been reported from Germany (Dierschke 1997). MG4 *Alopecurus-Sanguisorba* grassland is another key component of the BAP Lowland Meadows and related vegetation types occur elsewhere on the flood plains of the European lowlands where inundation of free-draining alluvial soils in the winter months has been combined with extensive traditional management as hay-meadow. Sometimes, this vegetation has been included within the Arrhenatherion, sometimes even as a sub-community of a very broad Arrhenatheretum, in other cases as some kind of Alopecuretum, as in Belgium (LeBrun *et al.* 1949), in earlier views of The Netherlands (Westhoff & den Held 1969), in Germany (Pott 1995 and Austria (Mucina *et al.* 1993). Other authorities have followed the proposal of Passarge (1964) that this vegetation is distinct enough to belong to a third major Molinio-Arrhenatheretea alliance, the **Alopecurion.** Usually this has been placed in the Arrhenatheretalia, sometimes in the Molinietalia, as in the Czech Republic (Moravec 1995), Lithuania (Balevičienė *et al*. 1998) and France (Julve 1993, where the Molinietalia was recast as the sub-class Agrostienea). In Hungary, a sub-alliance, the Alopecurenion, is recognised among the Molinietalia (Borhidi 2003) These grasslands are characterised by *Alopecurus pratensis, Festuca pratensis, Poa pratensis, Poa trivialis, Ranunculus repens, Sanguisorba officinalis, Fritillaria meleagris* and *Trifolium hybridum* and include the Alopecuretum Eggler 1933 but also more species-rich grasslands like the Trollio europaei-Cirsietum rivularis (Kuhn 1937) Oberdorfer 1957 in France (Julve 1993), the Sanguisorbo-Deschampsietum cespitosae Moravec 1965 and Sanguisorbo-Polygonetum bistortae Balátová-Tuláčková 1985 in the Czech Republic (Balátová-Tuláčková 1991, Moravec 1995) and the Carici vulpinae-Alopecuretum (Máthé & Kovács 1967) Soó 1971 corr. Borhidi 1996 of Hungary (Borhidi 2003).

Most obviously similar to the British Lowland Meadows of the MG4 *Alopecurus-Sanguisorba* type is the Fritillario-Alopecuretum Westhoff & den Held ex Corporaal *et al*. 1993 described from Dutch floodplains (Schaminée *et al*. 1996, Weeda *et al.* 2002) and, like our own vegetation, providing the major locus for the much declined and now nationally scarce *Fritillaria meleagris* (Corporaal *et al*.1993, Horsthuis *et al*. 1994). The other Dutch Alopecurion community, the Sanguisorbo-Silaetum Kallp ex Hundt 1964, has a stronger representation of Arrhenatherion and Cynosurion plants and looks more like a damp British MG5 Centaureo-Cynosuretum. Such vegetation also occurs on the floodplains of larger rivers in Germany, though there it is generally assigned to the Molinietalia. Re-examination of the data collected for a recent Defra research project on the hydrological control of flood-meadow vegetation (Gowing *et al*. 2002a) is likely to clarify the definition of MG4 *Alopecurus-Sanguisorba* grassland and the status of other wetter UK Lowland Meadows in relation to their European relatives.

That research will also help understand better the relationships between the Lowland Meadows of the MG8 *Cynosurus-Caltha* flood-pasture type (Rodwell 1992) and the plant communities recorded from other parts of western and central Europe that have been placed among the wet meadows and pastures of fertile, often manured soils, in the fourth Molinio-Arrhenathereta alliance, the **Calthion** (Tüxen 1937, Rodwell *et al*. 2002). Here, along with the Molinietalia species noted at the start of this section, there are preferential records for *Caltha palustris, Myosotis palustris* agg., *Scirpus sylvaticus, Angelica sylvestris, Polygonum* *bistorta* and, less exclusively, *Crepis paludosa, Geum rivale* and *Cirsium oleraceum,* though not consistently for *Molinia* itself which is patchy within the Calthion, in contrast to the Molinion alliance. The Calthion has occasionally been known as the Bromion racemosi (Braun-Blanquet 1947, Tüxen & Preising 1951, Tüxen 1955, Julve 1993) and sometimes broadened to include the *Filipendula* fens in which case the Calthion communities in the stricter sense have been included in a sub-alliance, the Calthenion, as with Mucina *et al*. (1993) in Austria and Moravec (1995) in the Czech Republic.

The Calthion is a complex and diverse group, sometimes tightly drawn but which, in its more liberal interpretation, includes vegetation dominated by big monocotyledons like *Scirpus sylvaticus* and rushy vegetation, analogous to our own MG10 *Holcus-Juncus* community, as well as wet pastures of the MG8 *Cynosurus-Caltha* type. In fact, as noted above, this latter community is an especially poorly-defined vegetation type in the NVC whose parallels are hard to understand without including further data from this country. What does seem quite clear (Rodwell *et al*. 1998) is that we probably also have what has elsewhere been most commonly called the Senecioni-Brometum Tüxen & Preising 1951, the Brometo-Senecionetum (Tüxen 1951) Oberdorfer 1957, the Bromo-Senecionetum Lenski 1953 or the Ranunculo-Senecionetum Van Schaik ex Schaminée & Weeda 1996 which has been recorded from France (Julve 1993), The Netherlands (Schaminée *et al*. 1996, Weeda *et al*. 2002), Germany (Bergmeier *et al.* 1984, Pott 1995, Dierßen 1996) and Poland (Matuszkiewicz 1981). In the Republic of Ireland, a similar Senecioni-Juncetum Br.Bl & Tx 1952 has been recorded and placed in the Calthion (O'Sullivan 1968b, 1976, 1982), though Sissingh (in O'Sullivan 1976) regarded it as part of the Elymo-Rumicion (White & Doyle 1982). Other (sometimes many) kinds of Calthion vegetation have been recorded from France (Julve 1993), the Netherlands (Schaminée *et al*. 1996), Germany (Pott 1996, Dierßen 1996), Poland (Matuszkiewicz 1981), Austria (Mucina *et al*. 1993), the Czech republic (Moravec 1995), Hungary (Borhidi 2003), Romania (Coldea 1991) and Lithuania (Balevičienė *et al*. 1998).

4.6 Coverage in Natura 2000

The Natura 2000 Habitat 6510 Lowland hay meadows (*Alopecurus pratensis, Sanguisorba officinalis*) (CEC 2003) are defined as comprising 'species-rich meadows on lightly to moderately fertilised soils of the plain to sub-montane levels, belonging to the Arrhenatherion and the Brachypodio-Centaureion nemoralis alliances', this latter an apparently defunct name for vegetation now subsumed into the Arrhenatherion. They are described as 'extensive grasslands rich in flowers that are not cut before the grasses flower and then only one or two times a year'. Typical plants are listed as *Arrhenatherum elatius, Trisetum flavescens, Pimpinella major, Centaurea jacea, Crepis biennis, Knautia arvensis, Tragopogon pratensis, Daucus carota, Leucanthemum vulgare, Alopecurus pratensis, Sanguisorba officinalis, Campanula patula, Leontodon hispidus, L. nudicaulis, Linum bienne, Oenanthe pimpinelloides, Rhinanthus lanceolataus, Malva moschata* and *Serapias cordigera.* In fact, of these, only *Arrhenatherum elatius* and *Daucus carota* are more specifically preferential to the Arrhenatherion (Ellenberg 1988, Dierschke 1995), an alliance of lowland European meadows, lightly grazed if at all, with *Knautia arvensis, Crepis biennis* and *Tragopogon pratensis* somewhat more broadly associated with both the Arrhenatherion and the sub-montane meadows of the Triseto-Polygonion. Many of the rest of the list are more generally characteristic of the Arrhenatheretalia, the order which includes all meadows and pastures on well-drained relatively fertile mineral soils in the temperate zone of lowland and sub-montane Europe. *Alopecurus pratensis* and, more especially, *Sanguisorba officinalis,* on the other hand, the two species specifically bracketed after the name of the habitat, are plants of the

Molinietalia, the order which includes the Molinio-Arrhenatheretea meadows and pastures characteristic of moister, often peaty, soils.

The distribution of the SACs for this habitat is shown in Figure 26 and the proportions of the total site number represented in each country are: Austria (2%), Belgium (5%), Finland)1%), France (9%), German (45%), Greece (<<1%), Ireland (<1%), Italy (4%), Luxembourg (1%), The Netherlands (1%), Portugal (1%), Spain (6%), Sweden (10%), United Kingdom (<<1%), Czech Republic (2%), Estonia (2%), Hungary (4%), Latvia (2%), Lithuania (1%), Poland (3%), Slovakia (4%) and Slovenia (<<1%).

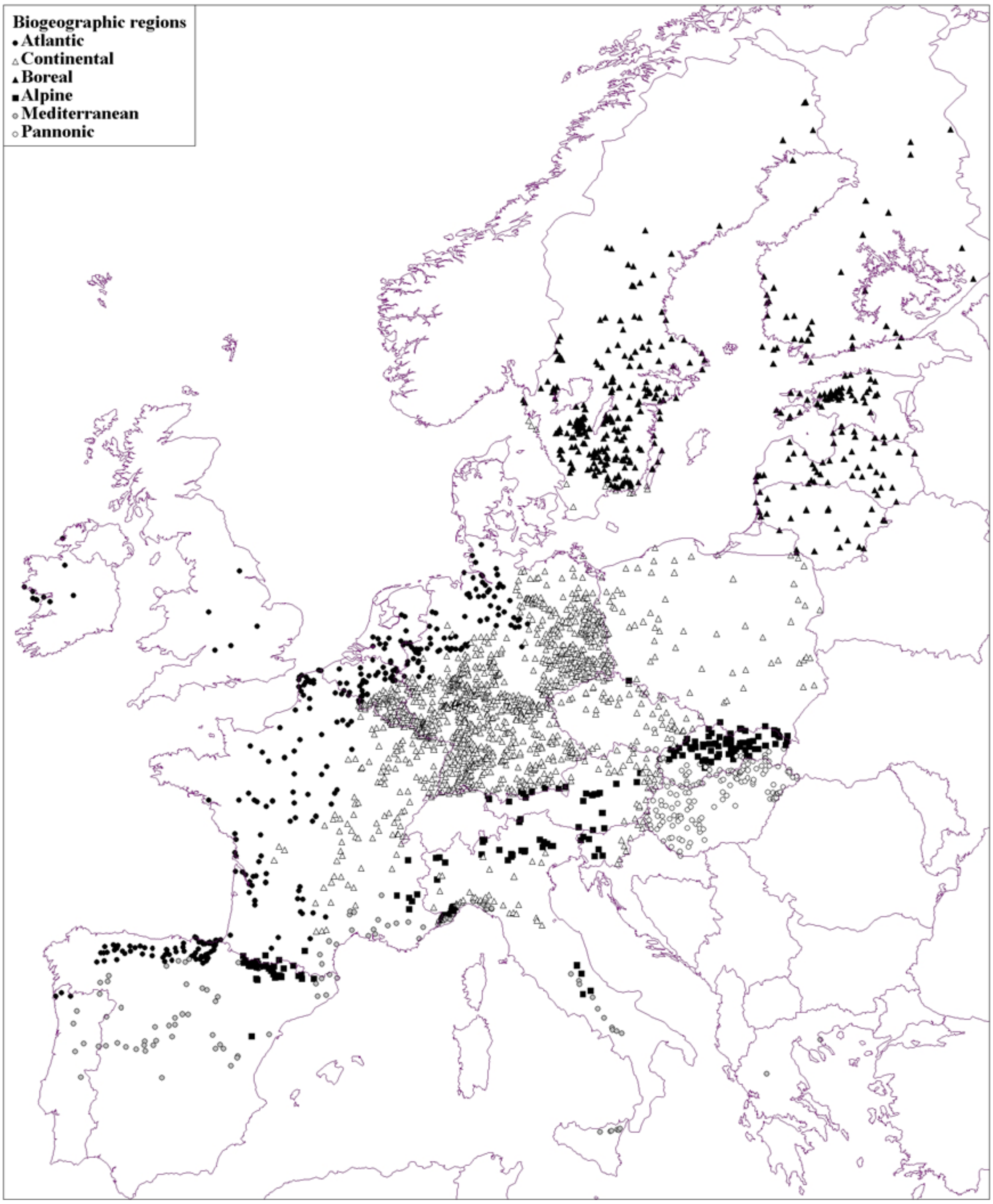

Figure 26 Annex I 6510 Lowland hay meadows

NATURA 2000 data notified to the European Commission by EU Member States and supplied by the European Topic Centre on Biological Diversity, Paris.

Among the EU countries, the UK has taken a narrow rather literal view of the title of this Natura 2000 habitat and designated sites for the only published vegetation type in this country where *Alopecurus pratensis* and *Sanguisorba officinalis* are both constant: the MG4 *Alopecurus-Sanguisorba* grassland (Jackson & McLeod 2002). Other countries where the Alopecurion or an Alopecuretum has been recognised and included explicitly within the habitat definition are Flanders (http://www.gisvlaanderen 2006), Germany (Ssymank *et al.* 1998), Austria (Ellmauer & Traxler 2000), Slovenia (Kaligaric *et al*. 2003), Lithuania (Rasomavicius *et al*. 2001) and Latvia (Kabucis *et al.* 2000). Outwith the EU, Bulgaria also refers the Alopecurion to this habitat (Meshinev *et al*. 2005)

Elsewhere, there has been a more generous interpretation where it is not always clear that *Alopecurus* and *Sanguisorba* are constant or especially characteristic but where the reference to the Arrhenatherion in the habitat definition is taken as the cue. This alliance figures explicitly in the interpretation of the 6510 Lowland hay meadows habitat in France (Bensettiti *et al.* 2005), Flanders (http://www.gisvlaanderen 2006), Germany (Ssymank *et al.* 1998), Poland (Herbicha 2004), Austria (Ellmauer & Traxler 2000), the Czech Republic (Chytry *et al.* 2001), Slovenia (Kaligaric *et al*. 2003), Lithuania (Rasomavicius *et al.* 2001) and Latvia (Kabucis *et al*. 2000); and implicitly through the listed species in Slovakia (Viceníková & Polák 2003) and, outwith the EU in Bulgaria (Tzonev in Kavrukova *et al.* 2005). In France (Bensettiti *et al.* 2003) and Slovenia (Kaligaric *et al*. 2003), some kind of Cynosurion has also been included within the definition, in Lithuania (Rasomavicius *et al.* 2001), the Calthion and in Bulgaria, the Deschampsion (Tzonev in Kavrukova *et al*. 2005). It should, however, be remembered that differences about phytosociological definitions among the meadows and pastures of the Molinio-Arrhenatheretea may actually mean that very similar vegetation types are sometimes being designated as falling within the Natura 2000 habitat. 6510 Lowland hay meadows have also been listed as occurring in Croatia, though with no further details given (State Institute for Nature Protection 2004).

4.7 Key threats to the habitat

In the *Common Standards Monitoring of Designated Sites: First Six Year Report* (Williams 2006), 42% of SSSI features and 38% of Natura 2000 features under the Neutral Grassland head (including also Upland Hay Meadows) were in Favourable condition, 26% and 25% respectively in Unfavourable Recovering, and 31% and 37% in Unfavourable. Among the random sample of non-statutory English sites for the BAP Lowland Meadow habitat included in Hewins *et al.* (2005), actually overwhelmingly MG5 *Cynosurus-Centaurea* grasslands, only 23% were found to be in Favourable condition.

For the BAP Lowland Meadows as a whole, the most general threat, particularly over the past half century, has been taken to be **agricultural improvement** and in the sample of Hewins *et al.* (2005), this clearly remains very important, particularly for those grasslands on better drained ground where the agricultural benefits are more immediate. This process has involved increased additions of chemical fertilisers, drainage, reseeding, often with ploughing, and a shift from hay-making to silage. Lowland Meadows have been especially vulnerable to such treatments because the unimproved levels of soil fertility are already high in many cases, the profiles typically being richer brown earths or alluvium.

However, a widespread and severe second threat nowadays (Hewins *et al.* 2005, Williams 2006) comes from **under-grazing, neglect of mowing and abandonment**, with the development of ranker swards, invasion of bracken, bramble or gorse and succession to W25 *Pteridium-Rubus*, W24 *Rubus-Holcus* or W23 *Ulex-Rubus* underscrub, or hawthorn and other woody species to produce W21 *Crataegus-Hedera* scrub, then woodland. It is also clear from those questionnaires returned from other parts of Europe that, right across the Continent, abandonment is replacing intensification as the major threat to all the alliances included within this habitat type.

Often, in the past, the traditional management of the Lowland Meadows we now value for their biodiversity has involved a fine balance of grazing and mowing, cropping and dunging and, in wetter meadows, the management of the water supply. In many places, particular traditions of common or multi-ownership and local customs integrated the traditional use of the resource with the social fabric of distinctive communities and areas. In some sites, such traditions probably remained consistent for centuries (Baker 1937, Green 1990, Brian 1993, Jefferson 1997) and, with the disintegration of these practices and societies, the maintenance and recovery of favourable condition can quickly become problematic. Sometimes rather particular situations can have a widespread impact: the recent unpopularity of cattle-rearing, for example, with the consequent **shortage of farmyard manure** is a real problem where maintaining the fertility of meadows for taking a hay crop is essential; the **popularity of horse-riding**, often with large numbers of animals being kept on small sites, is quite a widespread problem in altering the character of the sward.

With MG4 *Alopecurus-Sanguisorba* grassland, the most scarce and vulnerable of the various elements of the BAP Lowland Meadows and the UK interpretation of the Annex I 6510 Lowland hay meadows, dramatic losses over the past century have additionally been been due to **urban and industrial development** and **sand and gravel extraction** in flood plains (Gowing *et al*. 2002*b*), factors which are still in play outside the protected areas within which this vegetation is now almost wholly confined (Jefferson 1997). For the continuing sustainability of the community, there is a very particular dependency on a combination of factors associated with traditional meadow management (Page 1980, Rodwell 1992), though the details of this have not been fully understood (Jefferson & Robertson 1996). Gowing *et al*. (2002*b*) stressed that the first requirement was for year-round supply of moisture on soils with high holding capacity and/or natural sub-irrigation system that could maintain free drainage and that the vegetation is threatened more by the prospect of anoxia from **prolonged flooding** and inadequate surface drainage, than by any direct effects of changes in water management that enhance drainage, which these authors discovered was a widely perceived danger (see also Gowing *et al*. 1997, 2002*a*).

More risky, these authors thought, are the indirect effects of **changes in nutrient supply and surface pH** that come from alterations in sediment deposition with disruption of flooding or shifts in the nutrient load. Under traditional management, the vegetation is potentially quite productive, yielding annual hay crops of around 4 tonnes ha^{-1} with up to six months of aftermath grazing (see data sources in Gowing *et al*. 2002b), yields which are dependent on flood-water sediments and manuring from the stock. Increased **nutrient input from phosphorus-enriched silt**, enhanced by **atmospheric deposition of nitrogen** in the catchment and **earlier mineralization of organic matter with warmer springs**, let alone the heavy dressings of chemical fertilisers or slurry, also threatens the distinctive richness of the vegetation with its strong representation of dicotyledons.

Unimaginative nature conservation management which attempts to reproduce traditional routines come what may, could also be potentially damaging to Lowland Meadows: on flood-plains, for example, Gowing *et al*. (2002*b*) thought that a second hay cut in unfavourable MG4 *Alopecurus-Sanguisorba* grassland might help counteract high nutrient inputs or earlier cuts help control aggressive and rank eutrophic plants. Responding creatively to current challenges of this kind will be vital.

Neglect of undervalued elements of the resource is a danger, too**.** The failure to cherish the richer MG1 *Arrhenatherum* grasslands described above, not only on better road verges, but also as part of the fabric of what is at present suburban and urban wasteland, or on likely extensions of less-managed farmland, could be a missed conservation opportunity.

Continued loss of Lowland Meadows for all these reasons has added the danger of **fragmentation** of the surviving stands and this is especially threatening because all the emphasis in nature conservation has been site-based and focused on places which were often already of rather limited extent. **Failure to manage on an integrated landscape-scale** is therefore also a threat. For example, studies of floodplains (Gowing *et al*. 2002*a, b*) have shown how the sequence of vegetation types found there which can include, among Lowland Meadows, MG5 *Cynosurus-Centaurea* grassland, MG4 *Alopecurus-Sanguisorba* grassland, MG8 *Cynosurus-Caltha* grassland and variants upon them, as well as Bidention, Magnocaricion and Phragmition communities, depends upon an annual cycle of inundation that results in a gradient of flooding and drying, each vegetation type having its particular range of tolerance of the hydrological conditions. Or again, ecotones from managed species-rich meadows to mosaics of scrub and woodland could introduce valuable second-order diversity onto large sites and, of course, in many lowland landscapes, it is hedgerows, often older and more species-rich, which provide the usual field boundaries, where these survive (see, for example, Rodwell & Thorne 2004).

4.8 Conservation initiatives

The exact extent of Lowland Meadows designated within SSSIs is uncertain but, in England there are 66 sites with MG4 *Alopecurus-Sanguisorba* grassland and around 400 sites with MG5 *Cynosurus-Centaurea* grassland and some NNRs are especially important for this habitat, notably Mottey Meadows in the West Midlands and Cricklade North Meadow in Wiltshire for the former community and Fosters Green Meadows for the latter. In Scotland there are about 350 Lowland Meadow SSSIs and in Wales 103. Many of the SSSIs are the subject of management agreements intended to maintain the low-input farming necessary to sustain their biodiversity, and the grasslands included here also qualify for complementary funding under the various UK agri-environment schemes, though there is some feeling that the incentives for low-intensity cattle-rearing and hay-cutting are insufficient. Certain Environmentally Sensitive Areas, notably the Somerset levels and Upper Thames Tributaries, are especially rich in Lowland Meadows. Additionally, wildlife trusts and other NGOs, including those concerned with, for example, birds and butterflies, dependent on the habitat, are playing a major part in its conservation.

Fragmentation of this habitat is a major problem and one project specifically aimed at recovering the conservation value of small, isolated sites with Lowland Meadows is **Blue Remembered Hills** in the Shropshire Hills AONB. These sites tend to be owned by long-standing residents or newcomers to the area and are difficult to manage, yet include some of the most valuable Lowland Meadows of the county. The project provides advice and support and has a flock of sheep and cattle of its own that can be moved around where grazing is needed. Wild seed harvesting from existing meadows is helping enhance or create grasslands. The project also aims to increase physical and intellectual access to the Shropshire Hills by explaining the management of Lowland Meadows (www.shropshirehillsaonb.co.uk/bluehills/wildlifesites.htm).

The **Grazing Animals Project** (GAP) was formed in 1997 to support the development of conservation grazing throughout the UK and is especially important in the light of the widespread abandonment of Lowland Meadows. The initiative is a partnership between representatives from nature conservation, agricultural and livestock sectors and aims to help local delivery of grazing, to solve particular problems through training and handbooks and to develop a supportive network via a website, email discussion groups and quarterly newsletter. An equivalent organisation in Wales – PONT (the Welsh word for Bridge, but the acronym for Pori, Natur a Threftadaeth, or Grazing, Nature and Heritage) – was established in 2006. Key publications include a guide to best practice *Local Grazing Schemes* and, detailing the attributes and impacts of over 50 breeds of cattle, sheep, ponies, goats and pigs, the *Breed Profiles Handbook* (www. grazinganimalsproject.org and PONT@grazinganimalsproject.info).

Bringing new life to the way in which Lowland Meadow management was previously integral to the life of local communities, the **Parish Grassland Project** works with the people of St Briavels, Hewelsfield and Brockweir in the Wye Valley. Responding to the downturn in income from grazing cattle and sheep and the particular difficulties of the 2004 Foot & Mouth Disease episode, this is a community-based initiative offering expert survey, advice and practical help to pasture and meadow owners in the area, most of whom are not farmers. The project encourages use of Defra agri-environment funding, funds a newsletter and meetings through subscriptions, and, with the **Monmouthshire Meadows Group**, a similar project concentrated on the Trellech plateau, has bid successfully for Heritage Lottery funding which provides machinery, advice booklets and display boards (www.parishgrasslandsproject.org.uk & www.monmouthshiregreenweb. co.uk).

4.9 Research needs

The UK BAP estimated that about 70% of the less improved mesotrophic grasslands in England including Lowland Meadows had been surveyed since 1975, 80% in Wales with the prospect of complete coverage by 1999, but only about 30% in Scotland. Rodwell *et al.* (1998) made it clear that some of the grassland types that ought to be included within Lowland Meadows were ill-defined in the NVC while others had been completely omitted. Since that time, particular research projects, such as the Defra-funded study of the hydrological control of biodiversity in flood meadows (Gowing *et al.* 2002*a*), have generated further substantial amounts of new data and a revision of the mesotrophic grasslands within both Lowland Meadows and Coastal & Floodplain Grazing Marsh is pressing.

That study of the wetter Lowland Meadows and the review of their ecology, hydrology and nutrient dynamics in Gowing *et al.* (2002*b*) provide a model for the kind of understanding that is still required for other grassland types within this habitat, so that conservation management can be better informed. In particular, knowledge of what controls soil fertility and the balance between biodiversity and herbage productivity is still deficient. This will be important in understanding, for example, the role of residual soil phosphorus in relation to species-richness and the possible impacts of atmospheric nitrogen deposition. Knowing the deposition rates and critical loads do not themselves help understand just how eutrophication and acidification operate in these and other grassland systems.

Better understanding of the community dynamics and the assembly rules which operate in Lowland Meadows is essential for a realistic perspective on the restoration of these grasslands and for predicting species turnover under different climate-change scenarios. The continuing recording and analysis of long-term data-sets is important here: the Rothamsted plots (http://www.rothamsted.ac.uk), the Palace Leas study in Northumberland (http://www.staff.ncl.ac.uk/r.s.shiel/Palace_Leas/index.html) and the more recent research at Tadham Moor and various flood-plain grasslands (Gowing *et al*. 2002*a*) are a crucial resource in this respect.

5 Upland hay meadows

5.1 Summary of the BAP Habitat Type

This is the traditionally-managed hay meadow vegetation of the sub-montane zone of northern Britain, found mainly within the in-bye fields of Pennine and Lake District farms with scattered occurrences in Northumberland and Scotland, and also on road verges, graveyards, river banks and woodland clearings where similar environmental conditions prevail. It corresponds with MG3 *Anthoxanthum-Geranium* grassland, the British representative of the Polygono-Trisetion alliance which is widely distributed through the sub-montane and montane zones of western and central Europe and characterised by various contingents of plants of harsh climatic conditions in swards managed in a traditional fashion for hay crops. However, as here, this vegetation is gravely threatened by a decline in traditional management with a shift to more intensively managed grassland or abandonment. Surviving stands of 6520 Mountain Hay Meadows have been designated under Natura 2000 but coverage across Europe is only moderately good.

5.2 Synonymy

NVC MG3 *Anthoxanthum-Geranium* grassland.

Annex 1 6520 Mountain hay meadows.

EVS 26I03 Triseto-Polygonion bistortae.

EUNIS E2.2 Coarse permanent grassland and tall herbs, usually mown but little grazed, E2.3 Mountain hay meadows, E4.5 Alpine and subalpine enriched grassland.

5.3 Character and distribution of the NVC constituents

A single NVC community, MG3 *Anthoxanthum odoratum-Geranium sylvaticum* grassland, is included within the BAP Habitat Type and its known distribution is shown in Figure 27. This vegetation is the most distinctive element of traditionally-managed hay meadows on moderately fertile soils in the sub-montane zone of northern Britain, now largely confined to a few valley heads between 200 and 400m in the Yorkshire Dales, Lake District and Durham, with some outliers further north in Northumberland and Scotland (Cooper & MacKintosh 1996). It occurs also on road verges, graveyards, river banks and field margins where similar environmental conditions and treatments prevail. In Rodwell (1992), two sub-communities were characterised from such grazed and mown meadows, one somewhat more improved than the other, with a third (lacking a published data table) from habitats like road verges mown for amenity reasons but largely ungrazed. Subsequent more localised studies have provided a more detailed profile of the vegetation and its distribution, for example in the Yorkshire Dales National Park (Pacha 2004). Scottish riverbank stands can differ somewhat in their floristics (Cooper & MacKintosh 1996) being transitional to M27 *Filipendula-Angelica* tall-herb fen (Rodwell *et al.* 1998). There have been very extensive losses of this vegetation with agricultural improvement and many stands represent transitions to more eutrophic and impoverished grassland types. Also, further south in the upland fringes of

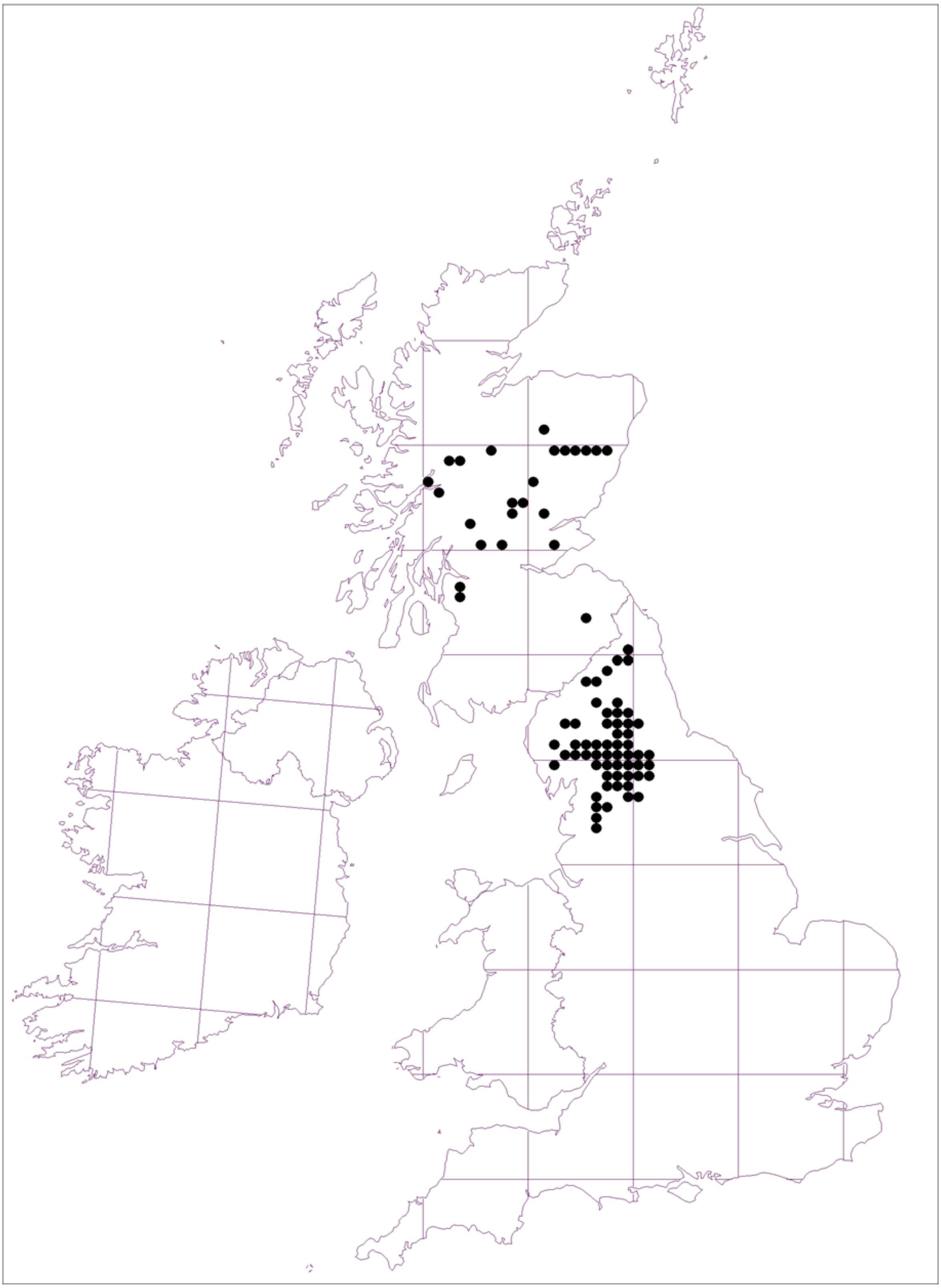

Figure 27 BAP Upland Hay Meadows (MG3 *Anthoxanthum-Geranium* grassland)

Britain and on northern flood plains like the Derwent Ings, vegetation intermediate between this community and traditionally managed lowland meadows like the MG5 *Centaurea-Cynosurus* and MG4 *Alopecurus-Sanguisorba* grasslands can be seen. The most recent detailed estimate of extent of the *Anthoxanthum-Geranium* meadows through northern England was 640ha (Cooch & Rodwell 1996).

5.4 The BAP type and its constituents in Northern Ireland

Although vegetation managed as meadow does occur at higher elevations in Northern Ireland, it is usually of the Purple Moor Grass and Rush Pasture type. *Geranium sylvaticum* occurs in grassland in one location in the province (Feystown ASSI in County Antrim), but in overall composition the sward there most closely resembles a type of MG5 *Cynosurus-Centaurea* meadow.

5.5 Character and significance of the UK habitat in the wider European context

Within a wider European frame, the kind of vegetation included in this BAP Habitat is clearly recognisable as part of the **Triseto-Polygonion** (or, as it is still often called, the Polygono-Trisetion, a form of the name that is now known not to be the original). This alliance includes low-input meadows of well-drained, relatively fertile mineral soils through the sub-montane and montane zones of northern and central Europe. Traditionally, it has been included within the Arrhenatheretalia, the order of European pastures and meadows of more fertile soils (see Table 6), but Mucina *et al.* (1993) took a narrower view of the alliance, retaining the Polygono-Trisetion, as they called it, for the more strictly montane Central European meadows and placing this, along with two other alliances of high altitude grasslands, in the new order Poo alpinae-Trisetalia. The sub-montane meadows like our own *Anthoxanthum-Geranium* grassland these authors placed in the Phyteumo-Trisetion alliance, a group first defined by Passarge (1969), within the Arrhenatheretalia. This is the view summarised in Rodwell *et al.* (2002).

An excellent overview of the Central European Triseto-Polygonion in its broader sense has been provided by Dierschke (1981), with subsequent additions from Theurillat (1992). Essentially, the alliance represents a montane counterpart to the unimproved lowland grasslands included within the Arrhenatheretalia, an altitudinal shift which is neatly shown in maps and graphs for the meadows of the Harz and Thuringia in Hundt (1964, 1966), summarised in Ellenberg (1988), and which, in Britain, we see most clearly in the contrast between MG5 *Centaurea-Cynosurus* grassland and MG3 *Anthoxanthum-Geranium* grassland. Species of the Molinio-Arrhenatheretea form a consistent element of the vegetation with grasses such as *Festuca rubra, Poa pratensis* and *P. trivialis,* forbs like *Trifolium repens, T. pratense, Ranunculus acris, Cerastium fontanum, Plantago lanceolata, Leontodon hispidus, Achillea millefolium* and climbers such as *Vicia cracca* and *Lathyrus pratensis* more or less common throughout. *Trisetum flavescens,* the grass which gives its name to the alliance (and to many of the continental associations that are the counterparts of our own grassland) is very frequent throughout but this is really an Arrhenatheretalia plant, widespread also at lower altitudes. Other species of this class that occur commonly in the Triseto-Polygonion are *Dactylis glomerata, Leucanthemum vulgare, Heracleum sphondylium, Lotus corniculatus, Taraxacum officinale* and *Veronica chamaedrys.* Other frequent plants occurring through the alliance that are of broader phytosociological affinity include *Agrostis capillaris, Anthoxanthum odoratum, Briza media* and *Luzula campestris.*

More especially characteristic of the Triseto-Polygonion alliance itself are the big ladies' mantles of the *Alchemilla vulgaris* agg. and also *Polygonum bistorta,* this latter being the other species used to name the alliance but one which, elsewhere in Europe as in Britain (Preston *et al*. 2002), is not entirely confined to higher altitudes though it is often related to locally harsh climates (Ellenberg 1988). Apart from the most easterly representatives of the alliance, these grasslands are also characterised by *Geranium sylvaticum, Trollius europaeus* and *Helictotrichon pubescens* and, except in the higher Alps, by *Festuca pratensis, Rumex acetosa, Holcus lanatus* and *Cynosurus cristatus. Sanguisorba officinalis* which, with us, is virtually constant in our Upland Hay Meadows, is more patchy in this kind of vegetation elsewhere in Europe, while *Phyteuma spicatum*, occasional to frequent across much of the continental Triseto-Polygonion is, in Britain, a Red Data Book plant now surviving in different habitats (Wigginton 1999, Wheeler & Hutchings 2002).

Dierschke (1981) recognised three major groups of meadows, ranked as sub-alliances within the Polygonio-Trisetion, that can be related to regional climatic differences with changes in latitude and altitude across Europe. Within the sub-montane zone of northern and western Europe, the sub-alliance Lathyro-Trisetenion is the characteristic meadow type, with *Lathyrus linifolius, Poa chaixii, Anemone nemorosa, Crepis mollis, Alopecurus pratensis, Centaurea nigra, C. jacea* and *Campanula rotundifolia* preferential. Our own *Anthoxanthum-Geranium* upland hay meadows are very similar to one of the two major associations within this group, the Geranio sylvatici-Trisetetum Knapp 1951 which is essentially Sub-Atlantic in distribution. It has been described from the hills of the Ardennes in Belgium (Lambert 1965), the Rhineland mountains and Mittelgebirge of Germany (Büker 1942, Knapp 1951, Baeumer 1956, Wilmanns 1956, Boeker 1957, Oberdorfer 1957, Lötschert 1973), Austria (Mucina *et al*. 1993), the Czech Republic (Moravec *et al*. 1995) and Hungary (Borhidi 2003). Essentially similar meadows have been described by Påhlsson *et al.* 1994 as the 5.2.2.4 *Geranium sylvaticum*-typ, including the Skogstorkenebb from Norway (see also Fremstad 2002), the Metsänkurjenpolviniitty of Finland and the Skogsnävaängs of Sweden. At higher latitudes in Scandinavia and Greenland, some of the distinctive Upland Hay Meadow plants appear in the 'Park Meadows' of the Adenostylion alliariae, vegetation we see in Britain in the high altitude mountain ledge U17b *Luzula-Geum* community (Nordhagen 1928, 1936, 1943, Sjörs 1954, Böcher 1954).

The other main association in this sub-alliance, the Meo-Festucetum (R.Tx. 1937) J. & M. Bartsch 1940, is more characteristic of the Sub-Continental sub-montane zone occurring in the Vosges in France (Issler 1942, Bardat *et al*. 2004), central and southern Germany (Tüxen 1937, Bartsch & Bartsch 1940, Oberdorfer 1957, Hundt 1964, Klapp 1965, Trautman 1973, Vogel 1977), Poland (Matuszkiewicz 1982) and (as the Meo-Cirsietum heterophyllae Blažková 1991) in the Czech Republic (Moravec *et al*. 1995). *Meum athamanticum* is the best diagnostic species for this association, with *Galium hercynicum* and *Arnica montana* less frequently preferential. Interestingly, a very few Lake District meadows and some Scottish streamside stands of vegetation of the upland hay meadow type have a striking abundance of *Meum* (Cooper & MacKintosh 1996), a Continental Northern plant (not western European as described in Stewart *et al*. 1994) and scarce with us. Dierschke (1981) also grouped within this first Triseto-Polygonion sub-alliance some related Sub-Continental meadows such as the Cardaminopsidi-Agrostietum Moravec 1965 and Melandrio-Trisetetum Moravec 1965 described from the Czech Republic (Moravec *et al*. 1995).

The second sub-alliance, the Campanulo-Trisetenion, Dierschke (1981) retained for the Triseto-Polygonion meadows of the Jura and the Alps where there is a definitive shift to a high montane character. Here, characteristic alpine preferentials indicative of the harsh climatic conditions at such altitudes are *Campanula scheuchzeri, Myosotis alpestris, Rhinanthus alectorolophus, Viola tricolor* ssp. *subalpina* and *Crocus albiflorus.*   The most widespread association, the Triseteteum flavescentis (Guyot 1920) Beger 1922 usually has additional character species such as *Rumex alpestris, Phleum alpinum, Veratrum album* and *Crepis pyrenaica* and has been described from Switzerland (Guyot 1920, Beger 1922, Marschall 1947), Austria (Dierschke 1979, Mucina *et al*. 1993) and Italy (Credaro & Pirola 1975). Since Dierschke's study, Donită *et al*. (2005) have also reported the Triseteum from Romania. The closely similar Geranio lividi-Trisetetum G. & R. Knapp 1953 with *Geranium phaeum* agg. has also been reported from Austria (Knapp & Knapp 1953, Mucina *et al*. 1993) and the Trisetetum lapponicum (Brockm.-Jerosch 1907) Marschall 1947 with *Salvia pratensis* from Switzerland (Brockmann-Jerosch 1907, Marschall 1947).

Essentially similar meadows occur at higher altitudes in the Swiss and French Jura (Simeray 1976, Bardat *et al*. 2004), further west in France in the Cevennes (Braun-Blanquet 1915), Auvergne (Luquet 1926) and Massif Central (Schaminée 1993) where the occurrence of *Narcissus radiiflorus, N. poeticus* and *N. pseudonarcissus* adds an especially striking note, nicely caught in the illustration of the Monts du Forez on page 80 in Rodwell *et al*. (2002). Julve (1993) also includes a similar Triseto-Heracleetum pyrenaici (Braun-Blanquet 1915) Hundt 1964 from the French Pyrenees. Theurillat (1992), using literature from France, Germany, Austria and Italy incorporated these meadows into a new Campanulo-Trisetenion association, the Anthrisco-Trisetetum, which includes extensive regional variation. Somewhat improbably for us, it is *Anthriscus sylvestris*, a plant we are used to seeing as a sign of eutrophication or of intermittent management in our own Upland Hay Meadows, that helps give this group of grasslands its floristic coherence. Julve's (1993) name for this sub-alliance is the Violo lutea ssp. sudeticae-Trisetenion.

Dierschke's (1981) third sub-alliance, the Alchemillo-Trisetenion includes high altitude meadows which retain a basic similarity to the Triseto-Polygonion and sometimes have alpine plants such as *Rumex alpestris , Poa alpina* and *Phleum alpinum* but which are additionally characterised by *Alchemilla walasii, A. crinita, Cardaminopsis halleri* and *Crocus scepusiensis.*   These are the sub-alpine meadows of the Tatra and west Carpathians like the Gladiolo-Agrostietum (Szafer *et al*. 1927, Pawłowski *et al*. 1960, 1962, Stuchlikova 1967, Kornaś 1967, Kornaś & Medwecka-Kornaś 1967, Hadač 1969, Matuszkiewicz 1984) where *Gladiolus imbricatus, Centaurea jacea* ssp. *oxylepis* and *Cruciata glabra* are diagnostic species.

5.6 Coverage in Natura 2000

The Natura 2000 Habitat 6520 Mountain hay meadows is defined (CEC 2003) as including species-rich mesophile hay meadows of the montane and sub-alpine levels (mostly above 600 metres) usually dominated by *Trisetum flavescens* and with *Heracleum sphondylium, Viola cornuta, Astrantia major, Carum carvi, Crepis mollis, C. pyrenaica, Bistorta major (Polygonum bistorta), Silene dioica, S. vulgaris, Campanula glomerata, Salvia pratensis, Centaurea nemoralis, Anthoxanthum odoratum, Crocus albiflorus, Geranium phaeum, G. sylvaticum, Narcissus poeticus, Malva moschata, Valeriana repens, Trollius europaeus, Pimpinella major, Muscari botryoides, Lilium bulbiferum, Thlaspi caerulescens, Viola tricolor* ssp. *subalpina*, *Phyteuma halleri, P. orbiculare, Primula elatior, Chaerophyllum hirsutum* 'and many others'.   The distribution of SACs designated for this habitat is shown in Figure 28 and the proportions of the sites that are represented in each country are Austria (3%), Belgium (8%), Finland (5%), France (15%), Germany (44%), Italy (12%), Spain (1%), Sweden (3%), United Kingdom (3%), Czech Republic (1%), Hungary (3%), Poland (1%), Slovakia (2%), and Slovenia (1%).

There is no explicit reference to phytosociological synonyms within the definition and the only corresponding categories given are vegetation types in the UK and Nordic countries. The species list includes some of the distinctive species of the Triseto-Polygonion, though the description hardly communicates the particular floristic and structural characteristic of the alliance. Nonetheless, almost all the EU countries which have designated sites for this habitat have interpreted it as equivalent to the Triseto-Polygonion as it is represented within their own country. In Britain, the Natura 2000 Habitat is taken to correspond exactly with MG3 *Anthoxanthum-Geranium* meadow though, as shown above, it is not true to say, as in the UK Interpretation Manual (Jackson & Mcleod 2002), that our own examples are unlike Upland Hay Meadows elsewhere in Europe. Indeed, part of the vegetation included within the designations for France (Bensettiti *et al.* 2005), Germany (Ssymank *et al*. 1998) and Austria (Ellmauer & Traxler 2000) is just the kind of Geranio-Trisetetum which is more or less identical to our own meadows. In these three countries, a range of other Triseto-Polygonion meadows is included within the designations. In other cases, as in Germany (Ssymank *et al*. 1998), other grasslands are included such as some of the cattle pastures of more fertile soils in the sub-alpine zone that are placed in the Poion alpinae.

In other cases, where phytosociological definitions are not included within the country interpretation manuals, species lists and descriptions sometimes indicate clearly that countries have designated an equivalent vegetation type to the Triseto-Polygonion: the Lk2 Horské Kosné lúky biotope from Slovakia, for example (Vicheníková & Polák 2003). More ambiguous is the interpretation of Slovakian Mountain Trisetum Grassland provided in Šeffer *et al*. (2002) which includes both 6520 Mountain hay meadows and 6230 Species-rich *Nardus* grasslands, a mixture of vegetation types also known from western Europe where there has been a shift from mowing to grazing in higher altitude grasslands of this kind (eg. Schaminée1995). Likewise, beyond the EU, the 1.1.3 Mesophytic and meso-xerophytic grasslands of higher altitudes (900-1800m) and 1.2.8 Mesophytic and meso-xerophytic grasslands of lower altitudes (< 900m) which Meshinev *et al*. (2005) have grouped within the 6520 Mountain hay meadows are also somewhat ambiguous in their composition, although both the brief description and photograph in Kavrukova *et al.* (2005) again suggest a generous definition that includes some more calcifuge pastures.

5.7 Key threats to the habitat

Reliable oral evidence suggests that the extent of Upland Hay Meadows has declined dramatically, particularly from the middle of the last century when subsidies for agricultural improvement became more substantial. Continued monitoring and survey (Critchley *et al*. 2004, Pacha 2004) have shown that, despite statutory protection and agri-environment funding, there has been no halt to the loss and deterioration of this habitat and its flora. In the *Common Standards Monitoring of Designated Sites: First Six Year Report* (Williams 2006), 42% of SSSI features and 38% of Natura 2000 features under the Neutral Grassland head (including also Lowland Meadows) were in Favourable condition, 26% and 25% respectively in Unfavourable Recovering, and 31% and 37% in Unfavourable. Among the random sample of non-statutory English sites for the BAP Upland Hay Meadows included in Hewins *et al*. (2005), only 7% were found to be in Favourable condition, the lowest score of any of the grasslands surveyed.

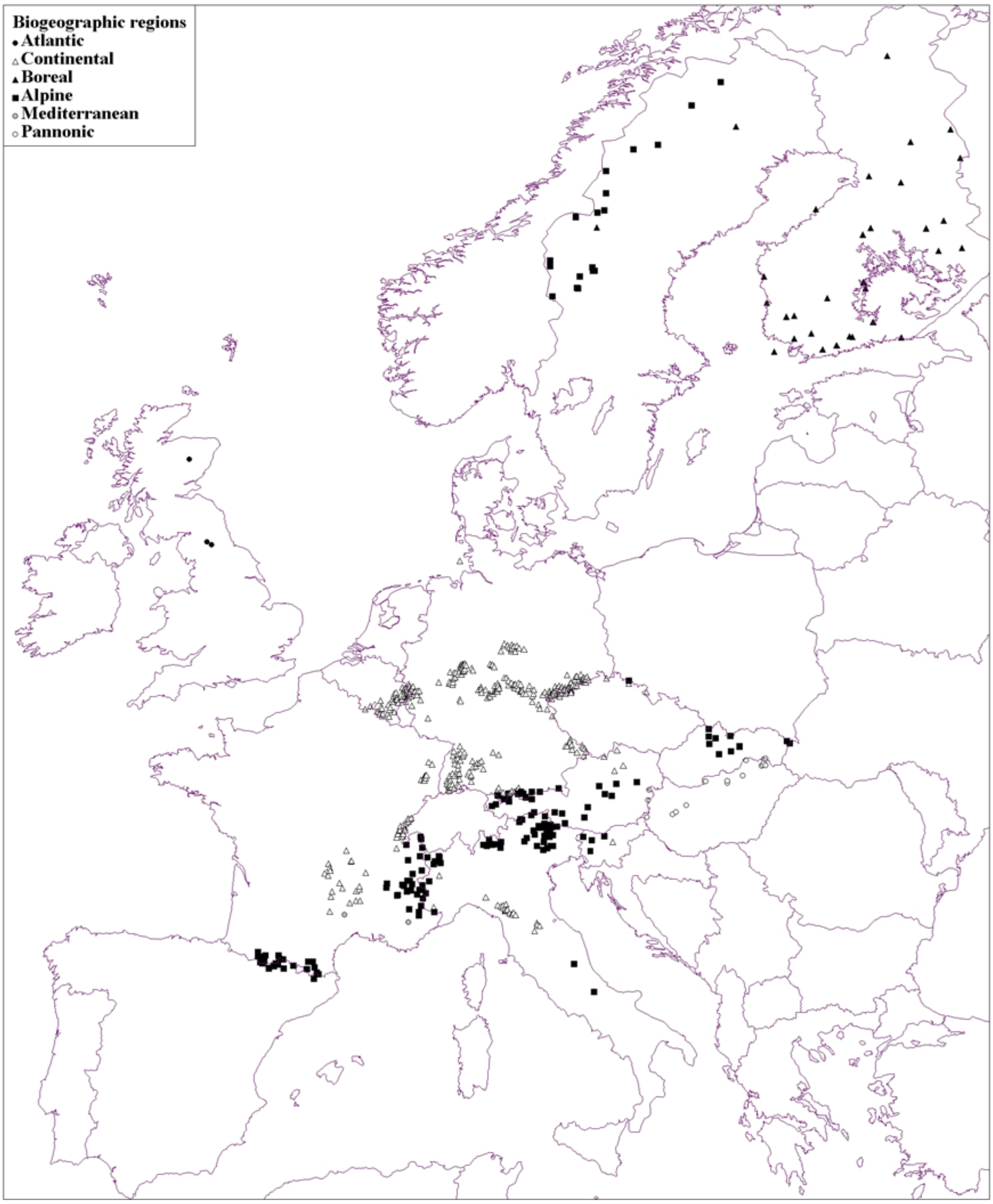

Figure 28 Annex I 6520 Mountain hay meadows

NATURA 2000 data notified to the European Commission by EU Member States and supplied by the European Topic Centre on Biological Diversity, Paris.

Farm studies and experimentation have provided informative insights into just how the various elements of the traditional treatment play a part in controlling the composition and structure of the vegetation. Cooper *et al.* (1997) summarised much of the information on the ecology and conservation value of Upland Hay Meadow vegetation and Jefferson (2005) has reviewed much of the more recent and experimental work. In the past, mixed stock rearing was the norm, usually with cattle tied in stalls through the winter, though, more recently, sheep have predominated in the Pennines and Lake District. Fertilising, apart from the dung and urine of the grazing stock, has been with one (sometimes two) dressings of farmyard manure each year, with occasional liming and additions of superphosphate. Any change which disrupts this management regime might be expected to have some kind of impact on the composition and structure of the vegetation - and on the productivity of the meadows which has been the rationale for their existence before the period when interest focused on their wildlife value.

Rates of application of farmyard manure under traditional regimes have varied considerably (Simpson & Jefferson 1996, Rodwell *et al*. 2006) but seem to have been more substantial than and less damaging than either current conservation management recommends (Croft & Jefferson 1999) or than some experimentation suggests (Smith 2005). Past farm practice and the existing character of the grassland, soil and microbial population are probably crucial in moderating the effect. The addition of chemical fertilisers in small amounts is not unknown from traditional farms (Rodwell *et al*. 2001*a*) and indeed it may be that natural levels of phosphate in the soils (Critchley *et al*. 2004) require occasional upgrade, but a more **substantial shift from farmyard manure to chemical fertilisers and slurry** has been very widespread and is known to affect the balance between grasses and dicotyledons (Jones 1984) and to diminish species-richness (Smith 1988, 1994), even where other elements of traditional management are retained.

Periodic ploughing of meadows for arable cultivation in times of national emergency has certainly occurred on traditional farms and has left a lasting mark in the floristic composition of the meadow vegetation, even when the interval has been brief and there was no fertilising with chemicals: the contrast between the *Briza* and *Bromus* sub-communities of MG3 *Anthoxanthum-Geranium* grassland probably reflects such interventions (Rodwell 1992). More extensive **ploughing and reseeding of meadows** on deeper soils with rye-clover mixes, together with more frequent cutting for silage, rather than hay, has been the biggest general change in the management of these grasslands in the sub-montane zone, as with the Lowland Meadows (UK Biodiversity Group 1998). This is a shift that has had implications, not just for individual farms, but at landscape scale because surviving stands have sufferede **fragmentation**. Evidence suggests that for both the flora (Pacha 2004) and bird populations (Small 2002) such changes affect the survival and integrity of the remaining populations.

In this country, the traditional treatment that has sustained this vegetation has involved winter and spring grazing, a shut-up in early May with removal of stock to the open hill grazings, a single mowing from late June onwards when periods of fine weather permit, and aftermath grazing in the late summer and autumn (Bradshaw 1962, Rodwell 1992). **Substantial changes in the timing and intensity of grazing** affect the character of the sward, with some spring grazing essential for maintaining the characteristic contingent of dicotyledons (Smith & Rushton 1994). However, heavy and prolonged spring grazing was related to deterioration in the meadows of the Pennine Dales Environmentally Sensitive Area (Critchley *et al.* 2004). **Radical changes in mowing times** also have an effect: despite the interest in the colourful forbs in this vegetation, by traditional hay-cut time it is grasses that generally predominate by dry weight (Edwards 1999, Taylor 2004) and late cutting has been shown to favour certain grass species (Smith *et al*. 1996*a*). Though deeper rooted dicotyledons may bring up trace elements from below, for the farmer an abundance of denser grass tissue in the hay is essential for the stock (Raven Frankland pers. comm.). The timing of the cut also affects which species contribute ripe seed in the drying hay that is able to enter the soil seed bank: the phenology of the Upland Hay Meadow is a rich and complex process in itself (Cooper *et al*. 1997) and a midsummer cut is most productive in this respect (Smith et al. 1996*b*). Elsewhere in Europe, where these meadows have been a traditional feature of the sub-montane and montane zones, complete abandonment of mowing is a widespread threat.

It is clear from farm diaries (Smith & Jones 1991, Rodwell *et al*. 2001*a, b*) that differences in weather from year to year have a marked influence on the timing and duration of hay-making and subsequent grazing of the aftermath, as well as on the size and quality of the crop. Such a flexible responsiveness, together with the spatial diversity of unimproved soils across the in-bye land of the sub-montane zone, has contributed greatly to the local distinctiveness of meadows from farm to farm, even from field to field, and year to year. On farms where high quality Upland Hay Meadows survive, **inflexible application of agri-environment regulations**, with fixed dates for hay-cutting and a narrow view of the need for maintaining soil fertility and hay productivity and quality, can therefore themselves be potentially damaging to the species-richness and diversity of the vegetation and the intimate inter-relationship between wildlife quality and agricultural value. Though most English Upland Hay Meadows were included within the then ESA schemes by the late 1980s (Jefferson 2005), the latest report indicates little progress towards restoration of any species-richness within semi-improved grasslands within the Pennine and Lake district landscapes (Critchley *et al.* 2004).

More diffuse dangers to the Upland Hay Meadow include background **deposition of atmospheric nitrogen** which may well have played some part in the general eutrophication of meadow and verge vegetation within the landscape where the habitat occurs. Some distinctive meadow plants, such as *Geranium sylvaticum*, survive surprisingly well among nitrophilous rank grassland and tall-herb vegetation, like various kinds of MG1 *Arrhenatherum* sward (Pacha 2005), though verge populations isolated from meadows have a less diverse genetic fingerprint (Napper 2003) and also flower earlier there thus limiting out-breeding with meadow populations.

Geranium sylvaticum is a Northern Montane plant with a striking lower altitudinal limit in Britain. This may be partly related to its vernalisation requirement (Hill 2001) but also important may be a need for low winter temperatures to prevent respiratory rundown of its carbohydrate and protein resources in the bulky rhizome, a reserve which it is able to draw on quickly after the temperature rises above the growing point in early May. **Rising winter temperatures**, already recorded in the Upland Hay Meadow landscape (Rodwell *et al*. 2001*b*), might be expected to threaten this plant's ability to retain such resources and its key role in this kind of vegetation. Loss of a sub-montane floristic element would leave the Upland Hay Meadows with a floristic composition essentially resembling MG5 *Centaurea-Cynorusus* grassland.

5.8 Conservation initiatives

The UK BAP Action Plan for Upland Hay Meadow states that between 500 and 1,000ha of the habitat are protected within 75 SSSIs, with Jefferson (2005) providing the more precise figure of around 770ha. Cooper *et al*. (1996) gave the generous upper figure for MG3 *Anthoxanthum-Geranium* grassland as 640ha of which only 50% was designated as SSSIs at that time. Management agreements are in place for many of these SSSIs. Three sites for this habitat are NNRs and, under the Habitats Directive, 59 SSSIs have been included within two composite SACs designated partly for 6520 Mountain hay meadows, which Averis *et al*. (2004) state as protecting 700ha or 70% of the total resource in the UK. These SACs constitute about 3% of the total number for this Annex I habitat across the EU. Particularly within the Pennine Dales Environmentally Sensitive Area, where Upland Hay Meadows are especially important, considerable effort has gone into recruitment for agri-environment schemes aimed at their recovery. However, the most recent re-survey of monitored quadrats (Critchley *et al*. 2004) shows that there is no apparent improvement in sward quality in the short term. In their random sample of non-statutory English sites for Upland Hay Meadow, Hewins *et al* (2005) showed no significant difference in condition between stands within and outside agri-environment agreements but many more of the grasslands shown to be improved agriculturally were outside schemes.

As with many traditionally managed grasslands, the diversity of fields of Upland Hay Meadows is often very striking and **Flora Locale** is one initiative that aims to foster such local distinctiveness through the local sourcing and use of the British and Irish wild flora. To promote good practice, it maintains a website with an on-line library, hosts an electronic network, publishes advisory notes, organises a training programme and produces two regular newsletters, one specifically for northern Britain. With its encouragement, the Yorkshire Dales **Hay Time** project, hosted by the Yorkshire Dales Millenium Trust, aims to enhance at least 120ha of MG3 *Anthoxanthum-Geranium* grassland, as well as 100ha of MG5 *Cynosurus-Centaurea* Lowland Meadow grassland over the next 3½ years. It uses its own machinery and contractor to harvest seed from existing local meadows for introduction into fields where the swards are being restored, generally through some agri-environment scheme. With a likely local shortage of seed, it is expected that some will probably have to be obtained from road verges.

5.9 Research needs

This kind of vegetation is now one of the best surveyed of all UK grasslands and one that is already well researched but a concerted effort is needed to coordinate existing data sources on a spatial platform to ensure an integrated response to threats and the precise identification of further research needs across the remaining range.

Simple studies by Edwards (1999) and Taylor (2004) have provided the first real indication of the productivity of Upland Hay Meadow vegetation, and this can be surprisingly high. With the continuing research interest in particular holdings and experimental sites, there is everything to be said for some whole-farm studies to calculate the balance of costs and benefits for herbage production and biodiversity in this kind of agricultural system. The appraisal of studies on soil microbes, mycorrhizae and soil fertility in Upland Hay Meadow systems (eg. Smith *et al*. 2005) should help understand what further research is needed into below-ground components of this habitat.

Germination studies (Smith & Jones 1991) have shown that the seed bank in the soils of traditional hay meadows do not reflect the existing composition of the vegetation, though more account needs to be taken of the germination requirements of particular species, such as the vernalisation essential for *Geranium sylvaticum* (Hill 2002). Such needs, like the conservation of over-wintering rhizome stores, are of critical interest with the prospect of climatic warming whose impact on the distinctive sub-montane element of Upland Hay Meadows might be severe. With the continuing fragmentation of Upland Hay Meadows (Pacha 2005) and the loss of genetic diversity in surviving road verge populations of *Geranium sylvaticum* (Napper 2003), further work also needs to be done on the prospect of recruitment of such key species to the flora in stands that are undergoing restoration.

The attempted restoration of MG3 *Anthoxanthum-Geranium* grassland at Colt Park has been documented by Smith *et al*. (1996*c*, 2000) and Smith (1997) where swards approximating to MG3 *Anthoxanthum-Geranium* grassland have been produced mainly by a combination of spring and autumn grazing, later cutting dates and the addition of seed, with or without chemical fertiliser. Such experiments need continued monitoring to obtain added value from investment while evidence suggests that further work is needed to understand the optimal levels of spring grazing, particularly within current agri-environment schemes.

Two wider aspects of the context in which Upland Hay Meadows occur merit further attention. Research by Smith & Jones (1991) and Rodwell *et al*. (2001*a, b*) has shown just how fruitful a source of information diaries can be about the yearly round of farm operations. An electronic database for New House Farm at Malham (Rodwell *et al*. 2001*a*) could serve as a model for wider research which needs to be integrated with understanding the social fabric through which such farming has been sustained – for example through reminiscence therapy with aging farmers.

Second, Upland Hay Meadows were formerly part of the habitat of the corncrake and remain of significance within the landscapes used by waders such as lapwing, curlew, snipe and redshank, some of which have drastically declined. Research by Small (2002) and Pacha (2005) has shown how important a landscape-scale approach is for understanding the survival of such fauna and the distinctive vegetation on which they somehow depend.

6 Purple Moor Grass and Rush Pastures

6.1 Summary of BAP Habitat Type

These are vegetation types of poorly-drained, usually acidic, peaty gleys and shallow peats in the lowlands in which *Molinia caerulea* and *Juncus acutiflorus* figure prominently, along with a distinctive associated poor-fen flora. Typically found on undulating plateaux and gentle slopes, streamsides and river valleys, they have been traditionally used for mowing a litter crop and/or for grazing, the best examples being those with mosaics of various constituent plant communities reflecting the differing ground conditions and variable extensive management. Though the terms 'fen-meadow' and 'pasture' can be rather loosely used with reference to this habitat to denote edaphic preferences, the former is best reserved here to indicate a mowing treatment, while the latter ought to be used for the vegetation when it is exclusively grazed. There can be little floristic difference between stands found on mineral soils and on shallow peats. More species-poor vegetation on deeper peats (more than 0.5m), while excluded from the BAP Habitat Action Plan, is here included for the sake of completeness.

Five NVC communities are included within the habitat, occurring quite often as mosaics in various combinations, and with other vegetation types. Comparable Molinietalia associations of the Molinion, Junco-Molinion, Calthion and Juncion acutiflori alliances occur widely across Europe, though often less extensively than in the UK. Designation for the Natura 2000 habitat 6410 *Molinia* meadows is narrower than the BAP habitat, generally including the Junco-Molinion and, more exclusively in continental areas, the Molinion. Throughout Europe, these vegetation types are threatened by drainage and reclamation with increasing difficulty in ensuring management on those often fragmented stretches that remain.

6.2 Synonymy

NVC M22 *Juncus-Cirsium* fen meadow, M23 *Juncus-Galium* rush-pasture, M24 *Molinia-Cirsium* fen meadow, M25 *Molinia-Potentilla* mire, M26 *Molinia-Crepis* fen-meadow.

Annex I 6410 *Molinia* meadows on calcareous, peaty or clayey-silt-laden soils (*Molinion caeruleae*).

EVS 26F02 Calthion, 26F07 Juncion acutiflori, 26F08 Junco-Molinion, 26F10 Molinion.

EUNIS E3.4 Moist or wet eutrophic and mesotrophic grassland, E3.5 Moist or wet oligotrophic grassland.

6.3 Character and distribution of the NVC constituents

The UK Lowland Grassland HAP Steering Group (1998) defines the habitat as including five NVC communities: M22 *Juncus subnodulosus-Cirsium palustre* fen-meadow, M23 *Juncus acutiflorus-Galium palustre* rush pasture, M24 *Molinia-Cirsium dissectum* fen meadow, M25 *Molinia-Potentilla erecta* mire and M26 *Molinia-Crepis paludosa* fen-meadow (Rodwell 1992). It is estimated that there are 21,544 ha of the habitat in England, 32,161 ha in Wales and 6768 ha in Scotland (Lowland Grassland UK HAP Steering Group 2005) and the known distributions of the various communities, together with the total extent of the habitat, are shown in Figures 29-34. Together with the substantial Northern Ireland total (see 6.4 below), the UK probably has almost 80,000 ha - more than survives in the whole of the rest of continental western Europe.

The range of vegetation included here is difficult to classify adequately because of the complex effects of past agricultural treatments and widespread more recent neglect. This has favoured the extensive spread throughout of competitive dominants like *Molinia caerulea* and various *Juncus* spp., many of which, in the Atlantic climate of this country, are more broadly tolerant anyway of different edaphic conditions than elsewhere in Europe. A further complexity is that, in less improved landscapes where there has been a diversity of treatments occurring side by side and often varying through time, several of the communities can occur in complex intimate mosaics, the constituents of which can now be hard to distinguish. In this sense, a broader descriptive category like the BAP habitat is useful (or the more precisely-defined Rhos Pasture originated by the Countryside Council for Wales, eg. Blackstock *et al*. 1997, and the Culm Grassland of Devon and Cornwall, although the various vegetation types these categories include are dependent on different soil and ground water conditions and interventions to sustain them, so a single management prescription might not be desirable.

The communities are best understood as a pair of climate-related sequences. Among the vegetation types where *Molinia* is the most common dominant, the M24 *Molinia-Cirsium* community includes most of the anthropogenic swards on well-aerated peats and peaty mineral soils in the warmer and drier south-east of Britain, typically in topogenous and soligenous mires, particularly in East Anglia and the Somerset Levels, and in flushed wet heaths, especially in the west. The vegetation was often treated as a fen-meadow, yielding an annual crop of litter, though most often now it is grazing which maintains the vegetation and this has maybe always been the commoner management in the west where the vegetation often takes on a distinctly heathy character with the appearance of ericoids and Junci in a more oceanic sub-community. Towards the limit of the community in Wales, essentially similar vegetation extends beyond the range of *Cirsium dissectum* and *Juncus subnodulosus* (Blackstock *et al*. 1993, 1998), but towards northern Britain a distinctive Continental Northern or Northern Montane element enters the flora on more distinctly base-rich peats and peaty mineral soils, usually in isolated topogenous fens, and there the M26 *Molinia-Crepis* community can be found. It is not so limited in occurrence as Rodwell (1991) implies but nonetheless scattered and local beyond the North Pennines.

The more substantial shift among *Molinia*-dominated vegetation towards the wetter and cooler west where well-aerated peats and peaty mineral soils are very widespread on gentler slopes in the hills, is to the M25 *Molinia-Potentilla* community in which the dominant grass reaches a peak of vigour in vegetation which is consequently often species-poor. Here, too, the common occurrence of *Juncus acutiflorus* makes for an especially difficult separation from the M23 *Juncus-Galium* community, particular where, as is usual, it is grazing which maintains the vegetation in less-improved enclosures and (beyond the limit of our interest here) in open hill pastures. Subsequent survey following the NVC has also revealed the widespread occurrence of swards of the M25 type but with less (sometimes very much less) *Molinia* and a close sward rich in small sedges and pasture herbs (Cooper 1993, Cooper & MacKintosh 1996, Rodwell *et al.* 2000, Blackstock & Stevens pers comm and Porley pers comm).

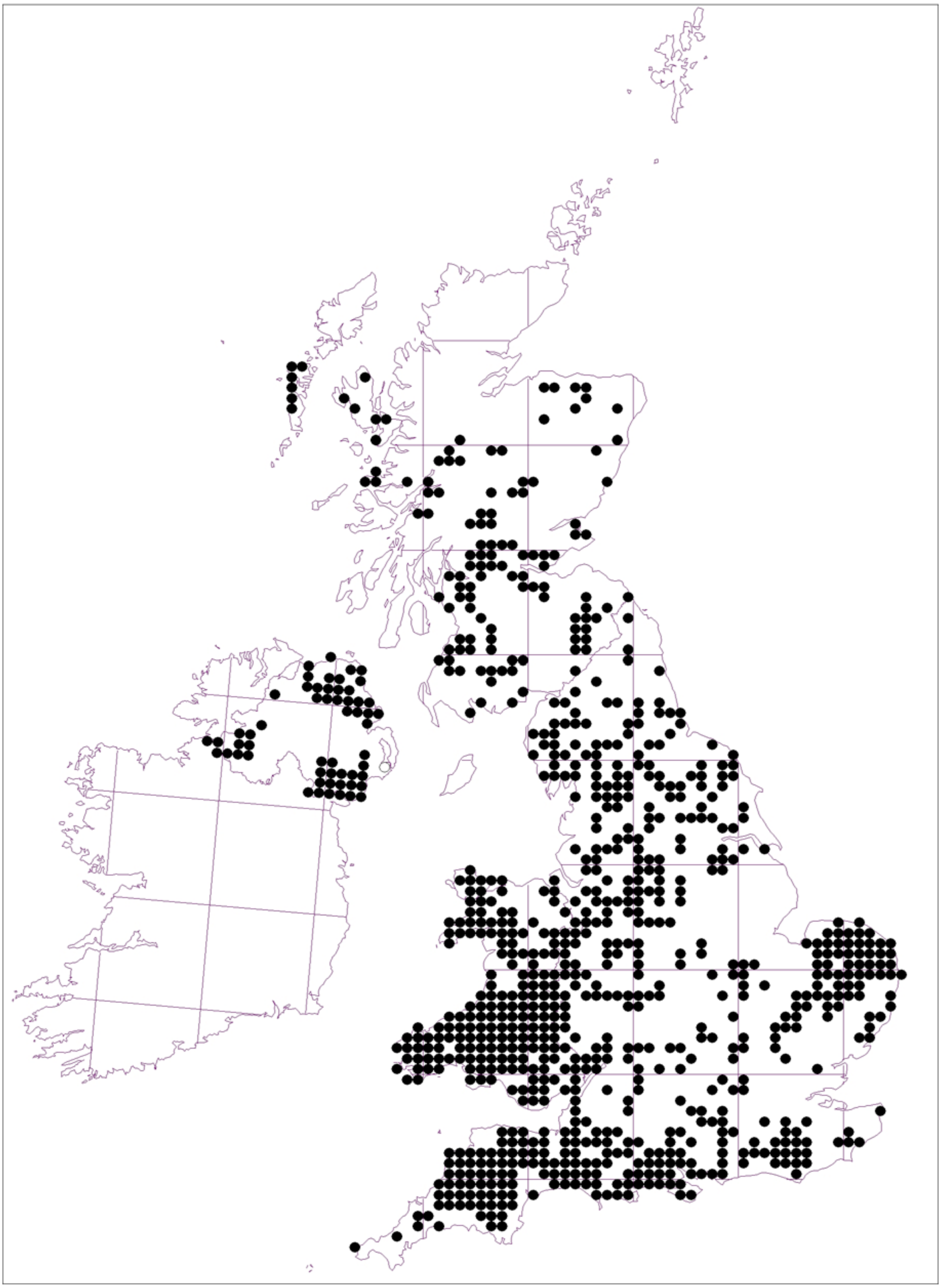

Figure 29 BAP Purple Moorgrass and Rush Pasture

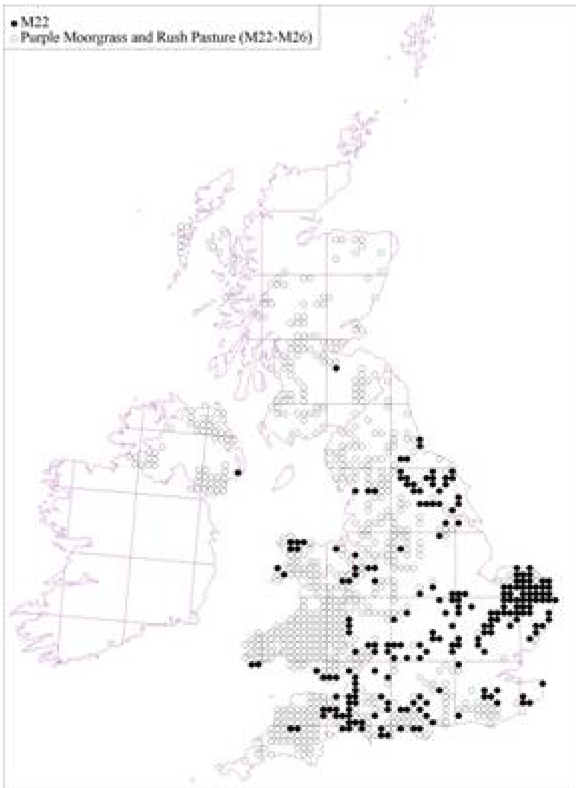

Figure 30 M22 *Juncus-Cirsium* fen-meadow

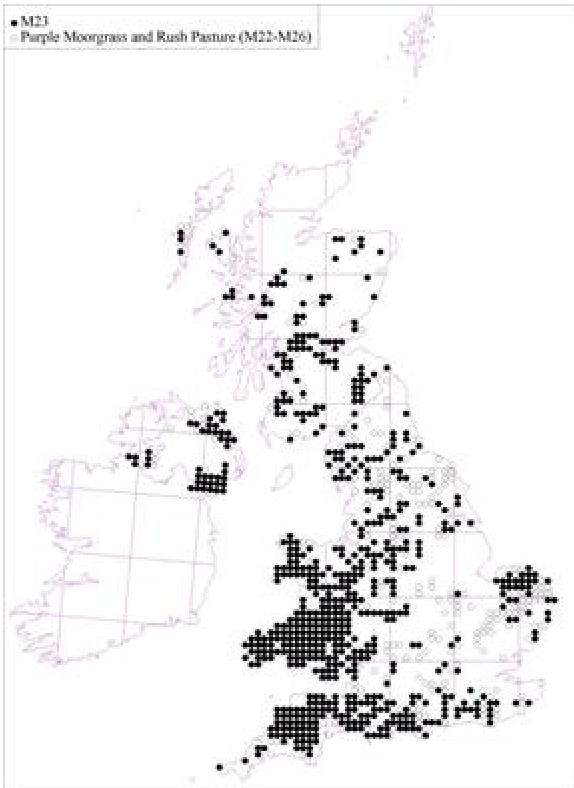

Figure 31 M23 *Juncus-Galium* rush-pasture

The 10km grid records from which these maps were prepared date from 1980 onwards and include vegetation recorded as intermediate between NVC communities. The filtering has been inclusive, including all sites where the target community was recorded, even if only part of an intermediate with one or more other communities.

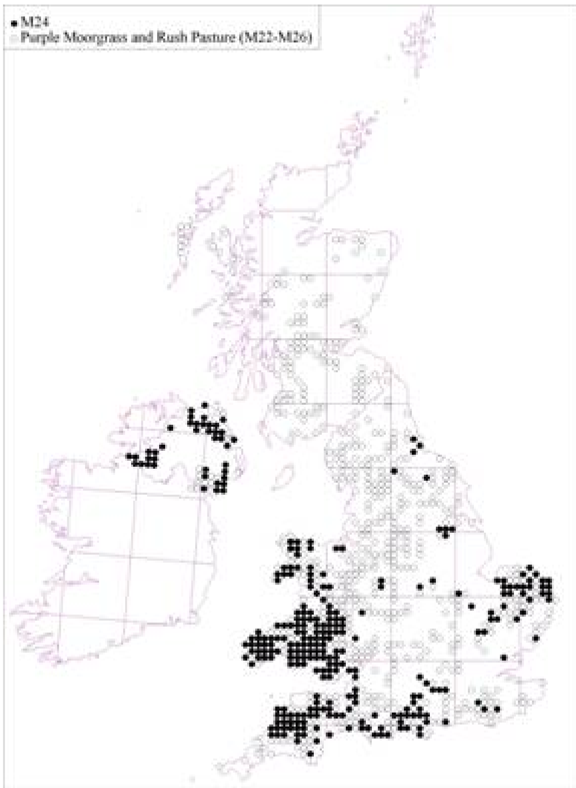

Figure 32 M24 *Molinia-Cirsium* fen-meadow

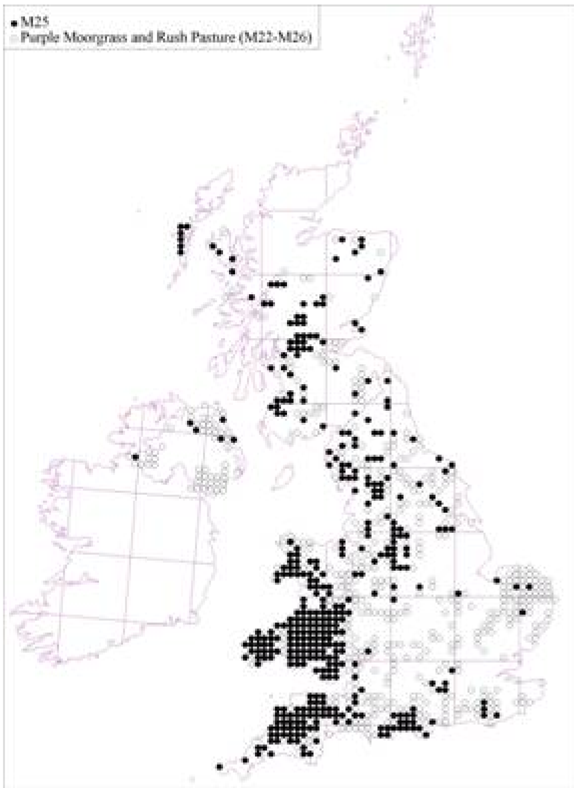

Figure 33 M25 *Molinia-Potentilla* mire

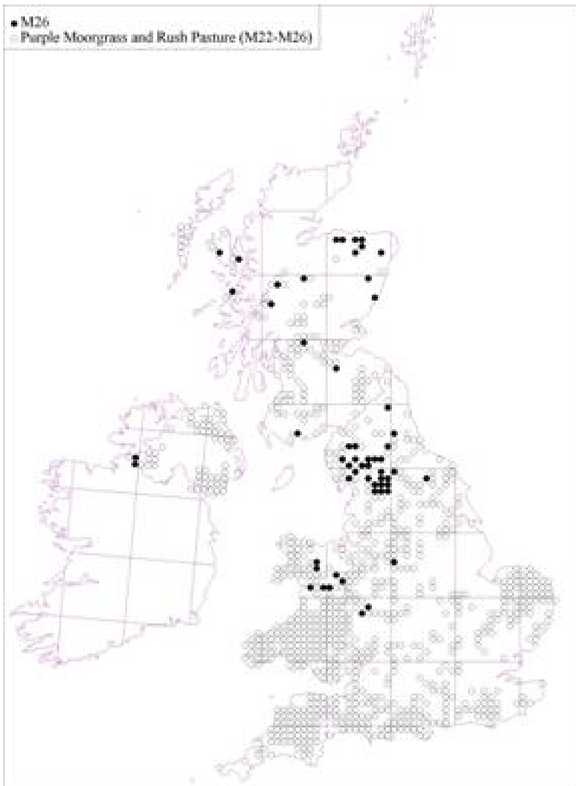

Figure 34 M26 *Molinia-Crepis* mire

The 10km grid records from which these maps were prepared date from 1980 onwards and include vegetation recorded as intermediate between NVC communities. The filtering has been inclusive, including all sites where the target community was recorded, even if only part of an intermediate with one or more other communities.

Among the more strictly rush-dominated vegetation included in this BAP habitat, the characteristic assemblage of the warmer and drier south-east is the M22 *Juncus subnodulosus-Cirsium palustre* community. This is a diverse vegetation type in its floristics and structure, with drier and swampier forms, but it is particular associated with fens of springs, seepage lines and topogenous mires where it has developed through mowing or grazing. It is especially concentrated in East Anglia but with numerous scattered localities further west and north. Forms richer in bulkier grasses have been reported since the NVC from Suffolk fens (Harding & Kay 1992, Harding 1993, Rodwell *et al*. 2000). Towards the wetter and cooler west, its counterpart among the rush-dominated vegetation of this habitat which occurs very widely on ill-drained peaty mineral soils, in flushes and around mire margins, is the M23 *Juncus acutiflorus-Galium palustre* community, a very common constituent of unimproved or reverted grazings. Forming a hazy transition between the two communities is the MG10 *Juncus effusus-Holcus lanatus* rush-pasture, a community that is not included in the BAP habitat, though it can have some interest in the milder west, where stands rich in *Iris pseudacorus* are a distinctive feature of wetter pastures in, for example, south-west England, Pembrokeshire and Anglesey.

6.4 The BAP Habitat and its constituents in Northern Ireland

In Northern Ireland, the main constituents of this Habitat are M23 *Juncus-Galium* rush-pasture and M24 *Molinia-Cirsium* fen meadow, though in both cases there are some differences to the published definitions or general understanding of the communities (as noted by Cooper & McCann 1994), some of which have been outlined in Rodwell *et al.* (2000). This is partly because of the character of the terrain and soils over which these vegetation types occur in the province. Over Carboniferous Limestone and Tertiary Basalts, for example, less pervious soils are often flushed with base-rich waters, and over drift deposits, the substrates vary within a small compass. Species-rich types of M23 *Juncus-Galium* rush-pasture (as detailed in Rodwell 2004) are therefore widespread. Then, there is the influence of the moist and equable climate, so that the heathier western M24c *Juncus-Erica* sub-community of *Molinia-Cirsium* fen meadow is frequently encountered (Rodwell 2004).

It has been recommended in Northern Ireland that more species-poor examples of rush-pasture and fen-meadow are excluded from this habitat so, along with the focus on stands in enclosed landscapes, this means that much M25 *Molinia-Potentilla* is not considered here. Nonetheless, the current extent of this BAP habitat in Northern Ireland is 18,919 ha, about a fifth of the UK total (Lowland Grassland UK HAP Steering Group 2005). Of this, just over 20% is M24 *Molinia-Cirsium* fen-meadow. Most is managed as pasture but some is cut for big-bale silage.

6.5 Character and significance of the UK habitat in the wider European context

Within the UK BAP, Purple Moor Grass and Rush Pastures includes vegetation that would be grouped in four alliances of the Molinietalia, the order of meadows and pastures of moister soils, often peaty, through the European lowlands. These vegetation types have sometimes been elevated to a class of their own, the Molinio-Juncetea (Braun-Blanquet 1947, Géhu 1992, Julve 1995), but more traditionally the Molinietalia is treated as part of the Molinio-Arrhenatheretea, a more generous interpretation of which also includes all the anthropogenic lowland grasslands of circumneutral mesotrophic soils. Dierschke (1995, largely following Tüxen 1937 and Tüxen & Preising 1951) has provided a useful syntaxonomic overview of these plant communities, in which the Molinietalia shares with the drier meadows and pastures of the Arrhenatheretalia frequent records for *Festuca pratensis, F. rubra, Holcus lanatus, Poa trivialis, P. pratensis, Anthoxanthum odoratum, Ranunculus acris, R. repens, Trifolium pratense, Plantago lanceolata, Rumex acetosa* and *Lathyrus pratensis*. By contrast with the Arrhenatheretalia, the Molinietalia has more *Filipendula ulmaria, Deschampsia cespitosa, Lychnis flos-cuculi, Galium uliginosum, Cirsium palustre, Achillea ptarmica, Equisetum palustre* and *Sanguisorba officinalis*, a group recognisable by us as tall herbs and sprawlers of poor fens. Despite giving its name to the order, *Molinia caerulea* itself is not frequent throughout.

There has been (somewhat) less argument about the ordering of alliances within the Molinietalia than in the Arrhenatheretalia (Dierschke 1995) and, in Rodwell *et al*. (2002), eleven are recognised, of which the four represented in the BAP habitat are the most widespread through Europe as a whole (See Table 6). One of the earliest to be defined and most stable is the **Molinion** (sometimes termed the Eu-Molinion to stress its centrality in the order), the alliance of unmanured wet meadows in the more continental lowlands of central Europe. This is where *Molinia* itself has its strong peak of occurrence, along with *Briza media, Succisa pratensis, Potentilla erecta, Selinum carvifolia, Linum catharticum, Carex flacca, C. nigra* and *C. panicea* occurring very commonly throughout, and *Epipactis palustris* and *Parnassia palustris* also preferential. Shared with the sub-Continental flood-plain meadows now usually separated off into the Cnidion (Nowak in Dierschke 1990) are frequent *Serratula tinctoria, Galium boreale* and *Centaurea jacea.* Among the vegetation of the BAP habitat, it is the M26 *Molinia-Crepis* community that most closely approximates to this alliance, though its continental character is a distinctly northern European one, a feature echoed in the floristics of calcareous pastures described from Sweden by Regnéll (1980), in the G12c Våt/fuktig middles naeringsrik described from Norway by Fremstad (1997), in the Molinion of Latvia (Kabucis 2000) and Lithuania (Rašomavičius 2001) and in some of the Pöhjamaade taimkattetüübid järgi of Estonia (Paal 2004). The 5.2.3.5 Blåtåtelängs-typ described from Sweden (Påhlsson 1994) also looks somewhat similar.

Further south than this in continental Europe, following the very early work on these vegetation types, a core Molinion association has often been defined as some form of Molinietum caeruleae medioeuropaeum Koch 1926, as in Belgium (LeBrun *et al*. 1949), Germany (Pott 1995), Poland (Matuszkiewicz 1984), Lithuania (Balevičienė *et al*. 1998), the Czech Republic (Moravec 1995), Romania (Coldea 1991). Beyond this broad level, treatment has varied considerably from country to country: as Ellenberg (1988) remarks, it has been easier to distinguish regional geographic sequences among these *Molinia* meadows, as in Germany (Philippi 1960, Korneck 1962/3) and Hungary (Kovács 1962) than it is to develop a coherent European overview. However, two associations have been recorded more widely: the Selino-Molinietum Kuhn 1937 from Germany (Pott 1995, Dierßen 1996), Austria (Mucina *et al*. 1993), Poland (Herbicha 2004) and Slovenia (Kaligaric et al. 2003) and the Gentiano-Molinietum Ilijanić 1968 from the Czech Republic (Vicherek et al. 2000, Balátová-Tuláćková & Hajek 1998), Slovakia (Balátová-Tuláćková 2000), Austria (Kuyper *et al*. 1978, Mucina *et al*. 1993), Slovenia (Zelnik 2005) and maybe also from Switzerland (Klötzli 1969). The Junco-Molinietum Preising 1951 described from Germany (Pott 1995), Austria (Mucina *et al.* 1993), Poland (Matuszkiewicz 1984) and Lithuania (Balevičienė *et al*. 1998) is a community of more acidic soils often at higher altitudes. In this vegetation, the prominence of *Juncus effusus, J. conglomeratus* and *J. acutiflorus* bring the floristics close to our own M25 *Molinia-Potentilla* community which is best not grouped in the Molinion at all (see below).

It was Westhoff (in Westhoff & den Held 1969) who first proposed a separate **Junco-Molinion** alliance to accommodate what had previously been distinguished from the more continental *Molinia* communities as a Molinietum caeruleae atlanticum Lemée 1937. *Juncus conglomeratus* was regarded as a good character species but *Succisa pratensis, Carex pulicaris, Parnassia palustris* and *Plantanthera bifolia* also tend to be preferential here. This is where our M24 *Molinia-Cirsium* community belongs, as a clear British counterpart to the Cirsio-Molinietum Sissingh & de Vries 1942 described from The Netherlands (Schaminée *et al.* 1996), Belgium (Duvigneaud & Vanden Bergen 1945, LeBrun *et al.* 1949), Germany (Ssymank *et al*. 1998) and Ireland (Brock *et al*. 1978, White & Doyle 1982).

The other early-recognised alliance of the Molinietalia was the **Calthion** (or Bromion racemosi as it was known by Braun-Blanquet 1947, Tüxen & Preising 1951, Tüxen 1955 and still by Julve 1993) which includes the wet meadows and pastures of more fertile, often manured soils, in both the Continental and Atlantic zones of Europe. Shared with the Molinion are frequent records for *Carex nigra, C. panicea* and *Valeriana dioica* but the character species here are *Caltha palustris, Myosotis palustris, Scirpus sylvaticus, Angelica sylvestris, Lotus pedunculatus, Agrostis canina* and *Cirsium oleracea. Juncus effusus* and *J. conglomeratus* can be common in these kinds of vegetation throughout the range of the alliance but in the UK we have the additional complication that species regarded as more diagnostic of the Calthion in central Europe tend to lose their affinities. Some British Calthion communities are described under the BAP Lowland Meadows habitat (see pp. 49-52 & 58-59), but among the Purple Moor Grass & Rush Pastures, the vegetation which most closely corresponds to the Calthion elsewhere in Europe, is the M22 *Juncus-Cirsium* fen-meadow.

Beyond that, what its precise affinities are, and quite how Calthion communities in different parts of Europe equate, remains somewhat unclear. Among our own Molinietalia communities, *Juncus subnodulosus* has a clear peak of occurrence in the *Juncus-Cirsium* fen-meadow but this contains only a fraction of the variation that was included in the Juncetum subnodulosi Koch 1926 characterised in early classifications elsewhere (and still in Poland: Matuszkiewicz 1984) to include more basiphilous rush-pastures. Of those more recently-defined associations for which detailed accounts are available, the most similar Calthion to our (more swampy) M22 *Juncus-Galium* vegetation seems to be the Lychnido-Hypericetum tetrapteri Meltzer 1945 emend Van 't Veer described from The Netherlands (Schaminée *et al.* 1993).

Among the most widespread related vegetation types in more continental regions is the Angelico-Cirsietum oleracei Tüxen 1937 which has been recorded from Germany (Pott 1995), Austria (Mucina *et al*. 1993), the Czech Republic (Balátová-Tuláćková 1981, 1983, 1987, Balátová-Tuláćková & Hajek 1998), Slovakia (Španiková 1983), Hungary (Borhidi 2003) and Croatia (Regula-Bevilaqua 1980). Here, *Cirsium oleraceum*, which is an introduced and locally naturalised plant with us (Stace 1997), can be dominant but the associated flora shows a broad similarity to that of the *Juncus-Cirsium* fen meadow, and there is a similar diversity of floristic and structural variation within the association.

Extending geographically closer among the European Calthion communities is the Crepido-Juncetum acutiflori (Braun 1915) Oberdorfer 1957 which has been described from the Czech

Republic (Moravec 1995), Germany (Pott 1995) and The Netherlands (Schaminée *et al*. 1993). Again, the abundance here of *Juncus acutiflorus,* and the sort of associated flora seen in the detailed account from The Netherlands, evoke richer stands of our western Purple Moor Grass and Rush Pastures. In Rodwell (2000), these M23 *Juncus-Galium* and M25 *Molinia-Potentilla* communities were both grouped in the **Juncion acutiflori**, an alliance first characterised by Braun-Blanquet in 1947 and included in the Molinietalia by Oberdorfer *et al.* (1957) to contain the meadows and pastures of moist peaty mineral soils with impeded drainage or flushing in the sub-Atlantic and Atlantic zones. In Dierschke's (1995) overview, this is the least well-defined part of the Molinietalia but the best preferentials listed there are *Anagallis tenella, Carum verticillatum, Oenanthe peucedanifolia, Scutellaria minor* and *Wahlenbergia hederacea.* Most analogous to our own vegetation of this type seems to be the Juncetum acutiflori subatlanticum Jonas which has been recorded from Belgium (LeBrun *et al*. 1949). White & Doyle (1982) list a Junco acutiflori-Molinietum Tuxen & O'Sullivan 1964 which has been widely described from Ireland (O'Sullivan 1968a, b, 1969, 1976) but this seems to be equivalent to the distinctive western type M24c of the Cirsio-Molinietum.

6.6 Coverage in Natura 2000

The Natura 2000 Habitat 6410 *Molinia* meadows on calcareous, peaty or clayey-silt-laden soils (*Molinion caeruleae*) is defined as comprising *Molinia* meadows of lowland to montane altitudes, on more or less wet soils, poor in the major nutrients nitrogen and phosphorus, stemming from extensive management, sometimes with a mowing late in the year, and also occurring on deteriorating peat bogs which have been drained (CEC 2003). Two sub-types are distinguished, the first being the Eu-Molinion, described as being on neutral to basic and calcareous soils, sometimes peaty and with a fluctuating water table which drops so as to dry out the substrate in summer. These are relatively rich in species and characterised by *Molinia caerulea, Dianthus superbus, Selinum carvifolium, Cirsium tuberosum, Colchicum autumnale, Inula salicina, Silaum silaus, Sanguisorba officinalis, Serratula timctoria, Tetragonolobus maritimus*. The second sub-type is defined unhelpfully as 'Junco-Molinion (Juncion acutiflori)' as if these two alliances were identical, and as being characteristic of more acidic soils. It excludes species-poor meadows on degraded peaty soils and is distinguished by *Viola persicifolia, V. palustris, Galium uliginosum, Cirsium dissectum, Crepis paludosa, Luzula multiflora, Juncus conglomeratus, Ophioglossum vulgatum, Inula brittanica, Lotus pedunculatus, Dianthus deltoides, Potentilla erecta, P. anglica* and *Carex pallescens.*

The distribution of the SACs that have been nominated for this habitat is shown in Figure 35 and the proportions of total site numbers in the various countries is: Austria (3%), Belgium (3%), Czech Republic (2%), Germany (27%), Denmark (3%), Estonia (3%), Spain (3%), Finland (>>1%), France (11%), Hungary (5%), Ireland (1%), Italy (5%), Lithuania (1%), Latvia (1%), The Netherlands (1%), Poland (3%), Portugal (1%), Sweden (23%), Slovenia (1%), Slovakia (1%) and the UK (2%).

Among the EU countries, the UK has designated what are the most recognisable vegetation types of the Molinion, the M26 *Molinia-Crepis* fen-meadow, and of the Junco-Molinion, the M24 *Molinia-Cirsium dissectum* fen-meadow (Jackson & McLeod 2002). France (Bensettiti *et al*. 2005) has taken a similar general line in recognising the presence of both more continental and more Atlantic meadows, including a great range of the associations distinguished there, both in the Molinion (9 associations) and especially in the Juncion acutiflori (25 associations). In Portugal (http://www.icn.pt/psrn2000), although no alliance is specified, the emphasis is also on rushy Atlantic Molinietalia meadows with *Juncus acutiflorus, J. conglomeratus* and *J. effusus.*

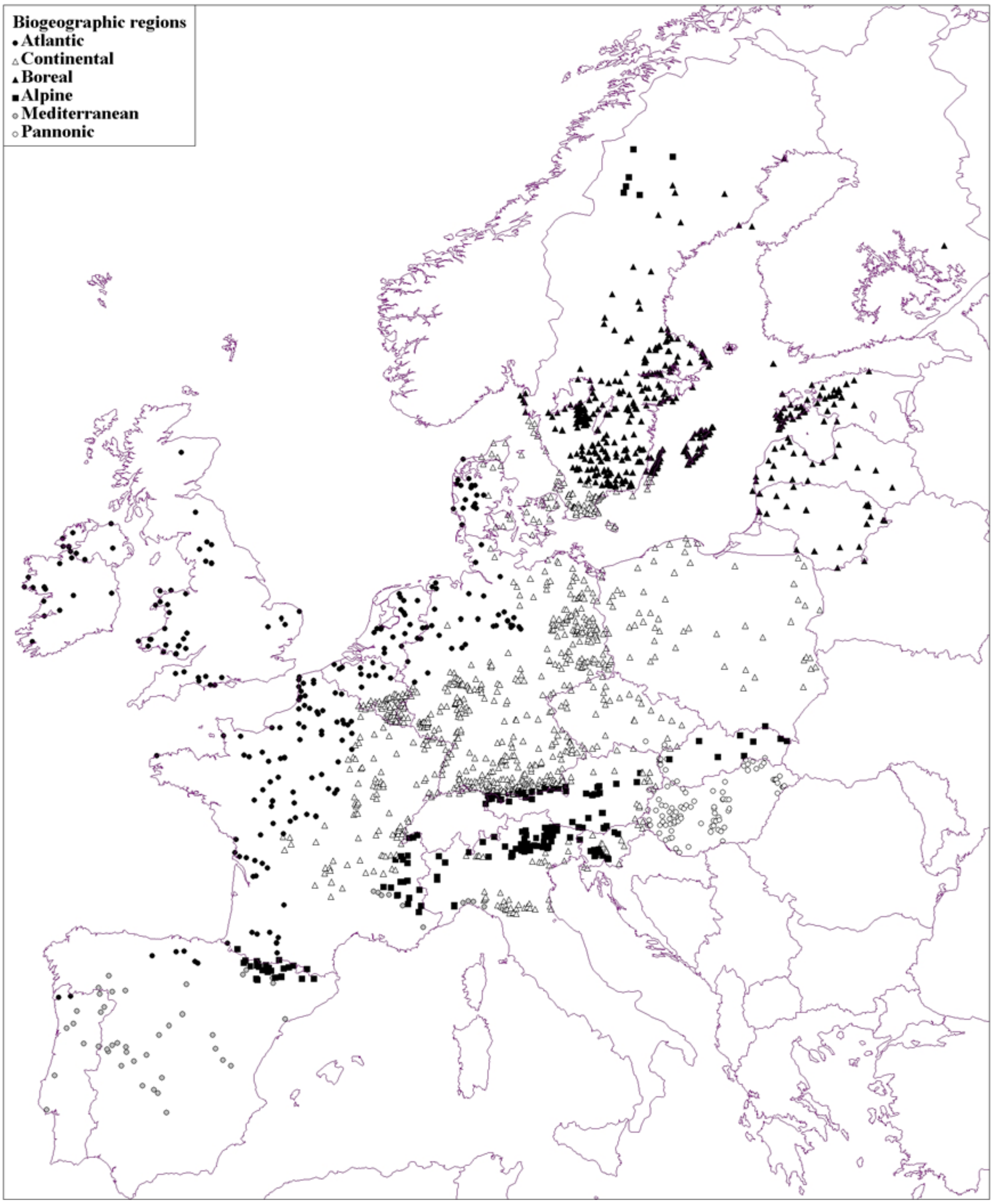

Figure 35 Annex I 6410 *Molinia* meadows

NATURA 2000 data notified to the European Commission by EU Member States and supplied by the European Topic Centre on Biological Diversity, Paris.

In Flanders (http://www.gisvlaanderen 2006) and the Netherlands (Jansen & Schaminée 2003), where more continental meadows do not survive, attention has focused on the Cirsio-Molinietum. In Belgium, however, and in Germany where some sites have also been designated for this kind of *Molinia* meadow (Ssymank *et al.* 1998), this association has been located in the Molinion, rather than the Junco-Molinion in the interpretation manuals. Within the Continental zone, it is necessarily the meadows of the Molinion which figure most obviously in the interpretation of the Natura 2000 habitat and many countries have used a generous but precise definition to ensure designation of sites which include the full range of meadows distinguished within their territory: Germany (Ssymank *et al.*1998), Poland (Herbicha 2004), the Czech Republic (Chytry *et al*. 2001), Slovenia (Kaligaric *et al*. 2005) and, outwith the EU, Romania (Donita *et al*. 2005). Other countries have defined the phytosociological affinities of the meadows less precisely – as in Austria (Ellmauer & Traxler 2000), Slovakia (Viceníková & Polák 2003), and Latvia (Kabucis *et al*. 2000) where at most the alliance Molinion is specified. Among non-EU countries Bulgaria (Dimitrov in Kavrukova *et al*. 2005) and Croatia (http://www.cro-nen.hr) have taken a similar approach in defining their vegetation in relation to the Habitats Directive.

6.7 Key threats to the habitat

In the *Common Standards Monitoring of Designated Sites: First Six Year Report* (Williams 2006), the Purple Moor Grass and Rush Pasture were included within Lowland Fens and Marshes but separate figures are given for the condition. Of SSSI/ASSI features, only 30% were found to be Favourable, with Scottish examples being in substantially better condition (62%) than those in either England (42%) or Northern Ireland (22%). Of SACs, Favourable examples were only 4% of the total. Unfavourable Recovering stands accounted for 32% of the SSSI/ASSI total and 56% of SACs. In the random sample of English non-statutory sites, mostly M23 *Juncus-Galium* rush pasture and M25 *Molinia-Potentilla* mire, 35% of stands were found to be Favourable. Losses in relatively recent times have been enormous: in Devon and Cornwall, for example, only 8% of the 1900 area now remains with 62% of sites and 48% of the extent being lost between 1984 and 1991.

This habitat is dependent on low-input management in an unimproved landscape with soils that are kept moist by a ground water table or high precipitation, so any shifts in this combination of factors pose a threat to sustainability. The various vegetation types are highly susceptible to any kind of **intensive agricultural improvement** such as the application of fertilisers and drainage, treatments which have been very widespread within the landscapes where this habitat occurs, together with subsequent cultivation and re-seeding to produce improved pastures or silage-leys of some kind. Reversion to something resembling the various vegetation types can occur where such treatments have been skimpy or sporadic but much of the habitat has been irreversibly lost. This has been part of a bigger shift in landscape character in places where the habitat was formerly extensive.

The various community accounts in Rodwell (1991) summarised knowledge at that time about the different environmental factors involved in sustaining each vegetation type and the work of Blackstock *et al*. (1998) has shown just how subtle and continuous are the relationships between these. When landscapes were more spacious and the habitat more extensive, it mattered less getting the management exactly right in any particular place for the survival of this or that one of the range of communities the habitat includes. Indeed, variation in the interactions between treatments and the varied ground conditions were probably all part of the spatial and temporal dynamic of the habitat within such landscapes. It is one of the threatening results of **fragmentation** that a precision of management now has to matter much more if the full range of diversity within the overall habitat is to be preserved, particular isolated stands having an character and value that is recognised as more distinctive and vulnerable. The demise of the marsh fritillary butterfly (*Eurodryas aurinia*), which survives by virtue of metapopulations, is a good illustration of the threats to dependent biota when an extensive dispersed patchwork of Purple Moor Grass and Rush Pasture disintegrates.

With the decline of traditional farming, and particularly now with the scarcity of cattle to graze this vegetation, **neglect and abandonment** has become widespread, affecting particularly those fragments left at the margins of viable agricultural improvement. The usual consequence of such treatment is for the vegetation to become more densely rushy or choked with tussocky *Molinia*, with a consequent decline of the less competitive associated flora. Such vegetation, termed basal by phytosociologists because of the difficulty in discerning its precise affinities (or known by the endearing term Rompgemeenschap by the Dutch) was already widespread at the time of the NVC (Rodwell 1992) and has since become more extensive (Rodwell *et al*. 1998) and is difficult to return to its original richer and more varied state. This is partly because of the accumulation of litter and nutrients, particularly among the *Molinia*-rich element of the vegetation. Tussockiness can effectively prevent further succession to scrub but where this is possible, invasion by willows and birch can be rapid. Figure 18 in Rodwell (1991) illustrates the impact of neglect and succession to scrub and woodland on a lowland vegetation sequence that involves the Purple Moor Grass and Rush Pasture.

Recovery of the habitat from more advanced successions is usually well-nigh impossible but more feasible attempts to retrieve the loss in earlier stages can also result in the **application of inappropriate management** such as over-intensive grazing, particularly by sheep which were probably not the usual (or only) stock in times past, or too-frequent burning. The latter is a tempting option when much *Molinia* litter has accumulated but it creates nutrient-rich ash and can effectively regenerate the grass by stimulating a new flush of unhindered growth in the spring,

Molinia is a grass that thrives on freshly-aerated and more fertile soils and has often been regarded by foresters as indicative of the best ground for planting. Certainly, in the past, **afforestation**, and usually for coniferous crops, has been a major threat to this habitat, particularly in the upland fringes.

In the lowlands, much land carrying this habitat in the more populous areas has been lost to **housing and road building**.

Maintenance of a high water-table or periodic flushing of soils that are usually neutral to acidic is essential, so in the lowlands **water abstraction** has sometimes contributed to deterioration of the habitat and, with reduced rainfall predicted by some models of **climate change,** this effect is likely to be accentuated in such catchments. Even where supplies remain sufficient, **eutrophication** of ground waters or through atmospheric nitrogen deposition is a threat.

6.8 Conservation initiatives

The total SSSI/ASSI coverage for Purple Moor-grass and Rush Pasture was estimated by the UK Biodiversity Group (1995) as about 3,800 ha with two NNRs but the present extent in designated sites is estimated as 17,000ha, that is about 80% of the total resource. Extensive tracts of the habitat have been designated in Devon and Cornwall with 27 sites covering 1,100 ha, in Wales with 93 sites totalling 1,172 ha with a further 630 ha occurring on SSSIs notified for other habitats, in Scotland with 5 SSSIs covering 317 ha and in Northern Ireland with 1 ASSI of 375 ha notified mainly for this habitat. Countryside Stewardship and Wildlife Enhancement Schemes have been widely applied to Purple Moor-grass and Rush-pasture, and the habitat occurs extensively within Dartmoor, the Stewartry and the West Fermanagh and Erne Lakeland ESAs and is on many farms within the Welsh Tir Gofal scheme. Hewins *et al*. (2005) showed that more than twice as many non-statutory English sites with Purple Moor-grass and Rush pasture within agri-environment schemes were in Favourable condition compared with those outside, and that this difference was statistically significant.

The need for a landscape-scale approach to sustaining this habitat, including non-designated and unmanaged land, as well as SSSIs and holdings in agri-environment schemes, is shown by the CCW's proposal for a **South Wales Coalfield** project. This area includes about 25% of the Purple Moorgrass & Rush Pasture in Wales and over half of the M24 *Molinia-Cirsium* fen-meadow and provides strongholds for *Carum verticillatum* and the marsh fritillary butterfly *Eurodryas aurinia*. The aim would be to improve the quality of existing sites, many of which have become rank and overgrown through neglect, others of which are over-grazed, to enlarge patch size and establish connectivity, and sustain mosaics with associated habitats.

As part of the above project at **Mynydd Mawr** in Carmarthenshire (http://www.carmarthenshire.gov.uk) and on the **Culm Grasslands** in north Devon and north-east Cornwall (www.butterfly-conervation.org/ne.news/culm-grasslands.html), partnerships have been established with Butterfly Conservation focusing on the importance of Purple Moor Grass and Rush Pastures for other biota like the Marsh Fritillary and Narrow-bordered Bee Hawk-moth. These initiatives work with landowners by offering free support and advice on relevant farming and wildlife grants and fostering cooperative working among landowners aimed at encouraging extensive summer grazing by cattle.

6.9 Research needs

There is a need to collate existing data from the Republic of Ireland and across Europe together with information from the UK so as to appreciate the full extent and quality of the Natura 2000 6410 *Molinia* meadows and the other equivalents of our Purple Moor-grass and Rush Pasture.

Research on the effects of habitat destruction on genetic diversity, sexual reproduction and clonal spread in *Cirsium dissectum* at Plymouth University highlights a wider need to understand how species such as this, regarded as key indicators of quality, survive and whether they can be successfully re-established in increasingly fragmented habitats.

Understanding community assembly rules and the relationship between edaphic conditions and the establishment of this kind of vegetation need further research, building on work on M24 *Molinia-Cirsium* fen-meadow at the North Wyke Research Station of the Institute of Grassland and Environmental Research (Tallowin & Smith 2001, Tallowin *et al*. 1998, 2002) and on M25 *Molinia-Potentilla* vegetation at Rhos Llawr Cwrt in west Wales (Adams *et al.* 1999). In particular, more testing is required of methods of nutrient depletion where restoration is targeted on previously productive land (Walker *et al*. 2004).

It is unlikely that BAP targets for this habitat will be met by the rehabilitation of neglected sites so research is needed on the larger task of how to target the agri-environment funding that will be the main mechanism for delivery, notably the Higher Level Scheme Options HK7 and HK8. This could entail an investigation of the vegetation, environmental features and management of existing sites and those being restored and monitored already, together with predictive modelling using soil, climate and species-distribution data. An expert system could be directed towards HLS advisors.

7 Metallophyte vegetation

7.1 Summary of the habitat type

This vegetation is at present under consideration for designation as a Priority BAP habitat. It comprises sparse swards characteristic of bedrocks and rubble rich in various heavy metals, occurring on mineral veins and mine spoil, on compacted river gravels and serpentine exposures. The vegetation is often poor in vascular plants but comprises a distinctive suite of metal-tolerant taxa and provides a locus for a range of scarce and rare species, including cryptogams, which can be numerous in more exposed situations. Similar Thlaspion calaminariae vegetation occurs in comparable habitats in Ireland, The Netherlands, Belgium and Germany and related forms in more continental and mountainous parts of Poland, Austria and France. Most of these countries have designated sites for Natura 2000 under 6130 Calaminarian grasslands and, as here, they are sometimes threatened by renewed mining activity or a lack of natural dynamism and renewal in the raw substrate.

7.2 Synonymy

NVC OV37 *Festuca-Minuartia* community.

Annex I 6130 Calaminarian grasslands of the Violetalia calaminariae.

EVS 16K01 Armerion halleri, 16K02 Thlaspion calaminariae.

EUNIS E1.B Metallophyte grassland.

7.3 Character and distribution of the NVC constituent

Rodwell (2000) recognised just a single vegetation type under this head, the OV37 *Festuca ovina-Minuartia verna* community, first characterized by Shimwell (1968) from rock outcrops and spoil heaps rich in heavy metals on the Carboniferous Limestone exposures of the Mendips, Derbyshire Dales, Yorkshire Dales and North Pennines. Jackson & McLeod (2002) suggested that there were probably several thousand such localities. The NVC account also recognised that similar vegetation had been reported from stable river gravels and redeposited mineral washings in Northumbria (Sellars & Baker 1988), among which the Tyne & Allen and Tyne & Nent gravels are the most extensive and particularly noted for their lichens. Sites along the South Tyne and its tributaries are being investigated in detail by Simkin (1999, 2003*a*).

In Scotland, Birse (1980, 1982, 1984) had already characterised several related associations from serpentine exposures which do not really surface in the NVC at all: the Sileno-Armerietum maritimae metallicolae (Br.-Bl. & Tx 1952) Ernst 1974 emend., the *Cerastium nigrescens- Armeria maritima* Association, an assemblage first noted by Spence (1957) and the *Lychnis alpina-Armeria maritima* Association. Since then, especially striking examples of such serpentine vegetation have been described from Caenlochan, at the Coyles of Muick, the Keen of Hamar, the Green Hill of Strathdon and the Hill of Towanreef (Averis 1991, Lusby & Wright 1996, Jackson & McLeod 2002, Averis *et al*. 2004). The map of sites (Figure 36) includes stands of all these assemblages, in both lowland and upland localities.

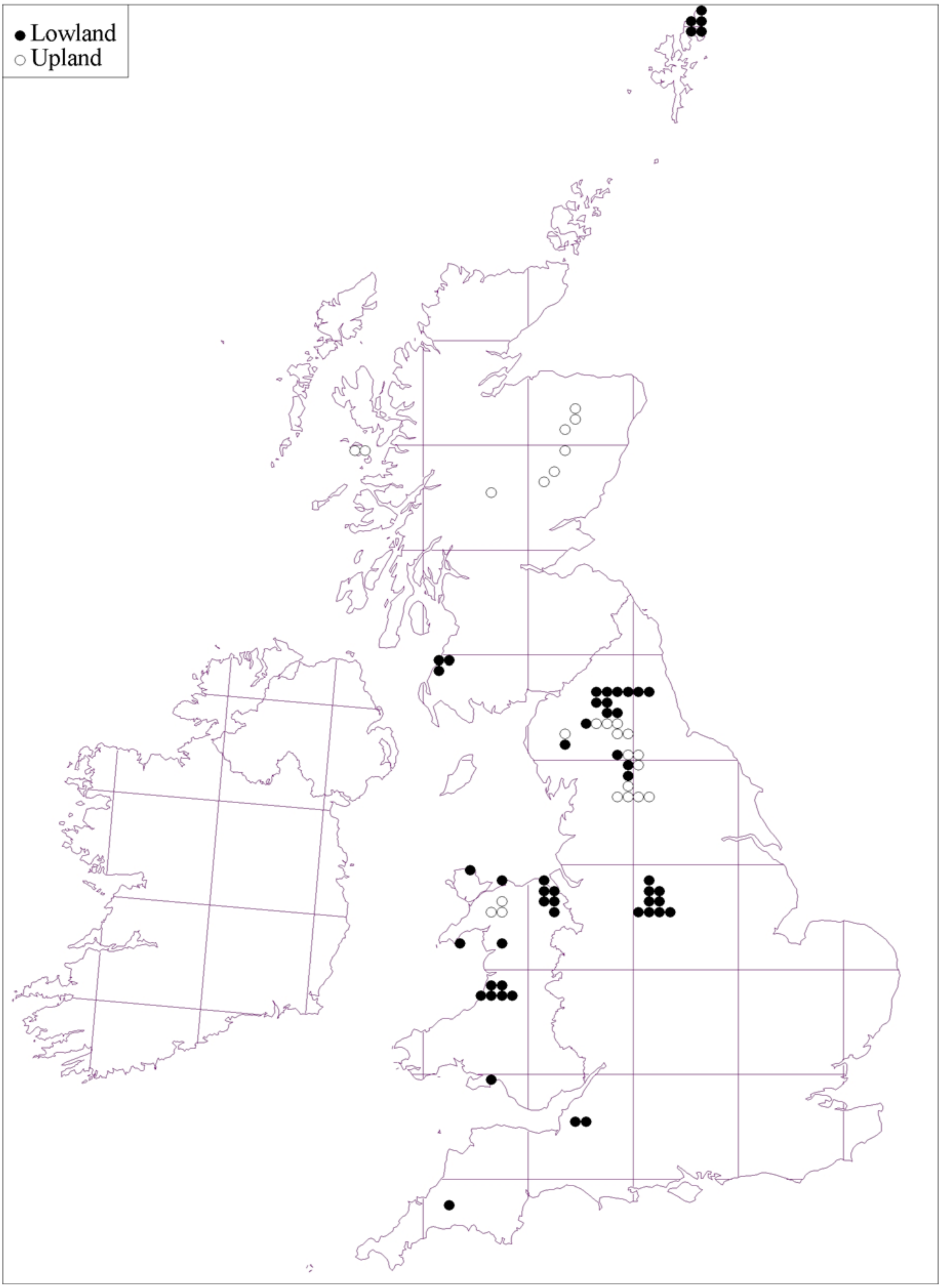

Figure 36 Heavy Metal Grassland (including upland occurrences)

Vegetation characterised just by distinctive cryptogams of metallophyte sites has been described from Elenydd in Wales and in Cornwall, too, there is a metallophyte element among the bryophytes (Holyoak 2000) and lichens (Giavarini 2002) on abandoned mine sites, particularly those with copper-contaminated substrates (Spalding 2005). Further work is needed to understand the relationships between these various vegetation types.

7.4 The habitat and its constituents in Northern Ireland

This habitat has not been described from Northern Ireland.

7.5 Character and significance of the UK habitat in the wider European context

Shimwell (1968) recognised the essential similarity of the British vegetation he described to the Minuartio-Thlaspietum Koch 1932, the core association that has been recognised from western European metallophyte habitats, described from Ireland (Doyle 1982, White & Doyle 1982) and western Germany (Pott 1995). In Belgium (leBrun *et al.* 1949), The Netherlands (Westhoff & den Held 1969) and Germany (Pott 1995), a very similar Violetum calaminariae Schwickerath 1931, has also been characterised, with *Viola calaminaria* or *V. lutea* ssp. *calaminaria* (Janssen & Schaminée 2003), not a taxon that has been recognised here, although *V. lutea* is a common plant with us and its occurrence on hevy metal spoil is well recognised (Stace 1997). The Sileno-Armerietum which Birse (1980) reported from Scotland had been first described from copper workings in Killarney by Braun-Blanquet & Tüxen (1952), and later more widely in Ireland (Doyle 1982, see also White & Doyle 1982). From the French Pyrenees and Cevennes, two further related associations have been described, the Thlaspio calaminaris-Armerietum elongatae Ernst (1966) 1974 and the Armerietim muelleri Ernst 1976.

Such vegetation types have generally been placed in the **Thlaspion calaminariae** - previously and sometimes, as in France (Julve 1993), still known as the Violion calaminariae - the more Atlantic alliance of the Violetalia calaminariae. This is the order which includes all natural and anthropogenic swards in Europe. In more continental parts of northern Europe, the Thlaspion is replaced by the **Armerion halleri** where ecotypes of *Armeria maritima* are the distinguishing feature and where *Thlaspi caerulescens (*previously *alpestre*) is less obvious, although this plant actually extends in other vegetation types right into Poland. The core association in this second alliance, the Armerietum halleri Libbert 1930, has been reported from France (Julve 1993), Germany (Pott 1995, Schubert *et al*. 1995) and Poland (Matuszkiewicz 1984), with more local assemblages such as the Armerietum bottendorfiensis Schubert 1953 and Armerietum hornburgiensis Schubert 1974 characterised by endemic forms of *Armeria maritima.* Pott (1995) also described a grassier Holco-Cardaminopsietum Hülbusch 1980 in the Armerion halleri from Germany.

In his monograph on these kinds of vegetation, Ernst (1974) distinguished a third alliance, the **Galio anisophylli-Minuartion vernae** of alpine metallophyte habitats where such montane plants as *Galium anisophyllum, Poa alpina* and *Dianthus sylvestris* occur along with *Minuartia verna* and *Silene cucubalis* var. *humilis,* in associations like the Violetum dubyanae Ernst 1965 and the Thlaspietum cepeaifolii Ernst 1965 from the Bavarian alps. The latter assemblage has also been described from Austria (Grabherr & Mucina 1993) but placed within the Thlaspion rotundifoli.

Originally, the general floristic and structural similarity of metallophyte vegetation to other open swards of drought-prone habitats led to their being grouped within the Brometalia of the Festuco-Brometea (as in leBrun *et al*. 1949, for example). It was Braun-Blanquet & Tüxen (1943) who elevated these vegetation types into their own class, the Violetea calaminariae, though Ernst (1974) has pointed out that *Minuartia verna* and *Silene vulgaris* are actually better character species than *Viola calaminaria*. Some more recent treatments have returned to the earlier notion of the higher affinities of such vegetation, locating the Violetalia as an order, or associations that would once have been assigned to it, within the class of scree and rubble vegetation, the Thlaspietea rotundifolii (as in Grabherr & Mucina 1993 and Rodwell *et al.* 2002). Others totally dissolve the traditional order and alliance affinities of the vegetation, as in Schaminée *et al*. (1995), where Metallophyte swards are treated as a sub-association of the Festuco-Thymetum serpylli Tx 1937, a community within the Plantagini-Festucion of the Koelerio-Corynephoretea. The equivalent treatment for us would be to stress the closeness of the OV37 *Festuca-Minuartia* community to the CG7 *Festuca-Hieracium-Thymus* grassland, a not altogether strange notion.

7.6 Coverage in Natura 2000

The Natura 2000 habitat 6130 Calaminarian grasslands of the Violetalia calaminariae is defined as comprising generally open natural or semi-natural swards on rock outcrops, river gravels or shingles and spoil heaps rich in heavy metals like zinc and lead. They are described as having a specialised flora with tolerant subspecies or ecotypes of such plants as *Thlaspi caerulescens, Armeria maritima, Minuartia verna, Silene vulgaris, Festuca ophioliticola* and *Cochlearia alpina.* Threatened endemic vascular plants are said to be generally absent from what are called pioneer stages which are not considered a priority in the Habitats Directive; and semi-natural sites are to be taken into account mainly where natural sites are very rare or absent from a region or where these provide a locus for characteristic or distinctive plants. The habitat has been designated in only a few countries (with the proportions of total number of SAC sites in brackets): Austria (5%), Belgium (8%), Germany (45%), Spain (3%), France (4%), Ireland (1%), Italy (8%), The Netherlands (1%), Slovenia (1%) and the UK (29%). The locations of the SACs are shown in Figure 37.

In general, the interpretation of the Natura 2000 habitat has been uncontentious, each country where it occurs including examples of all the Metallophyte communities that have been described from their territories, irrespective of their present syntaxonomic position - that is, whether or not they are actually now classified as within the Violetalia calaminariae, the order that is used to name the Annex I habitat (Ssymank *et al*. 1998, Bensettiti *et al*. 2005). Sometimes, as with the UK (Jackson & McLeod 2002) and Austria (Ellmauer & Traxler 2000), a more generous interpretation has included assemblages from serpentine rocks whose floristic relationships are either obviously broader or as yet rather uncertain and vegetation in which cryptogams dominate. Only with Poland, from where Armerion halleri vegetation has certainly been reliably described (Matuszkiewicz 1984), have there been no nominated sites, its representation in the country being considered insufficiently important.

Figure 37 Annex I 6130 Calaminarian grasslands

NATURA 2000 data notified to the European Commission by EU Member States and supplied by the European Topic Centre on Biological Diversity, Paris.

7.7 Key threats to the habitat

Concentrations of heavy metals like zinc, lead and copper are damaging to most plants but for some species which have developed tolerant varieties or ecotypes, habitats where such situations occur are effectively protected against invasion by more competitive plants (Ernst 1974, Kinzel 1982). Natural rock outcrops of this type are geologically scarce within the European lowlands or have been obliterated, but mining of such ores has been occurring since the Bronze Age, leaving a widespread heritage of anthropogenic sites, the earlier ones small and scattered but often richer in the metals because of the inefficiency of extraction in those times (Ellenberg 1988). In addition to the peculiar chemical environment, such habitats are usually very sharply-draining, and therefore drought-prone in drier climates, and poor in nutrients. Any change which ameliorates these harsh conditions therefore poses a threat to the distinctive vegetation able to capitalise on them.

Less rocky sites are vulnerable to **reclamation for agriculture,** or can be easily affected by operations around, or to the kind of **tidying up** that is often thought necessary for access and amenity, even (maybe especially) on sites which have a high cultural value because of their mining heritage.

Locally, there has been a **reworking of abandoned mineral veins** which can destroy existing colonised spoil though such activity also offers the prospect of creating new areas of this habitat. This can be especially important where, in less exposed conditions, **succession** is a threat to those less competitive vascular plants that are readily overwhelmed by the closure of the sward, the accumulation of a more fertile soil mantle with the prospect of grazing by stock.

Undervaluing the earlier stages in colonisation of debris, forms of this vegetation which are not so highly rated in the Habitats Directive, is therefore itself a threat particularly because of their importance for those cryptogams tolerant of heavy metals (Simkin 2003*b*). Among the distinctive lichens recorded at British sites, for example, are *Vezdaea cobria, V. acicularis, Lecanora handelii, Gyalidea subscutellaris, Thelocarpon impressellum* and, on river shingles, *Peltigera venosa, P. neckeri* and *Sarcosagium campestre* var. *macrosporum.* Among the bryophytes, the near endemic *Ditrichum plumbicola*, *D cornubicum, D. lineare, Grimmia ungeri, Pohlia andalusica, Scopelophila cataractae* (maybe an introduction on imported ore), *Marsupella funckii, Gymnomitrion obtusum, Lophozia sudetica, Cephaloziella integerrima, C. stellulifera* are noteworthy.

In old workings and in natural situations, the scattered nature of the resource means that populations of scarce and rare vascular plants dependent on them are vulnerable to further **fragmentation**. Apart from *Thlaspi caerulescens,* which is nationally scarce with us (Baker in Stewart *et al*. 1994), though now evaluated in the 'Least Concern' category of threat (Cheffings & Farrell 2005), vascular species for which these kinds of habitat offer a congenial locus in the UK include *Lychnis alpina, Cerastium fontanum* ssp. *scoticum, Cochlearia pyrenaica, Arabis petraea, Arenaria norvegica* ssp. *norvegica,* a serpentine form of *Asplenium adiantum-nigrum* and *Epipactis youngiana.* Designation and management on a landscape scale offers a more secure prospect of sustaining separate sites for this habitat and the conditions and processes on which they depend.

With **climate change**, it is also possible that some stands may experience more frequent, extreme or prolonged drought events which could threaten the distinctively Atlantic character of British examples of these swards. Where this causes the periodic demise of perennial vascular plants, it may help keep the swards open. Likewise, on river gravels, more unpredictable flood episodes could increase the prospect of habitat renewal.

7.8 Conservation initiatives

The SSSI and SAC series aim to provide a selection of both natural and anthropogenic sites, the approach to the latter being rather selective within Natura 2000. Simkin (2003*a*) has argued strongly for a landscape-scale approach to the conservation of the river-gravel examples of this habitat and one which attempts to integrate both the biodiversity and cultural value of the lead-mining heritage.

7.9 Research needs

To understand more fully the research needs for this habitat, it is important to re-examine data for both Metallophyte Vegetation in its stricter sense, similar assemblages from serpentine exposures and those comprising mostly cryptogams so as to gain an integrated overview of the variation represented there, the distribution among the various assemblages of particularly threatened or rare vascular plants and the importance of the bryophytes and lichens. Appreciating the real distinctiveness of the British (and Irish) examples also means setting such data within the wider context of information from other parts of Europe.

Simkin & Smith (2003, 2004, 2006) have undertaken an interesting series of management experiments at three sites on mid-reach river gravels on the South Tyne tributaries aimed at setting back the succession that is overwhelming the more open swards rich in cryptogams and metallophytes by attempting to regenerate the open, contaminated substrate using scrub-clearance, moss-killing, raking and soil-stripping. It is this kind of research which will help understand the balance between establishment and disturbance essential to sustain a habitat that originated through dynamic landscape processes, and the possible role which rabbit grazing can play in keeping swards more open.

8 Conclusions

8.1 The BAP Priority Habitat definitions of Lowland Grasslands and their constituent NVC plant communities

There is no standard format to the descriptions of the UK BAP Lowland Grassland habitats and they vary in the precision and clarity of their definition and the account of their basic floristics and ecology (www.ukbap.org.uk). Sometimes, as with the Purple Moor-grass and Rush-Pastures, subsequent clarification has been provided as to the character of the vegetation types covered (UK Lowland Grassland HAP Steering Group 1998) but some inconsistencies remain as to what should be included or not. With Lowland Dry Acid Grassland, for example, a part of SD12 *Carex-Festuca-Agrostis* grassland that is covered by the relevant Annex I habitat and which ought to be included for ecological reasons, is not covered.

Also, though the published version of the NVC (Rodwell 1991, 1992) has now been used explicitly to define the plant communities covered by all of the BAP lowland grassland habitats, there is no reference to the subsequent overview of coverage of the NVC (Rodwell *et al*. 2000) whose findings shift our understanding of a number of the habitats and highlight the need for additional survey and review of what should be included within the BAPs. With Lowland Dry Acid Grassland, inland Thero-Airion communities that are rich in threatened ephemeral calcifuges, need to be sampled and classified and, among Lowland Meadows, rushy MG5 *Centaurea-Cynosurus* grassland, herb-rich MG7c *Lolium-Alopecurus-Festuca* grassland and the sedge-rich relatives of MG8 *Cynosurus-Caltha* flood-pasture all need a thorough examination.

Beyond these possible additions, subsequent work has raised further questions. For example, Simkin (2006) shows that the definition of the OV37 *Festuca-Minuartia* community needs some revision, in particular to take account of the importance there of cryptogams, and we consider that this should be undertaken together with a review of all vegetation types from Serpentine exposures which hardly figured in the NVC. Whatever the precise character of the assemblages included within this habitat, there is clearly a case for considering whether Metallophyte Vegetation deserves provision with the UK BAP. The BAP UK Standing Committee is expected to effect this in 2007.

8.2 The wider phytosociological perspective on Lowland Grasslands

This project, like its forbear for English Nature on woodlands (Rodwell & Dring 2003), attempts to set important groups of vegetation types in a particular European country within a wider framework of understanding. The BAP categories under which the Lowland Grasslands are considered here are peculiarly British and broader than many of the habitats or biotopes defined in other countries, but a phytosociological approach to the plant communities which they comprise enables an overview of their analogues across the Continent to be developed.

However, the phytosociological literature is enormous, mostly written in languages other than English and difficult to access in this country. The Affinities sections of the community descriptions in the published version of the NVC (Rodwell 1991, 1992) outline the relationships as they were understood then and these were updated and summarised at the level of alliances in the phytosociological conspectus to the NVC provided by Rodwell (2000). This overview was further revised in Rodwell *et al*. (2000) for existing NVC plant communities and for those provisional assemblages proposed in that review. Since then, the European Vegetation Survey team has published the first European overview of alliances (Rodwell *et al*. 2002), a robust classification that has cross references to EUNIS, but one which is necessarily subject to further change as new data and analyses become available and understanding deepens. The EVS is expected shortly to make available on its section of the website of the International Association for Vegetation Science (www.iavs.org), a complete synonymy of alliances that should help make sense of the many different perspectives on how the vegetation of Europe should be classified, an often contentious subject with much factional energy.

The challenge of classifying Lowland Grasslands within the alliances at the level of associations is daunting, given the huge amount of information available, its dispersal in many sources, and the complexities of negotiating a complex synonymy. Again, the EVS has pledged to publish the huge bibliography produced by the Unit of Vegetation Science at Lancaster University that lies behind the Overview of Alliances, though extensive libraries containing these sources are few and far between. Those at the Orto Botanico in Rome and the research institutes at Bailleul in France and Rinteln in Germany are among the most extensive. Where such literature sources provide frequency tables, the kind of overviews developed by Dierschke (1981, 1995) can be attempted making more precise comparisons between associations, but here, because of the bigger scale of our task, we have used an essentially bibliographic approach.

The difficulties and benefits of classifying Lowland Grasslands bottom-up, working from actual relevés, are well seen in the study of the Cynosurion by Zuidhoff *et al.* (1997). To extend such an exercise across all the relevant European alliances, with the tasks of locating, coding and analysing what would be many tens of thousands of data items is not impossible, given the degree of cooperation nowadays among the phytosociologists of the European Vegetation Survey. However, it is difficult to think who would sponsor such an exercise and it is probably most likely to be undertaken piecemeal within an academic context by, say, postgraduate researchers working on particular alliances in PhD programmes. Collaboration between the supervisors involved could then ensure some evenness of coverage and avoid duplication in the accumulating overview.

8.3 The coverage of Lowland Grasslands in Natura 2000

Although not part of the brief, this project can provide the basis of a detailed Interpretation Manual for Lowland Grassland that is much needed to ensure comprehensive coverage within Natura 2000. As a result, we can see that, one way or another, what the UK BAP terms Lowland Grasslands are quite well covered by the Habitats Directive, though Members States can differ in just which Annex I categories they would include in such broad habitats. Sometimes this is because of climatic variations across Europe, such that vegetation types which are with us mostly beyond the limit of enclosure occur more widely within the lowlands elsewhere. With Lowland Dry Acid Grasslands, for example, the UK decision to include only the 2330 Inland dunes with *Corynephorus* as equivalent to this category would puzzle some other States where it is the 6230 species-rich *Nardus* grasslands of the Violion that are a more important component of grasslands on lowland sands. Here, this habitat is interpreted as an upland type and equivalent to mildly calcicolous swards of the CG10

Festuca-Agrostis-Thymus and CG11 *Festuca-Agrostis-Alchemilla* types. Again, with the equivalents of our Purple Moor-grass and Rush-pastures, the increasingly Continental climate towards the eastern lowlands of northern Europe means that it is true Molinion vegetation that figures more prominently there.

In other cases, some ambiguity in the definition of an Annex I habitat in the Interpretation Manual (CEC 2003) has allowed Member States considerable freedom in designating SACs for Lowland Grasslands which, as one habitat or another, they wish to see protected within the Natura 2000 network. With Lowland Meadows, for example, a more generous interpretation of 6510 grasslands with *Alopecurus* and *Sanguisorba* only partly reflects the wider occurrence of these species in grasslands other than equivalents of our own MG4 *Alopecurus-Sanguisorba* grassland. The narrower UK approach has made it impossible designate SACs for MG5 *Centaurea-Cynosurus* grassland, a mainstream unimproved Cynosurion sward which would readily qualify for inclusion under a more liberal interpretation of the definition. Fortunately, this type is well represented within BAP.

Second, there is the continuing neglect in the UK, even within BAP, of our richer MG1 *Arrhenatherum* grasslands, swards that can be quite diverse, that are the locus of a number of threatened plants and which provide a structure, with rank grasses, taller herbs and sprawlers that is appealing to invertebrates and small passerines. Moreover, these are vegetation types which can thrive in relatively commonplace situations such as suburban wasteland and road verges and which are relatively easy to manage by cutting without grazing. This is perhaps the clearest missed conservation opportunity highlighted by this research.

Then, conversely, the UK interest in Lowland Grasslands sometimes highlights deficiencies in coverage of a habitat within Annex I. Though Metallophyte Grasslands are not yet covered by a BAP Priority Habitat, the attention they have attracted shows up the failure of the Habitats Directive to give sufficient status to early stages in colonisation of heavy metals deposits in which cryptogams, including rare species, are well represented.

8.4 Key threats to Lowland Grasslands

Williams (2006) provides an indication of the major reasons for the unfavourable condition of broad habitat types (not quite corresponding with the BAP categories) in the SSSI and SAC networks and Hewins *et al*. 2005 a less formal review of threats to a random sample of sites with the BAP habitats outwith the network of designation. From these sources, research during the preparation of this report and the responses of expert readers of the draft text, it is clear that some generic threats to these vegetation types can be recognised and that certain threats are actually part of current attitudes and approaches to conservation management. As part of the questionnaire exercise with EVS members, we also asked how threatened different alliances were in different countries across Europe and which threats were most important there and we make occasional references to these results below.

It is clear that the **eutrophication** effects of agricultural improvement, which over the past century and more have been one of the major factors in the disappearance and degradation of most types of Lowland Grassland in the UK, continue to make an impact on surviving stands of these vegetation types where the measure of protection through some sort of designation frame or beneficial influence on management is low. This is of particular importance still with the Lowland and Upland Meadows in the wider countryside of the UK, especially where they occur on more fertile and better-drained soils where the benefits of upgrade are more immediate and economic. Even where such impacts of intensive farming have greatly lessened, as on Lowland Calcareous Grasslands for example, the undiscriminating impacts of atmospheric nitrogen deposition are likely to take a considerable toll and may already be widely implicated in the eutrophication of other Lowland Grasslands. With those swards which are somehow dependent on a ground water table, as with the alluvial MG4 *Alopecurus-Sanguisorba* Lowland Meadows or most of the Purple Moor-grass and Rush-pastures, the nutrient enrichment of inundating or flushing waters is likely to increase this burden of threat considerably.

However, much more pervasive now, and widely threatening to designated sites for Lowland Grasslands as well as in the countryside at large, are the impacts of **reductions in grazing** as low-intensity pastoral farming with its need for traditional stock management and its poorer returns has become uneconomic and unappealing. Such effects are being especially severely felt in Lowland Calcareous Grasslands and Lowland Dry Acid Grasslands which have been important resources in stock rearing, particularly towards the south-east, but also in the Purple Moor-grass and Rush-pasture that is so extensive in the west and which has often been simply abandoned for either grazing or cropping for hay and litter. With the long-time importance of rabbits in the maintenance of some of these systems, particularly the Lowland Calcareous and Lowland Dry Acid Grasslands, both for cropping of the herbage and reducing fertility away from their latrines, reductions in their populations through periodic infestation with myxomatosis or haemorrhagic disease, or the unpredictability of their numbers, have sometimes added severely to these problems. Lack of grazing also clearly has deleterious effects on Metallophyte Vegetation.

Both these threats are part of a **widespread disintegration of the cultural and social fabric of kinds of farming that produced habitats with high wildlife value** and which are very difficult to replicate within the legislative frameworks of designation and the rules and regulations of the various agri-environment subvention schemes. Many Lowland Grasslands were an integral part of complex and locally distinctive systems of farming so, even approximating to one element of these kinds of treatment, can leave the habitats wanting for some complementary impact. With those Lowland and Upland Meadows cut for hay, for example, a balanced yearly round of spring and autumn grazing with mowing timed in relation to weather, has been crucial for producing the biodiversity and aesthetic appeal we value now. With Lowland Calcareous and Lowland Dry Acid Grasslands, the forage value of the habitat has formed part of farming systems integrated with arable cultivation, or for the latter, with the management of heathlands, themselves a varied resource of grazing and fuel and periodically burned. Particular problems being experienced now like the unavailability of suitable breeds of stock and the shortage of manure, together with the disappearance of practices like the folding of animals, are all part of this complex change.

Unimaginative approaches to designating discrete sites for their wildlife value with long neglect of the quality of the intervening countryside has accentuated the fragmentation and isolation of stretches of habitat with any real character and adds further to the difficulties of managing many Lowland Grasslands in a coherent fashion and to the prospect of recruitment of flora and fauna in areas targeted for restoration. This kind of consideration is the spatial aspect of **a failure to conceive sustainability of these habitats on an appropriate scale**. These Lowland Grasslands have developed as part of wider landscapes, the habitats themselves at one time more extensive, but also dependent for their character on being integrated spatially with other kinds of vegetation whose own survival is often regarded as a quite separate target. The UK BAP sometimes draws attention to the need to consider projects directed to one habitat, like Lowland Dry Acid Grasslands, to another, like Lowland Heath, but such awareness ought to apply much more widely.

The integration of one habitat with another was often also often functional in character, so the second kind of scale-related threat has to do with insensitivity to time and processes. Agri-environment schemes, for example, are seen as offering a viable alternative to the management agreements which have been the mainstay for securing appropriate treatment for designated sites and also widely applicable outwith such networks but inflexible application of generalised fixed rules for the timing of operations means that there is often little sensitivity to those seasonal and longer term relationships between the vegetation, the climate and the needs of the farmer for a sustainable crop. Naïve trust in simply decoupling productivity and financial support for farming through new but rigid regulations will not be sufficient to ensure survival of Lowland Grasslands.

But this is just one part of a wider **anxiety about managing process** as much as pattern in the conservation of Lowland Grasslands. These habitats are dynamic, with patterns of change through each year and, even when climatic variation has been more stable than now, from year to year. For example, in the kind of landscape where Lowland Dry Acid Grassland occurs, a measure of repeated local disturbance is essential to maintaining the more open inland dune vegetation as well as the full range of associated vegetation types, like those rich in ephemerals.

Or again, while the kinds of successions that ensue with relaxation of grazing or abandonment are regarded as threatening to the richness of existing Lowland Grasslands, it may be that, in some situations, dynamic mosaics of such swards, together with ranker grasslands, bracken, sub-scrub and scrub, can bring their own benefits to sites, in terms of second order diversity and an appeal to biota that favour ecotones. Roomier approaches to landscape-scale patterns and processes might enable such phased retreat to be targeted in places where maintenance of grazing is unlikely.

Resistance to new forms of management of Lowland Grasslands is already evident in anxiety about taking a second cut on those Lowland Meadows on flood plains that are in unfavourable condition through eutrophication of ground waters. The benefits of mowing Lowland Calcareous Grasslands, long practiced elsewhere in Europe, are becoming clear and trialling such approaches may be essential where past forms of management are no longer sustainable.

Broader categories such as those like the BAP Priority Habitats can be beneficial if they bring a measure of confidence to sustaining a diversity of Lowland Grasslands, but **uncritical acceptance of existing definitions** of what is included in each would be unfortunate. For one thing, there are vegetation types that are poorly defined within the NVC, only belatedly recognised in the review of its coverage (Rodwell *et al*. 2000) or described since then, that need to be properly defined and considered for integration in the definition of the habitats and their Action Plans. In this respect, it is the Lowland Dry Acid Grasslands, the wetter swards among the Lowland Meadows and the Metallophyte Vegetation (including Serpentine assemblages) that we know already need most attention. Sometimes, too, it is the low value attached to well-known vegetation types that has ruled them out for inclusion. For example, there are those richer MG1 *Arrhenatherum* grasslands that are potentially much more interesting than so far thought, and quite readily manageable, and which could be a worthy part of the Lowland Meadows BAP habitat.

It might be thought that most of these threats will pale into insignificance with the prospect of **climate change** but the impacts of such shifts as reduced summer rainfall, milder winters and more unpredictable storm events and flooding on Lowland Grasslands may be to some extent predictable if there is a sound understanding of the ecology of the existing habitats and their various plant communities; and the effects of these climatic changes will be mediated through the heritage of past and present agricultural practice and wildlife management. Also, the more imaginative approach to existing challenges suggested above should help make response to these future and less manageable threats more positive.

8.5 Conservation initiatives for Lowland Grasslands

We have not undertaken any comprehensive review of conservation initiatives aimed at sustaining Lowland Grasslands in the UK but, though that scene is rapidly changing and widely accessible through the internet, there is indeed something to be said for providing a more comprehensive periodic summary or web-based gazetteer of projects for newcomers. In principle, the Biodiversity Action Reporting System (http://www.ukhap-reporting.org.uk) is supposed to fulfil this function, but it needs more comprehensive population with details of initiatives.

What is clear on even a cursory view is that the capture of the national habitat resources within designated sites, the condition of the habitats and the disposition of initiatives varies greatly between the different habitats, this last influenced by tradition and fashion. Lowland Calcareous Grasslands, for example, remain a favourite habitat and are benefiting greatly from new partnerships between vegetation interests and those concerned with other biota, particularly birds and butterflies, enthusiasts for the former being especially powerful. Lowland and Upland Meadows, too, often attract attention because of their species richness and aesthetic appeal but projects here have tended to be organised on a more fragmentary basis because of the scattered nature of the sites, unless a local authority or a national park provides some framework at a larger scale

Lowland Dry Acid Grasslands have generally fared much more badly than these habitats and continue to suffer some neglect in favour of the heaths that often accompany them. The poverty of vascular plants in the more closed swards has served them badly and more attention should be given in projects to the richer, open and disturbed vegetation types included in this habitat. The increasing and welcome tendency to consider the importance of cryptogams in various of the Lowland Grasslands should certainly reap some benefits in this particular case.

Champions for Purple Moor-grass and Rush-pasture have also been rarer, though regionally very effective in raising the profile of the vegetation types found in this habitat and their importance for, for example, butterflies. Metallophyte Vegetation, and the related plant communities of the Serpentine rocks of this country, have so far had but a few advocates and need the higher profile that BAP status can afford. A particular appeal here is the possibility of conservation initiatives highlighting the often close relationship between the biodiversity interest and the industrial origin of the habitat. This will therefore be a test case for partnerships between biodiversity and heritage interests, previously very scarce.

Finally, a striking feature of some Lowland Grassland projects is their attempt to foster relationships between habitats and the communities who live in the landscapes and to give a distinctive local flavour to their endeavours. But much more could be done in this respect, strengthening the links between biodiversity interests and organisations such as Common Ground.

8.6 Research needs for Lowland Grasslands

Although the NVC provides a good basis for defining the plant communities included within the Lowland Grasslands, it is clear that, for proper definition and protection of certain of these habitats, further survey and/or data analysis are needed to cover the full range of vegetation types or to complete our knowledge of their extent and distribution. In particular, with Lowland Dry Acid Grasslands, Thero-Airion assemblages of sandy tracks and rock outcrops need extensive sampling and further information is required on the location and character of U1 *Festuca-Agrostis-Rumex* grassland. Among the Lowland Meadows, the range of wetter grasslands now described from alluvial flood-plains should be integrated within the existing NVC framework, modifying the original definitions of MG4 *Alopecurus-Sanguisorba*, MG8 *Cynosurus-Caltha* and MG7c *Lolium-Festuca-Alopecurus* grasslands and characterising new communities where necessary. With Metallophyte Vegetation, further survey is needed of natural exposures and old mine sites to amend the OV37 *Festuca-Minuartia* community, together with analysis of vegetation from Serpentine rocks. More generally, it would be very satisfying to integrate an account of UK plant communities with those of both Northern Ireland and Eire, but this is especially pressing for Calcareous Grasslands, Lowland Meadows and Purple Moor-grass and Rush-pastures.

Despite some classic studies and continuing research interest in certain Lowland Grasslands, much still needs to be known about the basic ecology of their plant communities, and their relationships to particular soil and climatic conditions. Many of the vegetation types have developed and been sustained because they were an integral part of agricultural systems. Although the traditional management of some habitats, like Upland Hay Meadows and the wetter Lowland Meadows, has been well researched, not enough is known about the relationships between productivity and biodiversity in Lowland Grasslands and how favourable condition might continue to be maintained in a transformed agricultural situation. Continuing assessment of the effectiveness of agri-environment schemes is vital to see whether they can deliver their goals but new and creative approaches to management also need serious investigation and more than sporadic local experiment.

In particular, there is a continuing need for research into the effectiveness of different kinds of pastoral management – the intensity and periodicity of grazing, the impact of different kinds of stock in pastures and so on – and the way in which grazing can be integrated with mowing in meadows and rush-pasture. Projects such as GAP and PONT are of exemplary value in exchanging information but there is room for further development of networks and for making readier links between academic research and conservation practitioners. The meetings of the British Grassland Society and periodic British Ecological Society symposia provide the kind of varied forum within which such discussion can take place.

Understanding how such management can work on a landscape scale will be essential to sustain the range of different plant communities which make up the Lowland Grassland habitats and to ensure that these are dynamic systems and not static mosaics and ecotones. This is especially pressing for the swards and scrub of Lowland Calcareous Grassland, for the grasslands, heaths and open assemblages of Lowland Dry Acid Grasslands, for the sequences of inundation communities and grasslands in wetter Lowland Meadows and for the range of swards included within the Purple Moor-grass and Rush-pastures. With Lowland and Upland Meadows which often survive as small and fragmented sites, further research is needed on the consequences of genetic isolation and how these sites can be sustained within intervening landscapes that are largely improved.

Particularly for those Lowland Grasslands where more effective management of existing resources will be insufficient to meet BAP targets, a better understanding of options for restoration and of the technicalities of particular methods of restoration and aftercare is needed. Further research is especially required on species recruitment and assembly rules in vegetation under restoration, on coping with nutrient depletion in intensively farmed soils, on arable reversion and on mechanisms for disturbing those habitats which require repeated intervention to maintain dynamic processes. With more ambitious programmes such as are necessary for Purple Moor-grass and Rush-pasture, there needs to be research into the feasibility and targetting of restoration.

A European perspective on the Lowland Grasslands of the UK will be vital if this country is to play its full part in contributing to Natura 2000 and the sustainability of a full range of these important habitats more widely. This is important not simply from the point of view of understanding how the plant communities represented here relate to their analogues elsewhere but also in developing concerted approaches to what are clearly widespread threats right across the Continent – abandonment and agricultural improvement of these grasslands and global dangers such as atmospheric nitrogen- and acid-deposition and changes in climate. Conservation practitioners and those concerned with the development and delivery of policy need to develop better links with the international science community to set sensible research agendas and disseminate the results of such enquiries.

8.7 The future for Lowland Grasslands in Europe

The best prospect for developing an integrated overview of the character, extent and ecology of Lowland Grasslands of Europe, one that would serve the scientific community, policy makers and practitioners, is SynBioSys. This information system, pioneered in the Netherlands (Schaminée & Hennekens 2006) and now being developed for European application, has three tiers of data - on plant species, vegetation types and landscapes. Structurally, it comprises three classifications - the first integrated species list for the whole of Europe, the phytosociological alliances according to the EVS overview and a landscape-scale classification based on the Vegetation Map of Europe (Bohn *et al.* 2002). It also has a parameter frame for each set of units that includes data on their distribution, environmental relationships, conservation status and other values, and a GIS facility to visualise spatial aspects of the information. Ultimately, it will function as a distributed database with the prospect of interactive participation by a wide community of users already united by their common commitment to TURBOVEG (Hennekens & Schaminée 2001), a database platform which includes popular multivariate analytical software such as TWINSPAN, DECORANA and CANOCO. After a presentation of the interim results of this Natural England project at the EVS 15th Symposium in Catania, Sicily, in March 2006, there is the prospect of Lowland Grasslands serving as the first demonstration for population of SynBioSys Europe with detailed information.

Such an enterprise is part of the ongoing conversations and developing vision of the EVS network. Particular opportunities have arisen from this project through which our country agencies could continue to strengthen links with their European counterparts. For example, to obtain some interim appreciation of the extent of broad types of Lowland Grassland alliances across Europe, the questionnaire which we circulated to country representatives of the EVS winzipasked for each of the alliances to be scored in their territory with a crude value indicating whether the vegetation types were widespread and common, widespread but uncommon, local, rare, extinct or never recorded – the first time such an enquiry had been made. Replies were received for Bulgaria, the Czech Republic, Germany, Italy, Latvia, The Netherlands, Slovakia, Spain, Slovenia and, too late to include on the maps, Lithuania and Switzerland. Results for two alliances are shown in Figures 38 to 41. Even from modest initiatives such as this, a better international understanding of Lowland Grasslands can be developed.

Meanwhile, in this country, the Lowland Grasslands present one of the best options for developing a pilot project for a SynBioSys UK which could serve as a tool for the BAP user community. A first step in developing this would be to update the UK Vegetation Database with the many relevés collected among Lowland Grasslands since the completion of the NVC, both by the country agencies and through other survey initiatives. This would be best performed within TURBOVEG, as part of a wider shift from VESPAN (Malloch 1988) as the better operating platform for the Database. A second step would be to integrate this relevé data with a UK species database developed from the Biological Records Centre and now incorporated within the National Biodiversity Network. A third step would be to add the landscape-scale information later based on the UK contribution to the Vegetation Map of Europe, but rationalising the legend and polygon boundaries with the compatible but more precise Soilscapes map produced by the National Soil Resources Institute at Cranfield (Thompson & Rodwell 2004). The total cost for such a pilot project would be between £20& 25K.

Within the UK BAP process, there is a growing awareness of the wider landscape scale within which sites designated for particular habitats exist, of the importance of managing process and dynamism in the sustainability of sites and landscapes, and of the relationships between biodiversity and cultural resonances in the distinctiveness of place. Novel partnerships are beginning to recognise the synergies between these various strands but there is a need to focus this momentum in more concerted and explicit way within the BAP process. More widely, international initiatives are beginning to stress the agricultural context for habitats in High Nature Value Farmland (EEA/UNEP 2004), the need to safeguard cultural landscapes (http://ec.europa.eu/culture) and the importance of sharing best practice in conservation management (http://www.eurosite-nature.org). Lowland Grasslands provide a prime example of how such interests might coincide to promote a more integrated and dynamic approach to the sustainability of habitats across Europe.

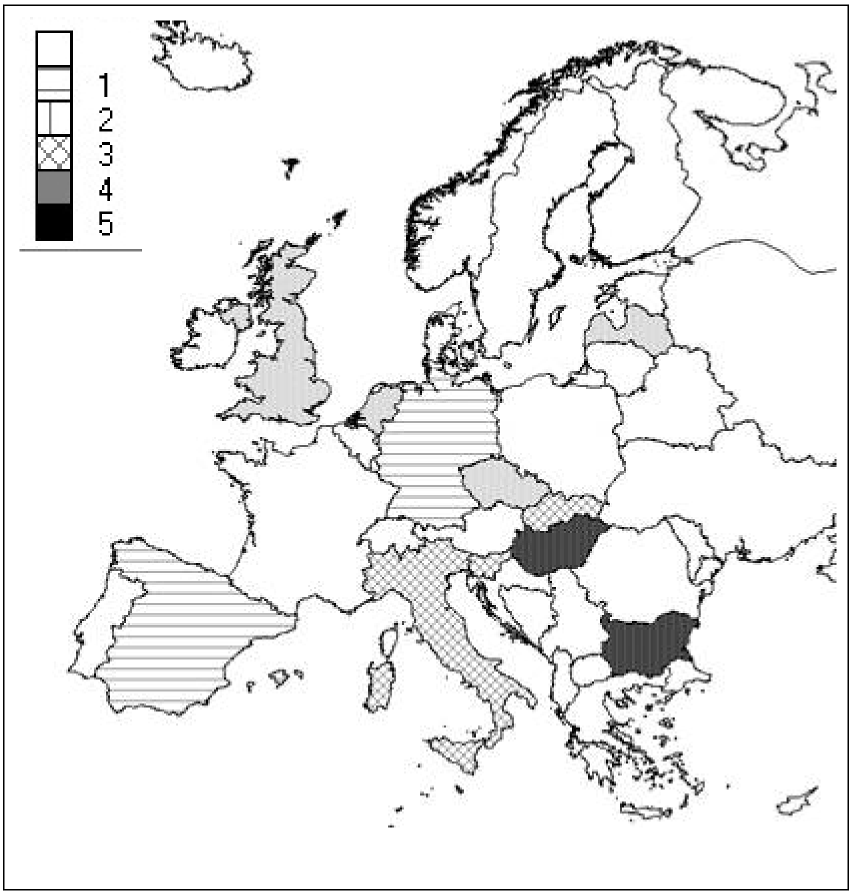

Figure 38 Extent of Alopecurion grasslands in selected European states
(blank = no data, 1 = never recorded, 2 = rare, 3 = local, 4 = widespread but uncommon, 5 = widespread and common)

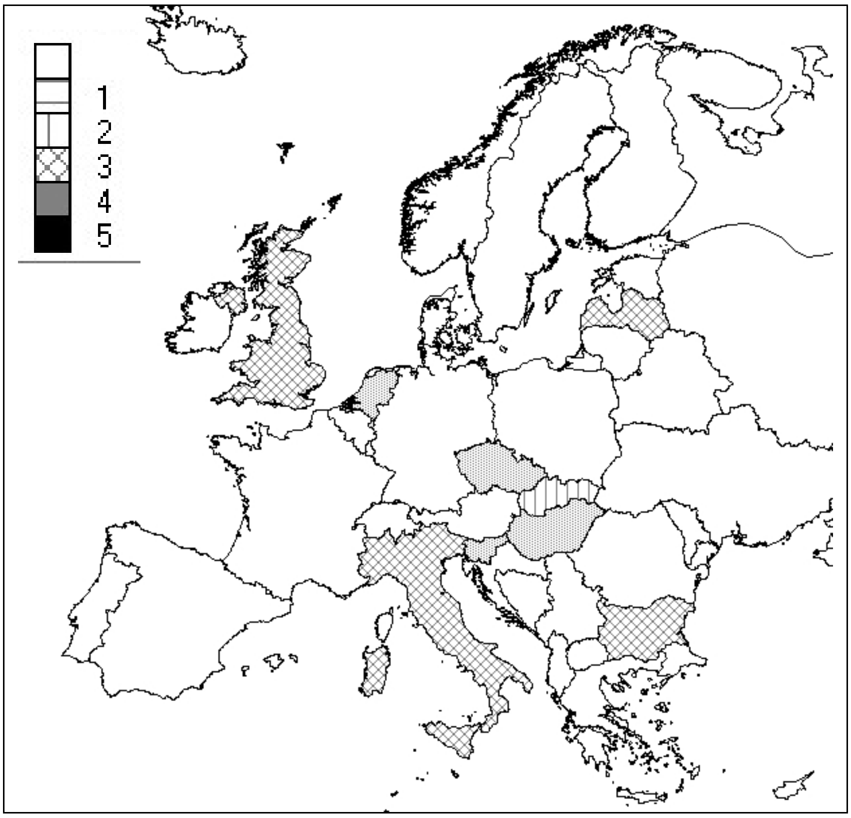

Figure 39 State of threat to Alopecurion grasslands in selected European states
(0 = no data, 1 = unthreatened, 2 = locally threatened, 3 = a nationally threatened, 4 = endangered, 5 = critically endangered)

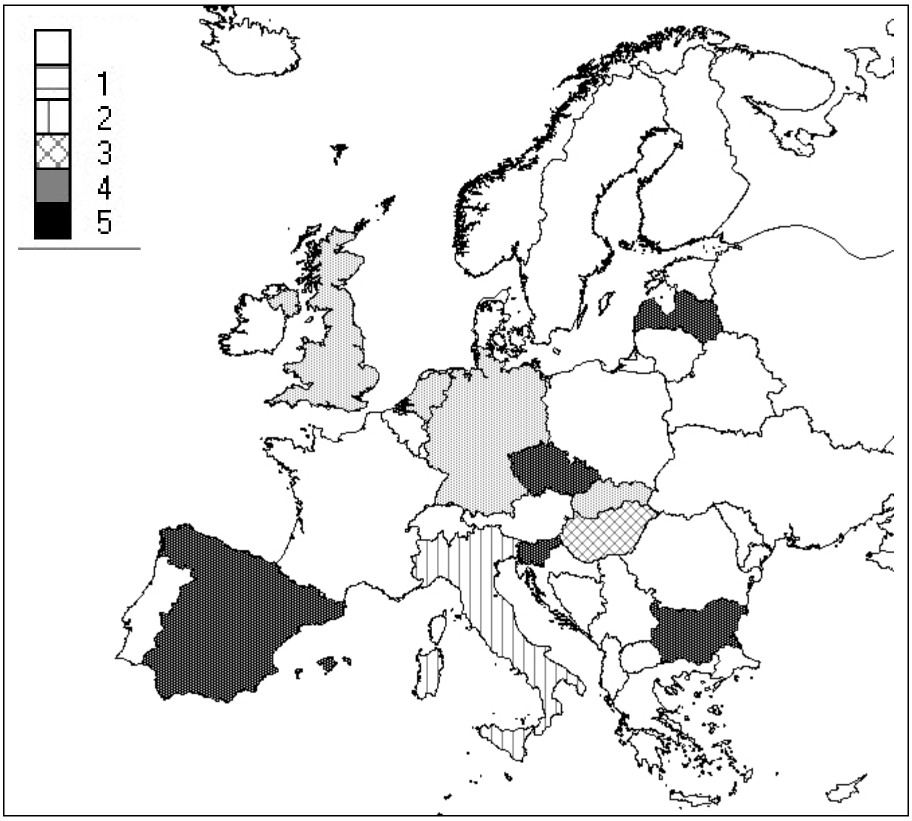

Figure 40 Extent of Calthion grasslands in selected European states
(blank = no data, 1 = never recorded, 2 = rare, 3 = local, 4 = widespread but uncommon, 5 = widespread and common)

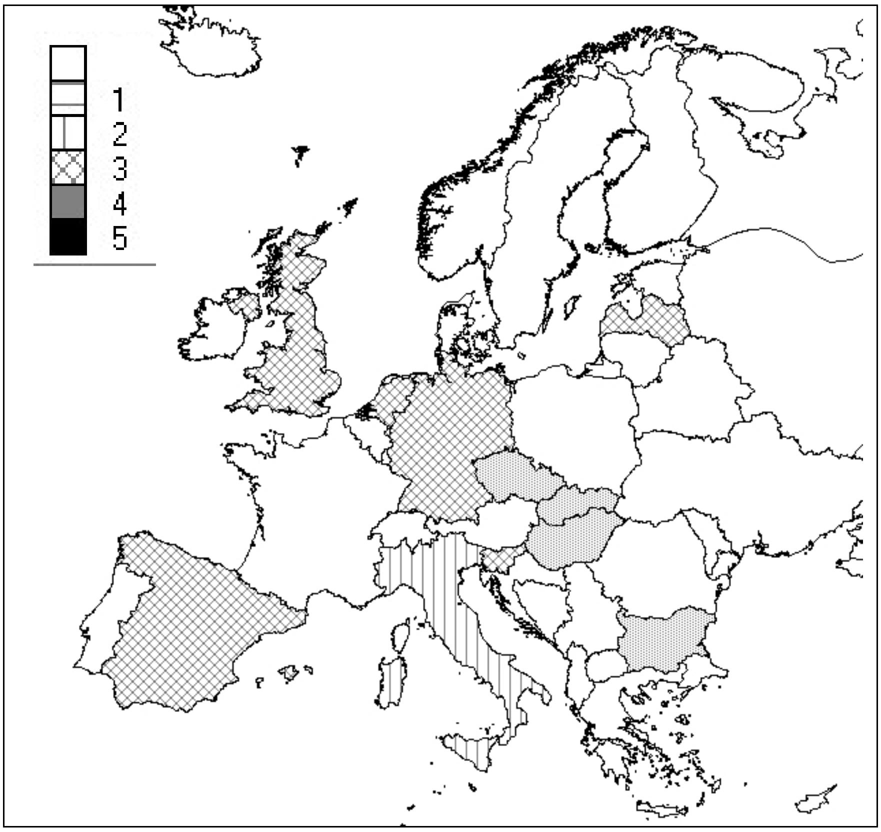

Figure 41 State of threat to Calthion grasslands in selected European states
(0 = no data, 1 = unthreatened, 2 = locally threatened, 3 = a nationally threatened, 4 = endangered, 5 = critically endangered)

9 Abbreviations & Glossary

Annex I
The Annex to the Species and Habitats Directive which lists habitats of nature conservation importance in the European Union

ASSI
Area of Special Scientific Interest, the equivalent in Northern Ireland to SSSI

BAP
Biodiversity Action Plan

BSE
Bovine Spongiform Encephalitis, popularly known as ‘Mad Cow Disease’

CEC
Commission of the European Communities

CORINE
A programme ‘Coordination of Information on the environment’, initiated by the European Union in 1985 and since 1994 an integrated part of the European environment Agency programme. Often used as shorthand for the habitat classification that underlies the EU Habitats Directive.

ESA
Environmentally Sensitive Area

EUNIS
European Union Nature Information System, a database on Species, habitats and Sites of significance in the European Union

EVS
European Vegetation Survey, a Working Group of the International Association for Vegetation Science including

GAP
The Grazing Animals Project, a partnership dedicated to optimal grazing of wildlife sites

humic
Organic character of topmost soil horizon

INDITE
A programme ‘Impact of Nitrogen Deposition on Terrestrial Ecosystems’ initiated by the DoE in 1994.

‘Least Concern’
The International Union for the Conservation of Nature Red List category including widespread and abundant taxa that do not qualify for more endangered status after evaluation against the criteria

‘Near Threatened’
The IUCN Red List category for taxa that are close to qualifying for categories of greater concern: vulnerable, endangered or critically endangered.

Natura 2000
The network of SACs and SPAs within the European Union

NGO
Non-governmental organisation

NNR
National Nature Reserve

NVC
National Vegetation Classification, the UK standard for defining plant communities.

PONT
The Welsh Grazing Animals Project, Pori, Natur a Threftadaeth meaning Grazing, Nature & Heritage, the acronym being the Welsh word for ‘bridge’

Relevé
A phytosociological sample of vegetation comprising complete species lists and cover-abundance values within a homogeneous plot

SAC
Special Area of Conservation, designated under the Habitats Directive

Saum
Vegetation intermediate between grassland and scrub in succession or ecotones

SPA
Special protection Area, designated under the Birds Directive

SSSI
Site of Special Scientific Interest

xeric
Habitat or vegetation with species tolerant of dry conditions

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11 References

ADAMS, W.A., ROUGHLEY, G. & YOUNG, R.J., 1999. An experimental study to re-establish *Molinia-Juncus* pasture from improved grassland at Rhôs Llawr Cwrt National nature Reserve. *Countryside Council for Wales Science Report,* No. 355.

ANON., 2001. *The Inventory of Seminatural Grasslands in Estonia 1999-2000.* Tartu: Estonian Fund for Nature & Royal Dutch Society for Nature Conservation.

AUSDEN, M., ALLISON, M. & KEMP, M., 2006. Creation of heathland and acid grassland on agriculturally improved land. *In:* H.D.V. PRENDERGAST, ed. *Heathlands - past, present and future,* 119-135. East Sussex County Council.

AUSTIN, M.P., 1968. Pattern in a *Zerna erecta* dominated community. *Journal of Ecology,* **56,** 197-218.

AVERIS, A.B.G. 1991. *A survey of serpentine-influenced vegetation at four sites in Grampian region, Scotland*. Report to NCC Scotland, Aberdeen.

AVERIS, A.M., AVERIS, A.B.G., BIRKS, H.J.B., HORSFIELD, D., THOMPSON, D.B.A. & YEO, M.J.M., 2004. *An Illustrated Guide to British Upland Vegetation.* Peterborough: Joint Nature Conservation Committee.

BACON, J.C., 1990. The use of livestock in calcareous grassland management. *In* S.H. HILLIER, D.W.H. WALTON & D.A. WELLS, ed. *Calcareous Grasslands – Ecology and Management,* 121-127. Huntingdon: Bluntisham, 121-127.

BAEUMER, K., 1956. Verbreitung und Vergesellschaftung des Glatthares (*Arrhenatherum elatius*) unde Goldhafers (*Trisetum flavescens*) im nördlichen Rheinland. *Decheniana,* **3**, 1-77.

BAKER, H., 1937. Alluvial meadows: A comparative study of grazed and mown meadows. *Journal of Ecology*, **25**, 408-420.

BALÁTOVÁ-TULÁČKOVÁ, E., 1981. Phytozönologische und ökologische characteristic der Feuchtwiesen NW-Böhmens. *Rozpravy češkoslovenske akademie ved.rad mat. A prir.,* **91**, 1-290.

BALÁTOVÁ-TULÁČKOVÁ, E., 1983. Feuchtwiesen des Landschaftsschutzgebietes Šumava. *Fol.Mus.rer.Natur.Bohem.Occident.Bot.,* **18-19**, 1-82.

BALÁTOVÁ-TULÁČKOVÁ, E., 1987. Beitrag zur Kenntnis der Feuchtwiesen des Gebirges Hostýnské vrchy. *Tuexenia,* **7**, 199-213.

BALÁTOVÁ-TULÁČKOVÁ, E., 1991. Feuchtwiesen des Brdy-Berglandes und seiner Randgebiete (Mittlebohnmen). *Folia Geobotanica,* **25**, 337-448.

BALÁTOVÁ-TULÁČKOVÁ, E., 2000. Vergleich der aus Mähren und der Slowakei beschrieben Subassoziation des *Gentiano pneumonanthis-Molinietum litoralis*. *Acta Botanica Croatica,* **59**, 157-165.

BALÁTOVÁ-TULÁČKOVÁ, E. & HÁJEK, M., 1998. Feuchtwiesengesellschaften des südlichenn Teiles des Landschaftsschutzgebietes Bile Karpaty (Südost-Mahren). *Verh. Zoologisch-Botanischen Ges. Österreich,* **135**, 1-40.

BALEVIČIENĖ, J., KIZIENĖ, B., LAZDAUSKAITĖ, Z, PATALASKAITĖ, D., RASOMAVIČIUS, SINKEVIČIENĖ, Z., TUČIENĖ, A. & VENCKUS, Z., 1998. *Lietuvos Augalija/Vegetation of Lithuania, 1 Pievos/Meadows.* Vilnius: Kaunas.

BALZER, S. & SSYMANK, A., 2005. *Natura 2000 in Deutschland.* Bonn: Bundesamt für Naturschutz.

BARDAT, J., BIORET, F., BOTINEAU, M., BOULLET, V., DELPECH, R., GEHU, J.-M., HAURY, J., LACOSTE, A., RAMEAU, J.-C., ROYER, J-M., ROUX, G. & TOUFFET, J., 2004. *Prodrome des végétations de France*. Paris: Patrimone Naturels.

BARTSCH, J. & BARTSCH, M., 1940. Vegetationskunde des Schwarzwaldes. *Pflanzensoziologie,* **4**.

BEGER, H., 1922. Assoziationsstudien in der Waldstufe des Schanfigg. *Jahresber. Naturf. Ge, Graubunden,* **1921/22**, 1-147.

BENSETTITI, F., BOULLET, V., CHAVAUDRET-LABORIE, C. & DENIAUD, J., 2005. *Cahiers d'habitats Natura 2000. Connaissance et gestion des habitats et des espèces d'intérêt communautaire. Habitats agropastoraux.* Paris: La Documentation française.

BENTLER, H. & BEUTLER, D., 2002. *Naturschutz und Landschaftspflege in Brandenburg.* Potsdam: Landesumweltsamt Brandenburg Abt. Naturschutz.

BENYON, P.R., 1998. *Lower Derwent Valley: MG4 grassland boundary survey.* Report to the Environment Agency, Leeds.

BERG, C., DENGLER, J., ABDANK, A. & ISERMANN, M., 2004. *Die Pflanzengesellschaften Mecklenberg-Vorpommerns und ihre Gefahrdung.* Textband und Tabellenband. Weissdorn: Verlag Jena.

BERGMEIER, E., NOWAK, B. & WEDRA, C., 1984. *Silaum silaus* – und *Senecio aquaticus* – Wiesen in Hessen. Ein Beitrag zu ihrer Systematik, Verbreitung und Ökologie. *Tuexenia,* **4**, 163-179.

BIONDI, E., ALLEGREZZA, M. & ZUCCARELLO, V., 2005. Syntaxonomic revision of the Apennine grasslands belonging to Brometalia erecti, and an analysis of their relationships with the xerophilous vegetation of *Rosmarinetea officinalis* (Italy). *Phytocoenologia*, **35**, 129-163.

BIRSE, E.L., 1980. *Plant Communities of Scotland: A Preliminary Phytocoenonia*. Craigiebuckler: Macaulay Institute.

BIRSE, E.L., 1982. Plant communities on serpentine in Scotland. *Vegetatio*, **49**, 141-162.

BIRSE, E.L., 1984. *The Phytcoenonia of Scotland.: Additions and Revision*. Craigiebuckler: Macaulay Institute.

BISHOP, G.F & DAVY, A.J., 1984. Significance of rabbits for the population regulation o*f Hieracium pilosella* in Brackland. *Journal of Ecology*, **72**, 273-284.

BLACKSTOCK, T.H., STEVENS, D.P. & YEO, M.J.M., 1993. *Comments on the phytosociological placement of some flushed pasture and related communities in south-west Scotland and Westmoreland.* Countryside Council for Wales Unpublished Report.

BLACKSTOCK, T.H., STEVENS, D.P. & YEO, M.J.M., 1997. Conservation and management of *Molinia* and *Juncus* pastures in wales, with reference to agri-environment schemes. *In:* R.D. SCHELDRICK, ed. *Grassland management in the Environmentally Sensitive Areas. British Grassland Society Occasional Symposium No 32*, 150-159. Reading: BGS.

BLACKSTOCK, T.H., STEVENS, D.P., STEVENS, P.A., MOCKRIDGE, C.P. & YEO, M.J.M., 1998. Edaphic relationships among *Cirsio-Molinietum* and related wet grassland communities in lowland Wales. *Journal of Vegetation Science*, **9**, 431-444.

BOCHER, T.W., 1954. Oceanic and continental vegetation complexes in south-west Greenland. *Meddelelser Grønland,* **148**, 82-418.

BOEKER, P., 1957. Basenversorgung und Humusgehalte von Böden der Pflanzengesellschaften des Grünlandes. *Decheniana* **4**.

BOHN, U, GOLLUB, G. & HETTWER, C., 2002. *Map of the Natural Vegetation of Europe*. Bonn: Bundesamt für Naturschutz.

BORHIDI, A., 2003. *Magyarország növenytársulásai.* Budapest: Akadémiai Kiadó.

BORHIDI, A. & SANTA, A., 1999. *Vörös Könyv: Magyarország Növénytársulásairól* Volumes 1 & 2. Budapest: Természet BÚVÁR Alapítvary Kiadó.

BOSCAIU, N., 1970. Palisti din Alianta Cynosurion din muntii Banatuli (Romania). *Studii si cercetari di Biolgie. Seria Botanica,* **22(5)**, 363-370.

BOURENERIAS, M., ARNAL, G. & BOCK, C., 2001. *Guide des Groupements vegetaux de la region Parisienne.* Paris: Belin.

BRADSHAW, M.E., 1962. The distribution and status of five species of the *Alchemilla vulgaris* L. aggregate in Upper Teesdale. *Journal of Ecology*, **50**, 681-706.

BRAUN(-BLANQUET), J., 1915. *Les Cevennes Méridionales.* Geneva.

BRAUN-BLANQUET, J., 1947. Les groupements végétaux supérieurs de la France. *In*: J. BRAUN-BLANQUET, L.EMBERGER & R. MOLINIER. *Instructions pour l'établissement de la Carte des Groupements Végétaux,* 19-32. Montpelier: SIGMA.

BRAUN-BLANQUET, J. & TÜXEN, R., 1952. Irische Pflanbzengesellschaften. *Veröffentlichungen des Geobotanischen Institutes Rübel in Zürich*, **25**, 224-415.

BRIAN, A., 1993. Lammas Meadows. *Landscape History*, **15**, 57-69.

BROCK, T., FRIGGE, P. & VAN DER STER, H., 1978. *A vegetation study of the pools surrounding wetlands in the Dooaghtry area, Co. Mayo, Republic of Ireland.* Catholic University of Nijmegen Thesis.

BROCKMANN-JEROSCH, H., 1907. *Die Pflanzengesellschaften des Schweizeralpen. I. Die Flora des Puschlav (Bezirk Bernina, Kanton Graubünden) und ihre Pflanzengesellschaften.* Leipzig.

BRUNO, F. & COVARELLI, G., 1968. I pascoli e I pratipascoli della Valsorda (Apepennino Umbro). *Notiziaro della Societa Italiana di Fitosociologica*, **5**, 47-65.

BRUUN, H.H. & EJRNAES, R., 2000. Classification of dry grassland vegetation in Denmark. *Journal of Vegetation Science*, **11**, 585-596.

BUCHWALD, E. & SOGAARD, S., 2000. *Danske naturtypr i det europaeiske NATURA 2000 netvaerk.* Copenhagen: Miljø- og Energiministeriet Naturstyrelsen.

BUKER, R., 1942. Beiträge zur Vegetationskunde des südwestfälischen Berglandes. *Beih. Bot. Cbl.* **56**, 452-558.

BYFIELD, A. & PEARMAN, D., 1996. *Dorset's disappearing heathland flora: changes in the distribution of Dorset's rarer heathland species.* London: Plantlife & RSPB.

CARNI, A., 2003. Vegetation of cultivated grasslands in the Goričko region (NE Slovenia). *Acta Biologica Slovenica*, **44**, 13-27.

CEC, 2003. Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora. As amended by the Accession Act of Austria, Finland and Sweden (1995) and the Accession Act of the Czech Republic, the Republic of Estonia, the Republic of Cyprus, the Republic of Latvia, the Republic of Lithuania, the Republic of Hungary, the Republic of Malta, the Republic of Poland, the Republic of Slovenia and the Slovak Republic (2003). Official Journal of the European Union L 236 33 23.9.2003. Brussels: European Commission 1992/95/2003.

CHEFFINGS, C.M. & FARRELL, L. (Eds), DINES, T.D., JONES, R.A., LEACH, S.J., McKEAN, D.R., PEARMAN, D.A., PRESTON, C.D., RUMSEY, F.J., TAYLOR, I., 2005. *The Vascular Plant Red Data List for Great Britain. Species status,* **7**, 1-116. Peterborough: Joint Nature Conservation Committee.

CHYTRY, M,, KUČERA, T. & KOČI, M., 2001. *Katalog biotopů České republiky.* Prague: Agentura ochramy přírody a Krajiny ČR.

COLDEA, GH., 1977. Studium der Festuco rubrae-Agrostietum tenuis Horv. 1951-Gesellschaft in dem Locvagebirge (Banat.) *Lucrari Stiintifice*, **14**, 37-45.

COLDEA, GH., 1991. *Prodrome des Associations Végétales des Carpates du Sud-Est (Carpates Roumaines).* Camerino: Universitá degli Studi.

COOCH, S. & RODWELL, J.S., 1996. *Preliminary study of key issues in relation to northern hay meadows.* Lancaster: Unit of Vegetation Science report to WWF (UK).

COOPER, A. & McCANN, T., 1994. The Botanical Composition of Grassland Land Cover Types in Northern Ireland. *Contract Report to Environment Service, DOE(NI).*

COOPER, A. & McCANN, T., 2002. *Habitat Change in the Northern Ireland Countryside. Technical Report of the Northern Ireland Countryside Survey 2000.* Belfast: University of Ulster.

COOPER, E.A., 1993. *Vegetation Survey of Malham Tarn Fen.* Lancaster: Unit of Vegetation Science report to the National Trust.

COOPER, E.A & MACKINTOSH, J., 1996. *NVC Review of Scottish grassland Surveys.* Lancaster: Unit of Vegetation Science Report to Scottish Natural Heritage.

COOPER, E.A., COOCH, S. & RODWELL, J.S., 1997. *Northern Hay Meadows.* Lancaster: Unit of Vegetation Science report to WWF (UK).

CORBETTA, F. & PIRONE, G., 1981. *Carta della vegetazione di Monte Alpi e zone contermini.* Roma: Consiglio nazionale della ricerche AQ/1/122.

CORPORAAL, A.. HORSTHUIS, A.M.P. & SCHAMINEE, J.H.J., 1993. Oecologie, verspreiding en plantensociologie positie van de Kievitsbloem (*Fritillaria meleagris* L.) in Nederland en Nordwest-Europa. *Stratiotes*, **6**, 14-39.

CORTINI PEDROTTI, C., ORSOMANDO, E., PEDROTTI, F. & SANESI, G., 1973. La vegetazione e I suoli del Pian Grande di Castelluccio di Norcia (Appenni Centrale). *Atti dell'Istituto Botanico e Laboratorio crittogamico dell'Universitá di Pavia*, **6(9)**, 1-249.

COX, W., 1995. *Phase II survey of Shapwick Heath NNR & part of the Somerset levels NNR using the National Vegetation Classification*. Taunton: English Nature.

COX, W. & LEACH, S., 1995. *Agrostis stolonifera-Carex* spp. grassland: a new plant community described from the Somerset Levels. *Ecology in Somerset*, **4**, 221-226.

CREDARO, V. & PIROLA, A., 1975. *La vegetazione della provincia di Sondrio.* Sondrio.

CRITCHLEY, C.N.R., FOWBERT, J.A., WRIGHT, B. & PARKIN, A.B., 2004. Monitoring of hay meadows in Pennine Dales ESA. *DEFRA Report MA01005*

CROFTS, A. & JEFFERSON, R.G., 1999. *The Lowland Grassland Management Handbook.* 2nd edition. Peterborough: English Nature & The Wildlife Trusts.

DAVIES, C.E., MOSS, D. & HILL, M.O., 2004. *EUNIS Habitat Classification Revised 2004*. CEH report to European Environment Agency.

DE FOUCAULT, B., 1981. Les prairies permanentes du Boicage virois (Basse-Normandie-France). Typologie phytosociologique et essai de reconstitution des séries évolutives herbagieres. *Documents Phytosociologiques*, **5**, 1-109.

DE FOUCAULT, B., 1986*a.* Note phytosociologique sur le système prairial mésophile du haut Jura Français. *Annales scientifiques de l'Université de Franche-Comté Besançon. Biologie Vegetale 4e Serie*, **6**, 45-55.

DE FOUCAULT, B., 1986*b.* Contribution á une étude phytosociologique des systèmes prairiaux hygrophile et mesophile de l'Aramgnac meridional (Hautes-Pyrenees et Gers-France). *Documents Phytosociologiques*, **10**, 222-254.

DE FOUCAULT, B. 1986*c*. Données systématique sur la vegetation prairiale mesophile du Pays Basque et les Landes de Gascogne. *Documents Phytosociologiques*, **10**, 204-219.

DELARZE, R., GONSETH, Y. & GALLAND, P., 1998. *Guide des Milieux Naturels de Suisse.* Lausanne: Delacaux et Niestlé.

DETR, 1994. *Biodiversity: the UK Action Plan – Volume II: Action Plans*. London: HMSO.

DEVILLERS, P. & DEVILLERS-TERSCHUREN, J., 2001. *Application & development of the Palaearctic habitat classification in the course of the setting up of the Emerald Project: Malta.* Strasbourg: Council of Europe.

DEVILLERS, P. & DEVILLERS-TERSCHUREN, J., 2002. *Application & development of the Palaearctic habitat classification in the course of the setting up of the Emerald Project: Croatia.* Strasbourg: Council of Europe.

DEVILLERS, P. & DEVILLERS-TERSCHUREN, J., 2002. *Application & development of the Palaearctic habitat classification in the course of the setting up of the Emerald Project: Cyprus.* Strasbourg: Council of Europe.

DEVILLERS, P. & DEVILLERS-TERSCHUREN, J., 2002. *Application & development of the Palaearctic habitat classification in the course of the setting up of the Emerald Project: Iceland.* Strasbourg: Council of Europe.

DEVILLERS, P. & DEVILLERS-TERSCHUREN, J., 2002. *Application & development of the Palaearctic habitat classification in the course of the setting up of the Emerald Project: Baltic States.* Strasbourg: Council of Europe.

DEVILLERS, P. & DEVILLERS-TERSCHUREN, J Devillers, P. & Devillers-Terschuren, J., 2002. *Application & development of the Palaearctic habitat classification in the course of the setting up of the Emerald Project: Slovenia.* Strasbourg: Council of Europe.

DEVILLERS, P. & DEVILLERS-TERSCHUREN, J .DEVILLERS, P. & DEVILLERS-TERSCHUREN, J., 2002. *Application & development of the Palaearctic habitat classification in the course of the setting up of the Emerald Project: Ukraine.* Strasbourg: Council of Europe.

DIERSCHKE, H., 1979. Grünland-Gesellschaften im oberen Paznauner Tal (Tirol/Österreich). *Phytocoenologia,* **6**, 287-302.

DIERSCHKE, H., 1981. Syntaxonomische gliederung der Bergwiesen Mitteleuropas (Polygono-Trisetion). *Berichte der Internationalen Symposien der Internationalen Vereinigung für Vegetationskunde* **1981**, 311-41.

DIERSCHKE, H., 1990. Syntaxonomische Gliederung des Wirtschaftsgrünlandes und verwandter Gesellschaften (Molinio-Arrhenatheretea) in Westdeutschland. *Berichte Reinhold Tuxen Gesellschaft*, **2**, 83-89.

DIERSCHKE, H., 1995. Syntaxonomical survey of Molinio-Arrheneatheretea in Central Europe. *Colloques Phytosociologiques*, **XXIII**, 388-99.

DIERSCHKE, H., 1997. Wiesenfuchsschwanz- (*Alopecurus pratensis*-) Wiesen in Mitteleuropa. *OsnabruckerNaturwissenschafliche Mitteilungen,* **23**, 95-107.

DIERßEN, K., 1996. *Vegetation Nordeuropas.* Stuttgart: Verlag Eugen Ulmer.

Οδηγος Παρακολογουθησης Τυπη Οικοτοπωη & Φυτικων Ειδων (DIMOPOULOS, P., BERGMEIER, E., THEODOROPOULOS, K., FISCHER, P & TSIAFOULI, M., 2006. *Monitoring Guide for habitat Types and Plant species in the Natura 2000 sites of Greece.* University of Ioannina & Hellenic Ministry for the Environment, Physical Planning & Public Works. Agrinio. With English summary).

DOLMAN, P., 1992. A review of lowland dry acid grassland birds in Britain: their status, ecological requirements and priorities for conservation. *JNCC Report No. 125.* Peterborough: JNCC.

DONIȚĂ, N., IVAN, D., COLDEA, GH., SANDA, V., POPESCU, A., CHIFU, TH., PAUCĂ-COMĂNESCU, M. & BOŞCAIU, N., 1992. *Vegetația României.* Cluj-Napoca & Iaşi: Editura Tehnica Agrocila.

DONITĂ, N., POPESCU, A., PAUCĂ-COMĂNESCU, M., MIHĂILESCU. & BIRIŞ, I-A., 2005. *Habitatele din România.* Bucuresti: Editura Tehnică Silvică

DOYLE, G.J., 1982. Minuartio-Thlaspietum alpestris (Violetea calaminariae) in Ireland. *Journal of Life Sciences, Royal Dublin Society*, **3**, 143-6.

DUFFEY, E. & WATT, A.S., 1971. *The Scientific Management of Animal and Plant Communities for Conservation.* Oxford: Blackwell.

DUFFEY, E., MORRIS, M.G., SHEAIL, J., WARD, L.K., WELLS, D.A. & WELLS, T.C.E., 1974. *Grassland Ecology and Wildlife Management.* London: Chapman & Hall.

DURING, H.J., 1990. The bryophytes of calcareous grassland. *In:* S.H. HILLIER, D.W.H. WALTON & D.A. WELLS, ed. *Calcareous Grasslands – Ecology and Management* 35-40. Huntingdon: Bluntisham, 35-40.

DUVIGNEAUD, P. & VANDEN BERGHEN, C., 1945. Associations tourbeuses en campine occidental. *Biologisch jaarboek Dodonae*, **12**, 53-90.

EDWARDS, A., 1999. *The Productivity of Traditionally Managed Hay Meadows in the Pennines.* Lancaster University MRes thesis.

EEA/UNEP, 2004. *High Nature Value farmland. Characteristics, trends and policy challenges*. EEA report No. 1. Copenhagen & Geneva: EEA & UNEP ROE.

ELLENBERG, H., 1988. *Vegetation Ecology of Central Europe.* Cambridge: Cambridge University Press.

ELLMAUER, T. & TRAXLER, A., 2000. *Handbuch der FFH-lebensraumtypen Ősterreichs.* Vienna: Umweltsbundesamt Ősterreichs.

ERNST, W., 1965. Ökologisch-Soziologische Untersuchungen der Schwermetall-Pflanzengesellschaften Mitteleuropas unter Einschluß der Alpen. *Abhandlungen aus dem Landesmuseum für Naturkunde zu Münster in Westfalen*, **27**, 1-54.

ERNST, W., 1968. Zur kenntnis der Soziologie und Okologie der Schwermetallvegetation Großbritanniens. *Sonderabdruck aus den Berichten der deutschen Botanischen Gesellschaft* Jg. **1968**.

ERNST, W., 1974. *Schwermetallvegetation der Erde.* Stuttgart: Fischer Verlag.

ESSL, F. *et al*., 2004. *Rote Liste der Gefährdeten Biotoptypen Österreichs.* Vienna: Umweltsbundesamt Österreichs.

FOSSIT, J., 2000. *A Classification of Irish Habitats.* Dublin: The Heritage Council

FREMSTAD, E., 1997. *Vegetatsjonstyper I Norge*. Trondheim: Norsk Institutt for natursforskning.

FREMSTAD, E., 2002. Natura 2000 in Norway. *NTNU Vitenskapsmus Rapp bot Ser.* ***2002-5****,* 1-38.

GÉHU, J.-M., 1992. Reflexions sur les fondements syntaxonomiques necessaries à une synthèse des végétations à l'échelle du continent européen et esquisse d'un synstème dans l'optique de la phytosociologie Braun-Blanqueto-Tuxennienne. Ebauche de synsystème por la france. *Annali di Botanica*, **50**, 131-147.

GIAVARINI, V.J., 2002. *The lichen interest and conservation importance of old mine spoil tips in Cornwall*. Unpublished report to English Nature.

GOOD, R., 1936. On the distribution of the lizard orchid (*Himantoglossum hircinum* Koch.) *New Phytologist*, **35**, 142-170.

GOWING, D.J.G., GILBERT, J.C., YOUNGS, E.G. & SPOOR, G., 1997. *Water regime requirements of the native flora – with particular reference to ESAs.* Silsoe: Cranfield University Final Report to MAFF BD0209.

GOWING, D.J.G., LAWSON, C.S., YOUNGS, E.G., BARBER, K.R., RODWELL, J.S. PROSSER, M.V., WALLACE, H.L., MOUNTFORD, J.O. & SPOOR, G., 2002*a*. The water-regime requirements and the response to hydrological change of grassland plant communities. Silsoe: Cranfield University Final Report to Defra BD1310.

GOWING, D.H.G., TALLOWIN, J.R.B., DISE, N.B., GOODYEAR, J., DODD, M.E. & LODGE, R.J., 2002*b*. A review of the ecology, hydrology and nutrient dunamics of floodplain meadows in England. *English Nature Research reports*, N^{o} 446. Peterborough: English Nature.

GRABHERR, G. & MUCINA, L., 1993. *Die Pflanzengesellschaften Österreichs, Teil II.* Jena: Gustav Fischer Verlag.

GREEN, B.H., 1973. Practical aspects of chalk grassland management in the Nature Conservancy's South-East region. *In:* A.C. JERMY & P.A. STOTT, ed. *Chalk Grassland: Studies on its Conservation and Managament in South-east England,* 42-47. Maidstone: Kent Trust for Nature Conservation.

GREEN, B.H., 1990. Agricultural intensification and loss of habitat, species and amenity in British grasslands – a review of historical change and assessment of future prospects. *Grass and Forage Science*, **45**, 365-72.

GUYOT, H., 1920. Le Valsorey. *Beitr. Geobot. Landsaufn. Schweiz.,* **8**.

HADAČ, E., 1969. Die Pflanzengesellschaften des Tales "Dolina Siedmich pramenov" in der Belaer Tatra. *Vegetacia CSSR.*

HARDING, M., 1993. *North Cove NVC Survey 1993.* Saxmundham: Suffolk Wildlife Trust.

HARDING, M. & KAY, S., 1992. *Lakenheath Poors Fen. NVC Survey 1992.* Saxmundham: Suffolk Wildlife Trust.

HENNEKENS, S.M. & SCHAMINÉE, J.H.J., 2001. TURBOVEG, a comprehensive database management system for vegetation date. *Journal of Vegetation Science*, **12**, 589-91.

HERBICHA, J., 2004. *Poradniki ochrony siedlisk I gatunkow Natura 2000 – podręcznik metodyczny.* Volumes 1-9. Warszawa: Ministerstwo Środowiska ul Wawelska.

HEWINS, E.J., PINCHES, C., ARNOLD, J., LUSH, M., ROBERTSON, H. & ESCOTT, S., 2005. The condition of lowland BAP priority grasslands: results from a sample survey of non-statutory stands in England. *English Nature Research Reports,* N^{o}636. Peterborough: English Nature.

HILL, P., 2001. *The ecology of* Geranium sylvaticum *with special reference to germination characteristics.* Lancaster University BSc dissertation.

HODA, P., MERSINLLARI, M., MULLAJ, A., RODWELL, J., DRING, J. & PIGNATTI, S., 1999. *Vegetation of Albania: Preliminary Conspectus.* Lancaster: Unit of Vegetation Science Report to the Darwin Initiative.

HOLYOAK, D.T., 2000. Bryophyte interest and conservation importance of former Metaliferous Mine Sites in Cornwall. *English Nature Research Reports*, N^{o}328. Peterborough: English Nature.

HORSTHUIS, M.A.P., CORPORAAL, A., SCHAMINÉE, J.H.J. & WESTHOFF, V., 1994. Die Schachblume (*Fritillaria meleagris* L.) in Nordwest-Europa, insbesondere in den Nederlanden: Oekologie, Verbreitung, pflanzensoziologische Lage. *Phytocoenologia*, **24**, 627-647.

HUNDT, R., 1964. Die Bergwiesen des Harzes, Thüringer Waldes und Erzgebirges. Pflanzensoziologie, **14**, 1-264.

HUNDT, R., 1966. Ökologische-geobotanische Untersuchungen an Pflanzen der mitteleuropäischen Wiesenvegetation. *Botanische Studien*, **16**, 1-176.

INSTITUTO DA CONSERVAÇÃO DA NATUREZA, 2005. *Plano Sectoral Rede Natura 2000*. Lisbon.

ISSLER, E., 1942. Vegetationskunde der Vogesen. *Pflanzensoziologie,* 5.

IVIMEY-COOK, R.B. & PROCTOR, M.C.F., 1966. The plant communities of the Burren, Co. Clare. *Proceedings of the Royal Irish Academy*, **B64**, 211-301.

JACKSON, D.L. & MCLEOD,C.R., 2002. Handbook on the UK status of EC Habitats Directive interest features: provisional data on the UK distribution and extent of Annex I habitats and the UK distribution and population size of Annex II species. *JNCC Report,* No. 312. Peterborough: Joint Nature Conservation Committee.

JANSSEN, J. & SCHAMINÉE, J.H.J., 2003. *Habitattypen.* Utrecht: KNNV Uitgeverij.

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

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

JEFFERSON, R.G. & ROBERTSON, H.J., 1996. Lowland grassland: Wildlife value and conservation status. *English Nature Research Reports,* No.163. Peterborough: English Nature.

JENTSCH, A. & BEYSCHLAG, W., 2003. Vegetation ecology of dry acidic grasslands in the lowland area of central Europe. *Flora*, **198**, 3-25.

JONES, R.M., 1984. *The vegetation of upland hay-meadows in the north of England with experiments into the causes of diversity*. Lancaster University PhD thesis.

JONES-WALTERS, L.M., 1990. A new approach to the management of chalk grassland with particular rererence to the integration of conservation measures for invertebrates. *In:*

S.H. HILLIER, D.W.H. WALTON & D.A. WELLS, ed. *Calcareous Grasslands – Ecology and Management*, 140-148. Huntingdon: Bluntisham, 140-148.

JULVE, Ph., 1993. *Synopsis Phytosociologique de la France (Communautés de Plantes Vasculaires)*. *Revue de Botanique*, **140**, 1-160.

JURKO, A., 1969. Übersicht über die Pflan Zengesellschaften des Cynosurion-Verbandes in den Karpaten. *Vegetatio*, **18**, 222-38.

KABUCIS, I. ed., 2000. *Biotopu rokasgrâmata: Eiropas Savienības aizsargājamie biotope Latvijā.* Riga: Latvijas Dabas Fonds.

KALIGARIC, M., SELIŠKAR, A. & VEEN, P., 2003 *Grasslands of Slovenia*. Ljubljana: Royal Dutch society for Nature Conzervation & Society for Natural History in Slovenia.

KARUKOVA, V., DIMOVA, D., DIMITROV, M., TZONEV, R. & BELEV, T. eds. 2005. *Rukovodstvo za opredelyane na mestoobitaniya ot evropejska znachimost v Bulgaria* (*Manual for a determination of habitats with European importance in Bulgaria).* Sofia: Geosoft EOOD.

KINZEL, H., 1982. Pflanzokologie und Mineralstoffwechsel. Suttgart: Ulmer.

KLAPP, E., 1965. *Grunlandvegetation und Standort – nach Beispielen aus West-, Mittel- under Suddeutschland.* Berlin und Hamburg.

KLÖTZLI, F., 1969. *Die Grundwasserbeziehungen der Streu- und Moorwiesen im nördlichen schweizer Mittelland.* Bern: Hans Huber.

KNAPP, E., 1951. Uber Pflanzengesellschaften der Wiesen im Vogelsberge. *Lauterbach Sammlungen*, **6**, 1-8.

KNAPP, G. & KNAPP, R., 1953. Uber anthropogene Pflanzengesellschaften im mittleren Tirol. *Ber. Dtsch. Bot. Ges.,* **66**, 393-408.

KOCH, W., 1926. Die Vegetationseinheiten der Linthebene unter berucksichtung der Verhaltnisse in der Nordostschweiz. *Jahrb. St Gallische Naturwiss. Ges*., **61(2)**, 1-144.

KORNAŚ, J., 1967. Montane hay-meadow Gladiolo-Agrostietum in the Polish Western Carpathians. *Contrib. Bot.,* **1967**, 167-76.

KORNAŚ, J. & MEDWECKA-KORNAŚ, A., 1967. Zespoły roślinne Gorców. I. Naturalne I na wpoł naturalne zespoły nieleśne. Plant communities of the Gorce Mts. (Polish Western Carpathians). I . Natural and semi-natural non-forest communities. *Fragment. Florist. Geobot*., **13**.

KORNECK, D., 1962/3. Die Pfeifengraswiesen und ihre wichtigsten Kontaktgesellschaften in der nördlichen Oberrheinebene und im Schweinfurte Trockengebiet. II. Die Molinieten feuchter Standorte. *Beitr.Naturk.Forsch.Sudw.-Deut*. **21**, 83-6 & **22**, 19-44.

KORNECK, D., 1974. Xerotherm vegetation Von Rheinland-Pfalz und Nachbargebieten. *Schriftenr. Vegetationskd.,* **7**, 1-196.

KOVACS, M., 1962. Die Moorwiesen Ungarns. *Die Vegetation ungarischer Landschaften 3.* Budapest.

KUYPER, T.W., LEEUWENBERG, H. & HUBL, E., 1978. Vegetationskundliche Studie an Feucht-, Moor- und Streuwiesen im Burgenland und östlichen Niederösterreich. *Linzer boil. Beit*. **10**, 231-321.

LAMBERT, J., 1965. La Prairie à colchiques: une des plus intéressantes formation végétales d'Ardenne, en voise de disparition. *Netherlands Journal of Agricultural science,* **13**, 129-42.

LEBRUN, J., NOIRFALISE, A., HEINEMANN, P. & VANDEN BERGHEN, C., 1949. *Les Associations végétales de Belgique.* Centre de Recherches écologiques et phytosociologiques de Gembloux, **8**.

LOCKLEY, R.M., 1964. *The Private Life of the Rabbit.* London: Deutsch.

LÖTSCHERT, W., 1973. Pflanzengesellschaften im Rhein-, Main- und Taunus-gebiet. *Jahrb. Nass. Ver. Naturk*. **102**, 16-68.

LUNN, J., 2000. Ecological and nature conservation aspects of mining in the Yorkshire coalfield. Sheffield University MPhil. thesis

LUQUET, A., 1926. *Les associations végétales du Massif des Monts-Dores*.

LUSBY, P. & WRIGHT, J., 1996. *Scottish Wild Plants: their history, ecology and conservation.* Edinburgh: The Stationery Office.

MacKINTOSH, J., 2004. Distribution and extent of unimproved lowland grassland vegetation (NVC) types in Scotland. *Botanical Journal of Scotland,* **56(2)**, 119-146.

MALLOCH, A.J.C., 1988. VESPAN II: A computer package to handle and analyse multivariate species data and handle and display species distribution data. Lancaster: Institute of Environmental & Biological Sciences.

MARRS, R.H., SNOW, C.S.R., OWEN, K.M. & EVANS, C.E., 1998. Heathland and acid grassland creation on arable soils at Minsmere: identification of potential problems and a test of cropping to impoverish soils. *Biological Conservation*, **85**, 69-82.

MARSCHALL, F., 1947. Die Goldhaferwiese (Trisetetum flavescentis) der Schweiz *Beitr. Geobot. Landesaufn. Schweiz,* **26**.

MATUSZKIEWICZ, W., 1984. *Przewodnik do Oznaczania Zbiorowisk Roślinnych Polski.* Warsaw: Państwowe Wydawnictwo Naukowe.

MATTHEWS, J.R., 1955. *Origin and Distribution of the British Flora.* London: Hutchinson.

MESHINEV, T., APOSTOLOVA, I.., GEORGIEV, V., DIMITROV, V., PETRA, A. & VEEN, P., 2005. *Grasslands of Bulgaria.* Sofia: Institute of Botany, Bulgarian Academy of Sciences & Royal Dutch Society for Nature Conservation.

MINELLI, A., 0000. *Italian Habitats.* Volumes 1-15. Udine: Ministerio dell'Ambiente e della Tutela del territorio & Museo Friulano di Storia Naturale.

MOORE, N.W., 1962. The heaths of Dorset and their conservation. *Journal of Ecology*, **50**, 369-391.

MORAVEC, J., 1995. *Rostlinná Společenstva České Republicky.* Pruhonice: Instute of Botany.

MORECROFT, M.D.,.CAPE, J,N., PARR, T.W., BROWN, J.C., CAPORN, S.J.M., CARROLL, J.A., EMMETT, B.A., HARMENS, H., HILL, M.O., LANE, A.M.J., LEITH, I.D., MILLS, G.E., REYNOLDS, B., SHEPPARD, L.J., SMART, S.M. & WOLSELEY, P.A., 2005. *Monitoring the impacts of air pollution (acidification, eutrophication and ground-level ozone) on terrestrial habitats in the UK: A Scoping Study.* NERC Centre for Ecology & Hydrology, Manchester Metropolitan University & the Natural History Museum: Report CPEA 20 to Defra, JNCC, EA, EHS (NI) & EN.

MORRIS, M.G., 1990. The effects of management on the invertebrate community of calcareous grassland. *In:* S.H. HILLIER, D.W.H. WALTON & D.A. WELLS, ed. *Calcareous Grasslands – Ecology and Management,* 128-133. Huntingdon: Bluntisham.

MUCINA, L., GRABHERR, G. & ELLMAUER, T., 1993. *Die Pflanzengesellschaften Österreichs, Teil III.* Jena: Gustav Fischer Verlag.

NAPPER, P., 2003. Genetic fingerprinting of verge populations of *Geranium sylvaticum.* Lancaster University MSc dissertation.

NORDHAGEN, R., 1928. *Die Vegetation und Flora des Sylenegebiets.* Oslo.

NORDHAGEN, R., 1936. Versuch einer Einteilung der supalpinen-alpinen Vegetation Norwegens. *Bergen Museums Årbok,* **7**, 1-88.

NORDHAGEN, R., 1943. *Sikilsdalen og Norges Fjllbeiter. Bergens Museums Skrifter 22.* Bergen: Griegs.

NOWAK, B. & SCHULZ, B., 2002. *Wiesen. Nutzung, Vegetation, Biologie unde Naturschutz am Beispiel der Wiesen des Südschwarzwaldes und Hochrheingebietes. Naturschutz-Spectrum Theme 93.* Ubstadt-Weiher:.Landesanstalt für Umweltschutz Baden-Wurtenberg.

OBERDORFER, E., 1957. Süddeutsche Pflanzengesellschaften. *Pflanzensoziologie,* **10**, 1-564.

OBERDORFER, E., 1978. *Süddentsche Pflanzengesellschaften*. Teil 2. Stuttgart: Fischer.

O'SULLIVAN, A., 1965. *A phytosociological survey of Irish lowland pastures*. University College Dublin PhD thesis.

O'SULLIVAN, A., 1968*a* . Irish Molinietalia communities in relation to those of the Atlantic regions of Europe. *In:* R. TÜXEN ed. *Pflanzensoziologische Systematik,* 273-80. Den Haag: Junk.

O'SULLIVAN, A., 1968*b*. *The Lowland Grasslands (Molinio-Arrhenatheretea) of County Limerick.* Dublin: An Foras Talúntais.

O'SULLIVAN, A., 1969. Grassland: botanical composition, ecology and management. *West Donegal Resource Survey, part 2* 36-47. Dublin: An Foras Talúntais.

O'SULLIVAN, A., 1976. The phytosociology of the Irish wet grasslands belonging to the order Molinietalia. *Colloques Phytosociologiques*, **5**, 259-67.

O'SULLIVAN, A., 1982. The lowland grasslands of Ireland. *Journal of Life Sciences, Royal Dublin Society*, **3**, 131-142.

OWEN, K.M. & MARRS, R.H., 2000. Creation of heathland on former arable land at Minsmere, Suffolk, UK: the effects of acidification on the establishment of *Calluna* and ruderal species. *Biological Conservation*, **93**, 9-18.

OWEN, K.M. & MARRS, R.H., 2001. The use of mixtures of sulphur and bracken litter to reduce pH of former arable soils and control ruderal species. *Restoration Ecology*, **9**, 397-409.

PAAL, J., 1997. *Eesti taimkatte kasvukohatüüpide klassifikatsion.* Tallinn: Tartu Ül kooli Botaanika ja Ökoloogia Instituut.

PAAL, J., 2004. *"Loodusdirektiivi" Elupaigatüüpide Käsiraamat.* Tallinn: Eesti Keskkonnaministerium.

PAAL, J., 2004. *Euroopas väärtustatud Elupaigad Eesti.* Tallinn: Eesti Keskkonnaministerium.

PACHA, M.J., 2004. *Fragmentation of northern hay meadows and populations of* Geranium sylvaticum *in the Yorkshire Dales National Park.* Lancaster University PhD thesis.

PAGE, M.L., 1980. *Phytosociological classification of British neutral grasslands*. Exeter University PhD thesis.

PÅHLSSON, L., 1994. *Vegetationstype I Norden.* Copenhagen: Nordisk Ministeraad.

PASSARGE, H., 1964. Pflanzengesellschaften des nordostdeutschen Flachlandes I. *Pflanzensociologie*, **13**.

PASSARGE, H., 1969. Zur soziologischen Gliederung mitteleuropäischer Frischwiesen. *Feddes Repertorium Berlin*, **80**, 357-72.

PAWŁOWSKI, B., PAWŁOWSKI, S. & ZARZYCKI, K., 1960. Zespoły róslinne kośnych lak północnej oześci Tatr I Podtatrza. Les associations végétales des prairies fauchables de la partie septentrionale des Tatras et de la Région Subtatrique. *Fragm. Florist. Geobott.*, **6**, 95-222.

PAWŁOWSKI, B., PAWŁOWSKI, S. & ZARZYCKI, K., 1962. Badania fitosocjologiczne łak ze szczególnym uwzględnieniem kósnych łak podtatrza I polskich tatr. *Inst. Melioracji I Uzytk. Zielonych. Bibl. 'Wiadomości Imuz'*, **5**, 7-63.

PEPPLER, C., 1992. Die Borstgrasrasen (Nardetalia) Westdeutschlands. *Diss Bot.,* **193,** 1-402.

PEPPLER-LISBACH, C. & PETERSEN, J., 2001. Calluno-Ulicetea (G3) - Teil 1. Nardetalia strictae – Borstgrasrasen. *In:* H. DIERSCHKE *Synopsis der Pflanzengesellschaften Deutschlands*. *Heft*, **8,** 1-205.

PHILIPPI, G., 1960. Zur Gliederung der Pfeifengrasswiesen in südlichen und mittleren Oberrheingebiet. *Beitr.Naturk.Forsch.Sudw-Deut*., **19**, 138-187.

PIGOTT, C.D., 1955. Biological flora of the British Isles: *Thymus* L. genus. *Journal of Ecology,* **43**, 365-000.

PIHL, S. *et al.,* 2001. *Habitat and Species covered by the EEC habitats Directive: A Preliminary Assessment of Distribution and Conservation status in Denmark.* Copenhagen: NERI Technical Report 365.

POTT, R., 1995. *Die Pflanzengesellschaften Deutschlands, 2 Aufl.* Stuttgart: Ulmer.

PRESTON, C.D., PEARMAN, D.A. & DINES, T.D. eds. 2002. *New Atlas of the British & Irish Flora.* Oxford: Oxford University Press.

PROCTOR, J. & WOODELL, S.R.J., 1971. The plant ecology of Serpentine I. Serpentine vegetation of England and Scotland. *Journal of Ecology*, **59**, 375-395.

PROCTOR, M.C.F., 1956. Biological Flora of the British Isles: *Helianthemum* Mill. *Journal of Ecology,* **44**, 675-692.

PROSSER, M.V. & WALLACE, H.L., 1992. *Vegetation changes at West Sedgemoor 1988-92.* Unpublished report to the RSPB.

PROSSER, M.V. & WALLACE, H.L., 1993. *Vegetation monitoring at West Sedgemoor 1993.* Unpublished report to the RSPB.

PROSSER, M.V. & WALLACE, H.L., 1995*a. The status of flood-pasture vegetation at west Sedgemoor following changes in hydrological management.* Unpublished report to the RSPB.

PROSSER, M.V. & WALLACE, H.L., 1995*b. West Sedgemoor: vegetation and hydrological monitoring 1993-1994.* Unpublished report to the RSPB.

PULTENEY, C., 1987. Mire vegetation of the Blackdown Hills and the National Vegeation Classification. Unpublished M.Sc dissertation, University College, London.

RAŠOMAVIČIUS, V., ed., 2001. *Europines Svarbos Buveines Lietuvoje.* Vilnius: Botanikos institutes.

REGNÉLL, G., 1980. A numerical study of successions in an abandoned damp calcareous meadow in S. Sweden. *Vegetatio*, **43**, 123-30.

REGULA-BEVILAQUA, L., 1980. Livadne zajednice razreda Molinio-Arrhenathereta na Strahinščici. *Acta Botanica Croatica,* **39**, 131-40.

RICH, T.C.G., COOPER, E.A., RODWELL, J.S. & MALLOCH, A.J.C., 1993. *Effects of climate change and air pollution on British calcicolous ecosystems.* Lancaster: Unit of Vegetation Science report to the Department of the Environment Air Quality Section.

RIVAS-MARTÍNEZ, S., DIAZ, T.E., FERNÁNDEZ-GONZÁLEZ, IZCO, J., LOIDI, J., LOUSÃ, M. & PENAS, A ., 2002. Vascular Plant Communities of Spain and Portugal. Addenda to the Syntaxonomical Checklist of 2001. *Itinera Geobotanica,* **15***,* 1-922.

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

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

RODWELL, J.S. ed, 1992. *British Plant Communities*. *Volume 3. Grasslands and montane communities*. Cambridge: Cambridge University Press.

RODWELL, J.S. ed, 2000. *British Plant Communities*. *Volume 5. Maritime Communities and Vegetation of Open Habitats*. Cambridge: Cambridge University Press.

RODWELL, J.S., 2004. *Lowland rush-pastures and fen-meadows in Fermanagh.* Report to DoE(NI), Environment & Heritage Service.

RODWELL, J.S. 2006. *National Vegetation Classification: users' handbook*. Peterborough: Joint Nature Conservation Committee.

RODWELL, J.S. & DRING, J., 2001. *European significance of British woodland types*. Lancaster: Unit of Vegetation Science. Report to English Nature.

RODWELL, J.S. & THORNE, K., 2004. *Future landscapes for the Severn/Vyrnwy Land Management Initiative.* Report to the Countryside Agency.

RODWELL, J.S., RICH, T.C.G. & MALLOCH, A.J.C., 1993. The example of calcicolous grasslands and nitrogen. *In*: HORNUNG, M. & SKEFFINGTON, R.A. *Critical loads: Concept and Applications,* pp. 24-30. London: HMSO.

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.* Peterborough: Joint Nature Conservation Committee.

RODWELL, J.S., SCHAMINÉE, J.H.J., MUCINA, L., PIGNATTI, S., DRING, J. & MOSS, D., 2002. *The Diversity of European Vegetation.* Wageningen: National reference centre for Agriculture, Nature & Fisheries.

RODWELL, J.S., HAYES, E.A. & DRING, J., 2001*a*. *Walter Umpleby's Diary: a Database for New house Farm.* Lancaster: Unit of Vegetation Science report to the National Trust and English Nature.

RODWELL, J.S., DRING, J. & HAYES, E.A., 2001*b*. *Walter Umpleby's Diary: Hay-making and Climate at New House Farm.* Lancaster: Unit of Vegetation Science report to the National Trust and English Nature.

RODWELL, J.S. TAYLOR, J. & EDWARDS, A., in press. Productivity of Polygono-Trisetion meadows in the Pennines, northern England. *Annali di Botanica* NS 6.

ROSENBERG, D.B. & FREEDMAN, S.M., 1984. Application of a model of ecological succession to conservation and land-use management. *Environmental Conservation*, **11**, 323-330.

SANDERSON, N.A., 1998. A review of the extent, conservation interest and management of lowland acid grassland in England. *English Nature Research Reports* No. 259. Peterborough: English Nature.

SCHAMINÉE, J.H.J., 1993. *Subalpine heathlands and adjacent plant communities of the Monts du Forez (Massif central, France)*. PhD thesis, University of Nijmegen, the Netherlands.

SCHAMINÉE, J.H.J., & HENNEKENS, S.M. 2006. SynBioSys Europe - examples from European forest communities. *Botanika Chronica,* 18, 201-210.

SCHAMINÉE, J.H.J., STORTELDER, A.H.F. & WEEDA, E.J., 1996. *Die Vegetatie van Nederland, 3 Graslanden, Zomen, Droge Heiden.* Uppsala: Opulus Press.

SCHUBERT, R., HILBIG, W. & KLOTZ, S., 1995. *Bestimmungsbuch der Pflanzengesellschaften Mittel- und Nordostdeutschlands.* Stuttgart: Jena.

SEFFER, J., LASÁK, R., GALVANÉK, D. & STANOVA, V., 2002. *Grasslands of Slovakia.* Bratiuslava: Daphne.

SELISKAR, A., 1993. Vegetacija polavnega obmocja Jovsi ob reki Sotli. *Hladnikia*, **1**, 35-46.

SELLARS, B. & BAKER, A.J.M., 1988. Review of Metallophyte Vegetation and its Conservation. *Nature Conservancy Council CSD Report 797.*

SHEAIL, J., 1971. *Rabbits and their History*. Newton Abbot: David & Charles.

SHIMWELL, D.S., 1968. *The phytosociology of calcareous grasslands in the British Isles.* University of Durham: PhD thesis.

SHIMWELL, D.S., 1971. *Festuco-Brometea* Br.-Bl. Et R.Tx. 1943 in the British Isles: the phytogeography and phytosociology of limestone grasslands. *Vegetatio*, **23**, 1-27 & 29-60.

SIMERAY, J., 1976. *Essaie d'interpretation des groupements végétaux de la region de Saint-Claude en vue d'une synthèse cartographique*. Thèse Université Besancon.

SIMKIN, J.M., 1999. A survey of heavy-metal contaminated sites in the North Pennines. *British Lichen Society Bulletin*, **85**, 29-30.

SIMKIN, J.M., 2003*a*. Lichen survey of North Pennines Lead Mines. *Report to English Nature.*

SIMKIN, J.M., 2003*b*. *Tyne and Allen River Gravels SAC*. Report to English Nature.

SIMKIN, J.M., 2006. *The Vegetation and Management of Calaminarian grasslands in the North Pennines, England*. Newcastle University PhD thesis.

SIMKIN, J.M. & SMITH, R.S., 2003. *Research report on Management Methods for Calaminarian Grassland,* First Year Report to English Nature.

SIMKIN, J.M. & SMITH, R.S., 2004. *Research report on Management Methods for Calaminarian Grassland*. Second Year Report to English Nature.

SIMKIN, J.M. & SMITH, R.S., 2006*.* *Research report on Management Methods for Calaminarian Grassland*. Third Year Report to English Nature.

SIMPSON, N.A. & JEFFERSON, R.G. (1996). The use of farmyard manure on semi-natural (meadow) grassland. *English Nature Research Reports*, No 150. Peterborough: English Nature.

SISSINGH, G., 1969. Über die Systematische Gliederung von Trittpflanzen-Gesellschaften. *Mitteilungen der Floristisch – soziologischen Arbeitsgemeinschaft*, **NF 14,** 179-192.

SJØRS, H., 1954. Sletterangar: grangärde Finnmark. *Acta Phytogeographica Suecica*, 34, 1-135.

SMALL, C., 2002. *Waders, habitats and landscapes in the Pennine Dales*. Lancaster University PhD thesis.

SMETTAN, H.W., 1981. Die Pflanzengesellschaften des Kaisergebirges/Tirol. Dissertation Universität Hohenheim.

SMITH, C.J., ELSTON, J. & BUNTING, A.H., 1971. The effects of cutting and fertiliser treatments on the yield and botanical composition of chalk turf. *Journal of the British Grassland Society,* **26,** 213-217.

SMITH, R.S., 1988. Farming and the conservation of traditional meadowland in the Pennine dales Environmentall Sensitive Area. *In:* USHER, M.B. & THOMPSON, D.B.A. (editors) *Ecological Change in the Uplands. British Ecological Society Special Publication No 7.* Oxford: Blackwell Scientific Publications & British Ecological Society.

SMITH, R.S., 1994. Effects of fertilisers on plant species composition and conservation interest of UK grassland. *In*: HAGGAR, R.J. & PEEL, S. (editors). *Grassland Management and nature Conservation,* 64-73. Occasional Symposium No 28 British Grassland Society. Reading: British Grassland Society.

SMITH, R.S., 1997. Upland meadow grasslands in the Pennine Dales Environmentally Sensitive Area. In SHELDRICK, R.D. (editor) *Grassland Management in the Environmentally Sensitive Areas,* 80-90. Occasional Symposium No 3 British Grassland Society. Reading: British Grassland Society.

SMITH, R.S., 2005. *Ecological mechanisms affecting the restoration of diversity in agriculturally improved meadow grassland.* Report to Defra BD1439.

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

SMITH, R.S. & RUSHTON, S.P., 1994. The effects of grazing management on the vegetation of mesotrophic (meadow) grassland in Northern England. *Journal of Applied Ecology*, **31**, 13-24.

SMITH, R.S., BUCKINGHAM, H., BULLARD, M.J., SHIEL, R.S. & YOUNGER, A., 1996*a*. The conservation management of mesotrophic (meadow) grassland in Northern England. I. Effects of grazing, cutting date and fertiliser on the vegetation of a traditionally managed sward. *Grass and Forage Science*, **51**, 278-91.

SMITH, R.S., PULLAN, S. & SHIEL, R.S. 1996*b*. Seed shed in the making of hay from mesotrophic grassland in a field in northern England: effects of hay cut date, grazing and fertiliser in a split-split-plot experiment. *Journal of Applied Ecology*, **33**, 833-41.

SMITH, R.S., CORKHILL, P., SHIEL, R.S. & MILLWARD, D., 1996*c*. The conservation management of mesotrophic (meadow) grassland in Northern England II. Effects of grazing, cutting date, fertiliser and seed application on the vegetation of an agriculturally improved sward. *Grass and Forage Science,* **51**, 292-305.

SMITH, R.S., SHIEL, R.S., MILLWARD, D. & CORKHILL, P., 2000. The interactive effects of management on the productivity and plant community structure of an upland meadow: an 8-year field trial. *Journal of Applied Ecology*, **37**, 51-64.

SMITH, R.S., PEACOCK, S., SHEIL, R.S., BARDGETT, R.D., SIMKIN, J.M., HOBBS, P.J. & QUIRK, H., 2005. *Effect of residual fertility, FYM amendments and* Rhinanthus minor *on the diversity and species composition of meadow vegetation on soil microbes and VA-mycorrhizal colonisation of plant roots and on plant nutrient content in a mesocosm experiment.* Report to Defra D1439.

SMITH, U.K., 1979. Biological flora of the British Isles: *Senecio integrifolius* (L.) Clairv. *Journal of Ecology,* **67**, 1109-1124.

SOUGNEZ, N., 1957. *Texte explicatif de la carte phytosociologique de Henri-Chapelle (Planchette 123 W).* Bruxelles.

SOUGNEZ, N. & LIMBOURG, P., 1963. Les herbages de la Famenne et de la Fagne. *Bulletin de l'Institut agronomique et des Stations de Recherches de Gembloux*, **31(3)**, 359-413.

ŠPANIKOVA, A., 1983. Rastline spoločenstva radu Molinietalia W. Koch 1926 na Slovensku. *Acta Botanica Slovaca, ser. A,* **7**, 1-135.

SPALDING, A., 2005. The nature conservation value of abandononed metalliferous mine sites in Cornwall. *British Wildlife,* **February 2005**, 175-83.

SPENCE, D.A., 1957. Studies on the vegetation of Shetland. I. The serpentine debris vegetation in Unst. *Journal of Ecology*, **45**, 917-945.

SPENCER, J. & HAWORTH, R., 2005. *Heathland on the Forestry Commission Estate in England*. Bristol: Forestry Commission England.

SSYMANK, A. *et al.*, 1998. *Das europäische Schutzgebietssyetm NATURA2000.* Bonn: Bundesamt für Naturschutz.

STACE, C.A., 1997. *New Flora of the British Isles.* Second edition. Cambridge: Cambridge University Press.

STATE INSTITUTE FOR NATURE PROTECTION, 2004. *Habitat Types in Croatia.* On http://www.cro-nen.hr

STEWART, A., PEARMAN, D.A. & PRESTON, C.D., 1994. *Scarce Plants in Britain.* Peterborough: Joint Nature Conservation Committee.

STUCHILKOWA, B., 1967. Zespoły łąkowe pasma Policy w Karpatach Zachodnich. Meadow associations of the Polica Range (Polish Western Carpathians). *Fragmenta Florist. Geobot*., **13**, 357-402.

SZAFER, W., PAWŁOWSKI, B. & KULCZYŃSKI, S., 1927. Die Pflanzenassoziationen des Tatra-Gebirges. III. Die Pflanzenassoziationen des Kościeliska-tales. *Bull. Internat. Acad. Polon. Sci. et Lettres, Suppl.,* **2**, 13-78.

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.

TALLOWIN, J.R.B., KIRKHAM, F.W., SMITH, R.E.N. & MOUNTFORD, J.O., 1998. Residual effects of phosphorus fertilisation on the restoration of floristic diversity to wet hay meadows. *In:* C.B. JOYCE & P.M. WADE, eds., *European Lowland Wet Grasslands: Biodiversity, Management and Restoration.*, London: John Wiley, 249-263.

TALLOWIN, J.R.B., SMITH, R.E.N., PYWELL, R.F., GOODYEAR, J. & MARTYN, T., 2002. Use of fertiliser nitrogen and potassium to reduce soil phosphorus availability. *In* J.FRAME, ed. *Conservation Pays? Reconciling Environmental Benefits with Profitable Grassland Systems*, British Grassland society Occasional Symposium 36, Reading: BGS, 163-166.

TAYLOR, J., 2004. *Productivity of Traditional Pennine Hay Meadows.* Lancaster University MSc thesis.

TELES, A.N., 1970. Os Lameiros de Montanha do norte de Portugal. *Separata da agronomia Lusitana*, **31**, 1-130.

THEURILLAT, J-P., 1992 Les Prairies à Trisetum flavescens (L.) P. Beauv. (Triseto-Polygonion) dans la région d'Aletsch (Valais) et en Suisse. *Candollea,* **47**, 319-56.

THOMPSON, R. & RODWELL, J.S., 2004. Mapping soils and vegetation – soilscapes and ecoscapes. *Soils and Nature Conservation Newsletter of the Soils Lead Conservation Network*, **3**.

TRAUTMANN, W., 1973. Vegetationkarte des Bundesrepublik Deutschland 1:200 000 – Potentielle naturliche Vegetation – Blatt CC5502. *Schriftenr. F. Vegetationskd,* **6**, 7-172.

TUBBS, C.R., 1986. *The New Forest*. London: Collins.

TUBBS, C.R., 1991. Grazing the lowland heaths. *British Wildlife*, **2**, 276-291.

TÜXEN, R., 1937. Die Pflanzengesellschaften Nordwestdeutschlands. *Mitteilungen der Floristisch-soziologischen Arbeitsgemeinschaft,* **3**, 1-170.

TÜXEN, R., 1955. Das System der nordwestdeutschen Pflanzengesellschaften. *Mitteilungen der Floristisch-soziologischen Arbeitsgemeinschaft*, **NF5**, 155-176.

TÜXEN, R. & OBERDORFER, E., 1958. Eurosibirische Phanerogamen-Gesellschaften Spaniens mit Ausblicken auf die Alpine- und die Mediterran-Region dieses Landes. *Veröffentlichungen des Geobotanischen Institutes Rübel in Zurich*, **32**, 1-328.

TÜXEN, R. & PREISING, E., 1951. Erfahrungsgrundlagen fur die pflanzensoziologische Kartierung des westdeutschen Grunlandes. *Angewandte Pflanzensoziologie*, **4**, 1-28.

UBALDI, D., 1978. The *Cynosurus cristatus* meadows in the Montefeltro (Italy). *Notizario della Societa Italiana di Fitosociologia*, **13**, 13-21.

UK BIODIVERSITY STEERING GROUP, 1995. *Biodiversity: the UK Steering Group Report*. Volume 2: Action Plans. London: HMSO.

UK BIODIVERSITY GROUP, 1998. *Tranche 2 Action Plans. Volume 2. Terrestrial and Freshwater Habitats*. Peterborough: English Nature.

VAINIO, M, KAKALAINEN, H., ALANEN, A. & PYKALA, J., 2001. *Traditional rural biotopes in Finland.* Helsinki: Finnish Environment Institute.

VALACHOVIČ, M., 1995. *Rastlinné Spoločenstvá Slovenska, 1. Pionierska Vegetácia.* Bratislava: Slovenska académia vied, Botanický ustar.

VICENÍKOVÁ, A. & POLÁK, P., 2003. Európsky významné biotopy NA SLOVENSKU. Bratislava: Daphne Institute of Applied Ecology.

VICHEREK, J., ANTONIN, V., DANIHELKA, J., GRULICH, V., GRUNA, B. HRADILEK, Z., ŘEHOŘEK, V.. ŠUMBEROVA.,K., VAMPOLA, P & VÁGNER, A., 2000. *Flora e vegetace na soutoka Moravy a Dyje.* Brno: Mararykova universita.

VOGEL, A. (1977). *Die Wiesengesellschaften des Westharzes.* Gottingen University Diplome.

WALKER, K.J., STEVENS, P.A., STEVENS, D.P., MOUNTFORD, J.O., MANCHESTER, S.J. & PYWELL, R.F., 2004. The restoration and recreation of species-rich lowland grassland on land formerly managed for intensive agriculture in the UK. *Biological Conservation*, **119**, 1-18.

WARD, L.K., 1990. Management of grassland-scrub mosaics. *In:* S.H. HILLIER, D.W.H. WALTON & D.A. WELLS, eds. *Calcareous Grasslands – Ecology and Management,* 134-139. Huntingdon: Bluntisham.

WATT, A.S., 1940. Studies in the ecoloty of Breckland. IV. The grass heath. *Journal of Ecology*, **28**, 42-70.

WATT, A.S., 1957. The effects of excluding rabbits from Grassland B (Mesobrometum) in Breckland. *Journal of Ecology*, **45**, 861-878.

WATT, A.S., 1974. Senescence and rejuvenation in ungrazed chalk grassland (Grassland B) in Breckland: the significance of litter and moles. *Journal of Applied Ecology*, **11**, 1157-1171.

WATT, A.S., 1981. Further observations on the effects of excluding rabbits from Grassland A in East Anglian Breckland: the pattern of change and factors affecting it (1936-73). *Journal of Ecology*, **69**, 509-536.

WEEDA, E.J., SCHAMINEE, J.H.J 7 VAN DUUREN, L., 2002. *Atlas van Plantengemeenschappen in Nederland.* Utretcht: KNNV Uitgeverij.

WELLS, T.C.E., 1968. Land-use changes affecting *Pulsatilla vulgaris* in England. *Biological Conservation*, **1**, 37-43.

WELLS, T.C.E., 1969. Botanical aspects of conservation management of chalk grasslands. *Biological Conservation*, **2**, 36-44.

WELLS, T.C.E., 1971. A compartison of the effects of sheep grazing and mechanical cutting on the structure and botanical composition of chalk grassland. *In* E. DUFFEY &

A.S. WATT, *The Scientific Management of Animal and Plant Communities for* Conservation, 497-515. Oxford: Blackwell.

WELLS, T.C.E. & COX, R., 1993. The long-term effects of cutting on the yield, floristic composition and soil nutrient status of chalk grassland. *English Nature Research Reports,* No 71. Peterborough: English Nature.

WESTHOFF, V. & DEN HELD, A.J., 1969. *Plantengemeenschappen in Nederland.* Zutphen: Thieme & Cie.

WHEELER, B.R. & HUTCHINGS, M.J., 2002. *Phyteuma spicatum* L. Biological flora of the British Isles. *Journal of Ecology,* 90, 581-91.

WHITE, J & DOYLE, G., 1982. The Vegetation of Ireland: a Catalogue Raisoné*. Journal of Life Sciences of the Royal Dublin Society,* 289-368.

WIGGINTON, M.J. ed., 1999. *British Red Data Books. 1. Vascular Plants.* 3rd edition. Peterborough: Joint Nature Conservation Committee.

WILLEMS, J.H., 1978. Observations on North-West European limestone grassland communities: phytosociological and ecological notes on Chalk grasslands of southern England. *Vegetatio*, **37**, 141-150.

WILLIAMS, J.M. ed., 2006. *Common Standards Monitoring for Designated Sites: First Six Year Report.* Peterborough: JNCC.

WILMANNS, O., 1956. Die Pflanzengesellschaften der Äcker uner des Wirtschaftsgrunlandes auf der Reutlinger Alb. *Beitr. Naturkdl. Forsch. SW-Dtschl.* **15,** 30-51.

WILMANNS, O., 1998. *Ökologische Pflanzensoziologie.* Wiesbaden: Quelle und Meyer Verlag.

ZELNIK, I., 2005. Meadows of the order Molinietalia caerulea Koch 1926 in south-eastern Slovenia. *Fitosociologia*, **42**, 3-32.

ZUIDHOFF, A.C., RODWELL , J.S. & SCHAMINEE, J.H.J., 1995. The Cynosurion cristati Tx. 1947 of central, southern and western Europe: a tentative overview, based on the analysis of individual releves. *Annali di Botanica* **LIII**, 25-47.

Web references

http://www.camarthenshire.gov.uk
for details of the Mynydd Mawr Project
[Accessed January 2007]

http://www.cro-nen.hr
for details of the Habitats Directive interpretation in Croatia.
[Accessed January 2007]

http://www.defra.gov.uk/research
for details of the 3-year programme of assessment of sustainability and dynamics in restored Lowland Dry Acid Grassland
[Accessed January 2007]

http://www.ecn.ac.uk
for details of the Porton Down Environmental Change network site
[Accessed January 2007]

http:/www.eunis.eea.europa.en/related-reports.jsp
for details of the EUNIS Habitat Classification
(Accessed January 2007)

http://www.gisvlaanderen
for the Habitats Directive interpretation in Flanders, Belgium.
[Accessed January 2007]

http://www.icn.pt/psrn2000
for details of the Habitats Directive interpretation in Portugal
[Accessed January 2007]

http://www.natural-england.org.uk/thh
for details of the Tomorrow's Heathland heritage Project
[Accessed January 2007]

http://www.rothamsted.ac.uk
for details of the long-term Rothamsted plots
[Accessed January 2007]

http://www.rspb.org.uk/england/southwest/conservation/salisbury_life_project.asp
for details of the Salisbury Plain EU Life Project
[Accessed January 2007]

http://www.rspb.org.uk/supporting/campaigns/wildplaces/manorfarm/index.asp
for details of the Manor Farm Project
[Accessed January 2007]

http://www.staff.ncl.ac.uk/r.s.shiel/Palace_Leas/index.html
for details of the long-term Palace leas grassland plots
[Accessed January 2007]

http://www.ukhap-reporting.org.uk
for details of the Biodiversity Action Reporting System
[Accessed January 2007]

www.butterfly-conservation.org/ne.news/culm-grasslands.html
for details of the Culm Grasslands Project
[Accessed January 2007]

www.countryside-management.org.uk
for details of the Downlands Project
[Accessed January 2007]

www.ehsni.gov.uk
for details of the Northern Ireland Habitat Action Plans
[Accessed January 2007]

www.eurosite-nature.org
for details of the Eurosite initiative
[Accessed January 2007]

www.floralocale.org
for details of Flora locale and the Yorkshire Dales Hay Time project
[Accessed January 2007]

www.grazinganimalsproject.org
for details of the work of the Grazing Animals Project
[Accessed January 2007]

www.iavs.org
for details of the European Vegetation Survey, a Working Group of the International Association for Vegetation Science
[Accessed January 2007]

www.lincstrust.org.uk
for details of the Lincolnshire & Rutland Limestone Project
[Accessed January 2007]

www.monmouthshiregreenweb.co.uk
for details of the Monmouthshire Meadows Group
[Accessed January 2007]

www.parishgrasslandsproject.org.uk
for details of the Parish Grassland Project
[Accessed January 2007]

www.shropshirehillsaonb.co.uk/bluehills/wildlifesites.htm
for details of the Blue Remembered Hills Project
[Accessed January 2007]

www.ukbap.org.uk
for details of the UK Biodiversity Habitat Action Plans
[Accessed January 2007]

www.ukbap.org.uk/BAPGroupPage.aspx?id=98
for areas of UK Lowland Grasslands
(Accessed January 2007)

Appendix 1 UK Lowland Grassland distribution: data sources and quality

The great majority of records on UK Lowland Grasslands come from three main sources, which are defined below. Table 7 summarises their characteristics.

UK lowland grassland database

This is a large and important collection of Lowland Grassland community records for the whole of Great Britain. It is currently being improved and developed as a tool for data storage and reporting of HAP work. It is unusual in that it can store quadrat or rélevée records as well as biotope summary information and can therefore be used to validate community records, to assess change, and for other ecological and phytosociological analysis. So far detailed quadrat records are available for Wales and England and summary community information is available for Scotland.

Priority habitat inventories for England

Each Biodiversity Action Plan priority habitat has an individual inventory which represents English Nature's best assessment of its distribution, based on existing available datasets, including earlier versions of the two other main sources used in this European project. It was based on the digitised version of the published, paper, lowland grassland inventory (English Nature 1993-; Jefferson 1997), which was refined by reference to aerial photographs and archived field records. In some areas Local Record Centres also helped to up-date the inventory.

To extract community records, the data were filtered using MapInfo software to select the relevant polygons, which were then assigned to the relevant 10km squares.

More detailed metadata for this dataset are available from Nature on the Map (http://www.natureonthemap.org.uk with links below) where the inventories can also be viewed as maps.

Purple moorgrass & rush pasture
http://www.natureonthemap.org.uk/bap/metadata/pdf/M_NBNSYS0000004620_V1_1.pdf

Lowland meadows
http://www.natureonthemap.org.uk/bap/metadata/pdf/M_NBNSYS0000004613_V1_1.pdf

Lowland calcareous grassland
http://www.natureonthemap.org.uk/bap/metadata/pdf/M_NBNSYS0000004615_V1_1.pdf

Lowland dry acid grassland
http://www.natureonthemap.org.uk/bap/metadata/pdf/M_NBNSYS0000004617_V1_1.pdf

Upland hay meadows
http://www.natureonthemap.org.uk/bap/metadata/pdf/M_NBNSYS0000004614_V1_1.pdf

English Nature's SSSI notified features database

This is an evolving dataset about SSSI being being up-graded in 2006-9. At the time of data collation for this report, data could be attributed to named SSSI, but not to SSSI unit. The level of detail is greater than broad habitat types and often includes NVC community records.

Table 7: Main sources of NVC data from Great Britain

	UK lowland grassland database	England: priority habitat inventories	England: SSSI notified features database
Scope and size	All Lowland Grassland habitats: **England**: >8000 sites; field data collected between 1981 and 1999 **Wales**: >1000 sites; field data collected between 1987 and 2004 **Scotland**: c650 sites; field data collected between 1983 and 2001	Lowland Calcareous Grassland: >4500 sites Lowland Meadows: >5000 sites Upland Hay Meadows: 250 sites Purple Moorgrass and Rush Pasture: >3000 sites Lowland Dry Acid Grassland: >1500 sites	>4000 Sites of Special Scientific Interest (habitats, species and geology)
Origin	Phase 2 field survey data	Site habitat maps digitised in the early 1990's, to broad habitat level.	Part of the information system for Designated Sites.
Strengths	• Data were quality assured (QA) • Relevee (quadrat) data • NVC communities recorded • Most data backed up by detailed field cards • Reasonable data for extent • Full coverage in Wales	• GIS inventories • Some up-dating	• Linked to SSSI GIS data at level of whole site. • Base-data more stable than those for undesignated areas, as these sites are protected by statute.
Weaknesses	• Not a GIS inventory, ie no polygons, just grid references • Not fully up-to-date • In England, NVC determinations often cautious, leading to intermediates • English data were collected piecemeal, without consistent data standards • Significant gaps, particularly in England	• QA may have been inconsistent • Extent is not always of a single NVC community • NVC data not consistently recorded	• Imprecise linking to GIS polygons so no useful extent data • QA may be inconsistent as up-grade incomplete.

For two habitats, additional sources were used. These are shown in Table 8.

Table 8: Additional sources of NVC data from Great Britain

Habitat	Community	Source and notes
Lowland Meadows	MG4	Gowing and others (2002). A spreadsheet of site data which were used to compile Appendix 1 of David Gowing's report formed the basis for most of the English records reported here.
Calaminarian grassland	OV37 (and others)	Jackson & McLeod (2000). Spreadsheets showing the 10 km square records shown on the maps in the report (also viewable on the JNCC website) were made available from JNCC. Colleagues in the country agencies were consulted to separate squares containing at least some lowland sites from those which are exclusively upland in character. Two additional Welsh squares came from Averis and others (2004). (TBC).

Data quality in the NVC distribution maps

The maps of the UK distribution of the NVC communities (Figures 4-13, 16-20, 23-25, 30-34) could easily give a misleading impression to those who are not aware of the sources and limitations of the records. In particular they could give a visual over-estimate of the abundance of habitats which are widely but very thinly distributed, many of which have suffered severe decline and fragmentation and continue to be threatened.

An example

As an example, consider the Lowland Meadow community MG5 *Centaurea nigra – Cynosurus cristatus* grassland, the 2005 known distribution map for which is shown below as Figure 40. Each dot on the map means that vegetation matching or related to MG5 has been recorded from that square since 1980. It gives no information about the accuracy of the determination beyond the quality assurance incorporated into the various sources. It gives no information about the extent of the community now or in the past.

Precision of records

Many of the English records are of intermediate vegetation types. Intermediates (see Table 9 for examples) are recorded where surveyors feel that vegetation is truly intermediate between two or more communities, or where they wish to denote the affinities of vegetation for more than one community. There is little standardisation between competent, reputable surveyors on this matter. Some value the depth of information which can be recorded using intermediates (which reflects the real complexity of semi-natural vegetation), while others prefer the clarity of recording a 'best fit' determination based on expert knowledge (they assume that data users will be aware of the innate breadth of the community types and rely on the quadrat data as a 'voucher' of their judgement).

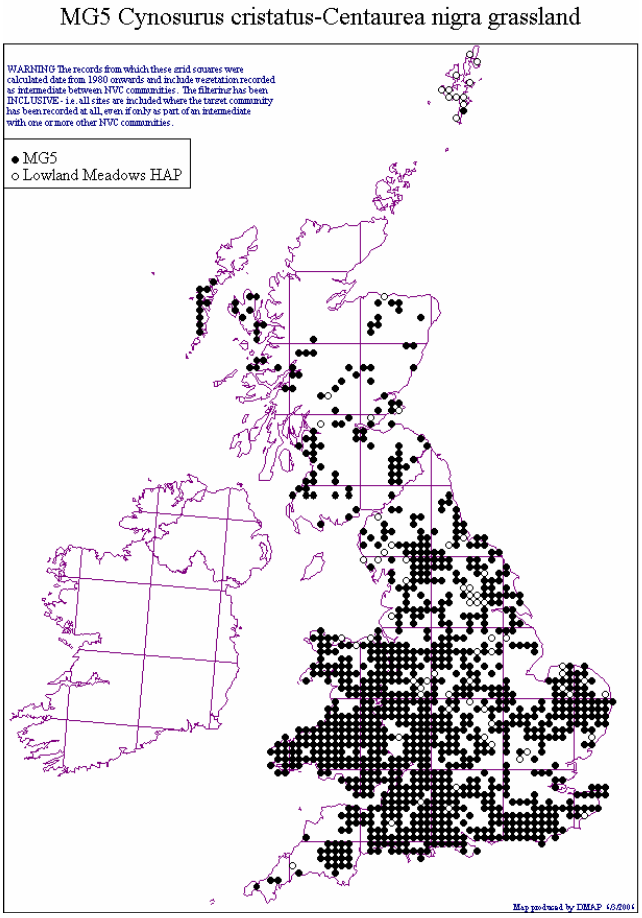

Figure 42 Distribution of MG5 Centaurea-Cynosurus grassland in Great Britain (2005)

In the English part of the UK database, a large number of intermediates have been recorded. For example 178 intermediates including MG5 are recorded, all of which would be included in our maps. They include the following:

Table 9 Examples of MG5 intermediates recorded in England

Spread of intermediate	Within MG5	Within mesotrophic grasslands	Within grassland	With other vegetation classes
Examples	MG5/MG5a	MG6/MG5b	CG10a/MG5b	H8/MG5c
	MG5a/MG5b	MG5a/MG4	CG6a/CG6b/MG5b/CG2b/CG3c	MG9/MG5/MG6/M27
	MG5a/MG5c	MG6/MG5	MG8/MG5a/M25/M10b/M25	
		MG5c/MG5b/MG5a/MG6	MG5a/MG10a/M22b	

Thus although we are reasonably confident that the dots on the map represent the judgement of a competent botanist that MG5-related vegetation has occurred there, we cannot be precise about the nature of the vegetation.

Presence in 2006

We cannot be sure that all sites which contributed records to the maps still contain the plant communities which were recorded. Therefore some of the squares may no longer hold any of the relevant habitat. Surveillance of undesignated sites is inadequate for us to quantify this potential source of error for the whole of the UK. We do however know that losses of semi-natural grasslands have continued throughout the period during which the records were collected, i.e. since 1980. For example Hewins and others (2005) showed that out of a sample of 108 non-SSSI lowland meadow sites from English Nature's Lowland Meadows Priority Habitats Inventory, 41 are no longer BAP priority grassland.

Alternative approaches to mapping extent

Not all of our sources allow an estimate to be made of extent, for example the priority habitat inventories measure extent at the level of broad habitat rather than NVC community. Of those that do record NVC communities by extent, it is not measured at all sites. This means that it is impossible to make really comprehensive maps which show the extent as well as the distribution of each community. It is for this reason that we chose to map only known distribution in its broadest sense.

Where extent is known, it is possible to produce maps which give a much more realistic impression of a community's abundance. For example Figure 43 shows 2005 extent data from the UK Lowland Grassland Database, expressed as extent and as the percentage of the total surface area of each ten km square (land and sea) which is recorded as MG5 in the database.

Comparing Figures 42 and 43 shows that a number of occurrences are left out of the latter, most especially in southwest England: this map is therefore not as accurate as the first. It does however give a more realistic impression of the scarcity of the habitat in the UK and is in that sense more precise.

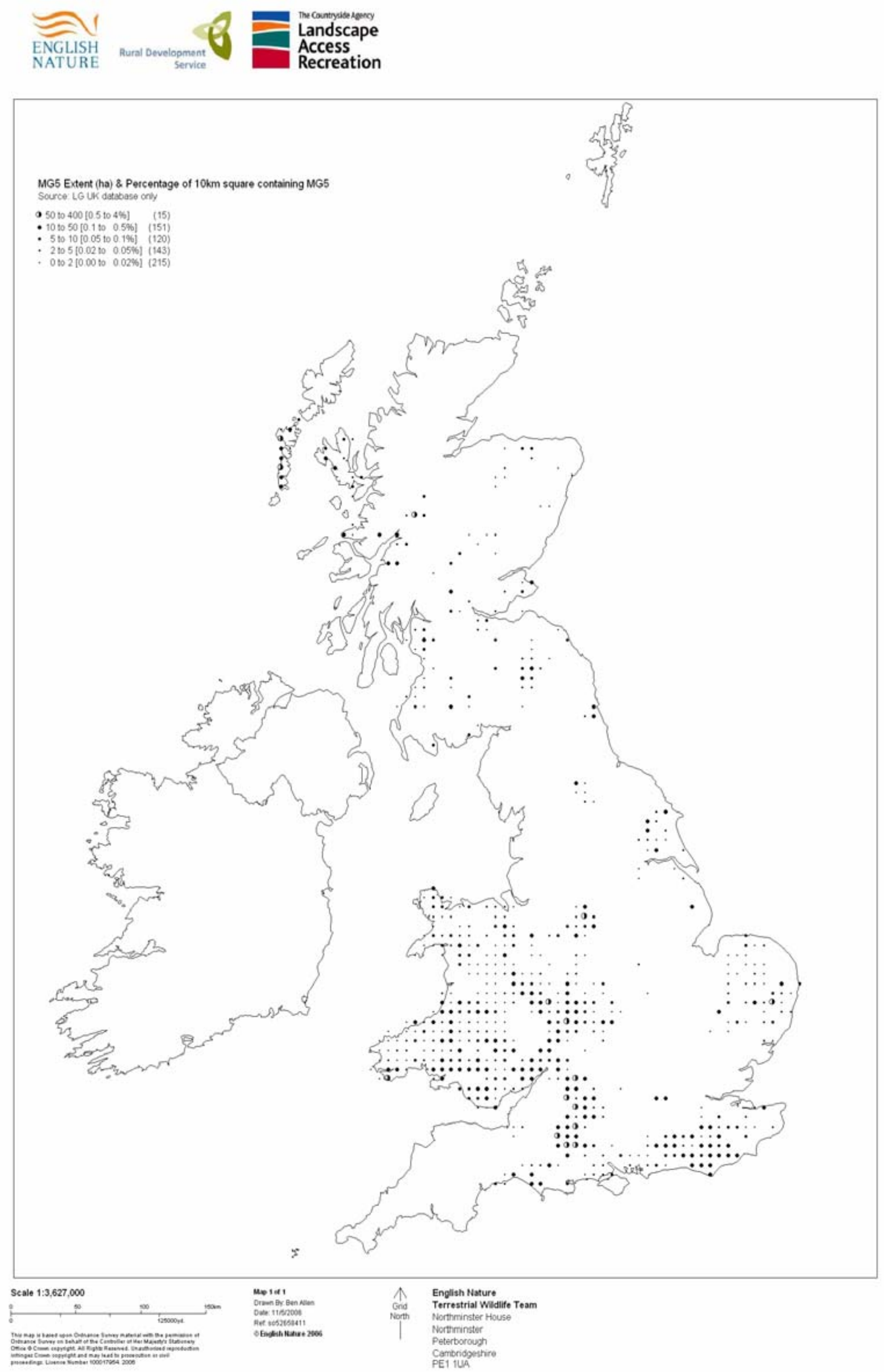

Figure 43 Distribution of MG5 in Great Britain by recorded extent

The Welsh dataset is more complete than the others, so a comparison of two maps just for Wales shows more clearly how the use of data on extent can give a more meaningful map, as shown in Figure 44.

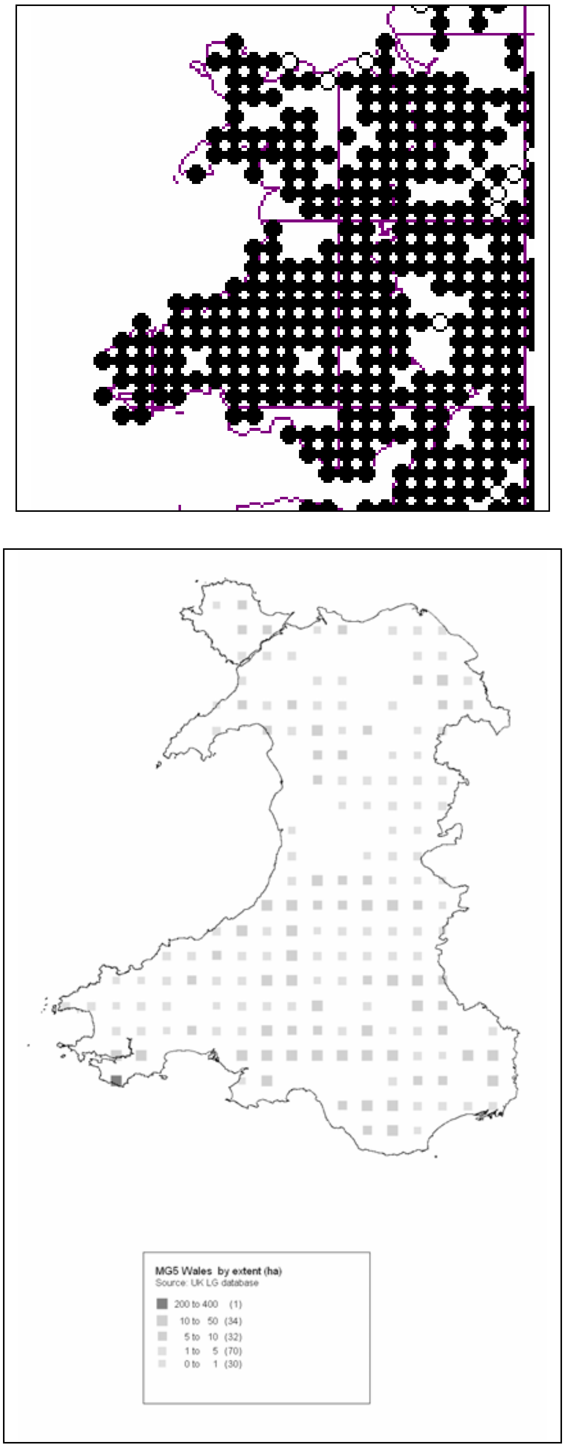

Figure 44 MG5 in Wales: maps of distribution and extent (2005)

Fragmentation

Even where we have records of the extent of habitats at particular sites, we do not usually have digitised information about patch sizes. In many surveys, extent figures are summed for each site to give a total for each community or sub-community. Where detailed habitat maps have been digitised into GIS applications, as in Wales, it would be possible to measure and analyse patch size. We have not attempted it in this project.

Different surveys have adopted differing definitions of an individual site: some based on individual fields or management units, some on whole farms or other large units. In the latter case, figures for extent may suggest larger patch sizes than really exist. Conversely, small patches of MG5 vegetation can occur as part of larger patches of semi-natural grassland, in which case extent figures reflect patch size only in the narrowest sense, which may not be key to the conservation and survival of MG5 grassland.

Nonetheless extent can be cautiously accepted as an adequate surrogate for true patch size, and it can be seen from Table 10 that MG5 is highly fragmented in all three countries.

Table 10 Statistics for extent (ha) of MG5 recorded at each site in the UK lowland grassland database in 2005

	England	**Scotland**	**Wales**
Average (mean) (ha)	2.88	2.87	2.5
median (ha)	1.41	1.35	1
maximum (ha)	94	31.9	361.7
minimum (ha)	0.01	0.05	0.1
Number of records	1751	294	639

Appendix 2 Habitats Directive interpretation manuals & related sources

Albania

HODA, P., MERSINLLARI, M., MULLAJ, A., RODWELL, J., DRING, J. & PIGNATTI, S., 1999. *Vegetation of Albania: Preliminary Conspectus.* Lancaster: Unit of Vegetation Science Report to the Darwin Initiative.

Austria

ELLMAUER, T. & TRAXLER, A., 2000. *Handbuch der FFH-lebensraumtypen Őesterreichs.* Vienna: Umweltsbundesamt Őesterreichs.

ESSL, F. *et al*., 2004. *Rote Liste der Gefährdeten Biotoptypen Österreichs.* Vienna: Umweltsbundesamt Österreichs.

Belgium

For Flanders: http://www.gisvlaanderen.be/geo-vlaanderen/ 3fagrapporter/ abstrakter/abs 3675 uk.asp

For Wallonia: http://www.wallonie.be/dgrne/sibw/sites/Natura2000/habitatliste

Bulgaria

MESHINEV, T., APOSTOLOVA, I.., GEORGIEV, V., DIMITROV, V., PETRA, A. & VEEN, P., 2005. *Grasslands of Bulgaria.* Sofia: Institute of Botany, Bulgarian Academy of Sciences & Royal Dutch Society for Nature Conservation.

KAKRUKOVA, V., DIMOVA, D., DIMITROV, M., TZONEV, R. & BELEV, T. Editors, 2005. *Rukovodstvo za opredelyane na mestoobitaniya ot evropejska znachimost v Bulgaria* (*Manual for a determination of habitats with European importance in Bulgaria).* Sofia: Geosoft EOOD.

Croatia

STATE INSTITUTE FOR NATURE PROTECTION, 2004. *Habitat Types in Croatia.* On http://www.cro-nen.hr

DEVILLERS, P. & DEVILLERS-TERSCHUREN, J., 2001. *Application & development of the Palaearctic habitat classification: Croatia.* Strasbourg: Council of Europe.

Cyprus

DEVILLERS, P. & DEVILLERS-TERSCHUREN, J., 2000. *Application & development of the Palaearctic habitat classification: Cyprus.* Strasbourg: Council of Europe.

See also Biocyprus CD and Antonio Antonius in the Ministry of the Environment, Cyprus.

Czech Republic

CHYTRY, M,, KUČERA, T. & KOČI, M., 2001. *Katalog biotopů České republiky.* Prague: Agentura ochramy přírody a Krajiny ČR.

Denmark

PIHL, S. *et al.,* 2001. *Habitat and Species covered by the EEC habitats Directive: A Preliminary Assessment of Distribution and Conservation status in Denmark.* Copenhagen: NERI Technical Report 365.

BUCHWALD, E. & SOGAARD, S., 2000. *Danske naturtypr i det europaeiske NATURA 200 netvaerk.* Copenhagen: Miljø- og Energiministeriet Naturstyrelsen.

Estonia

ANON, 2001. *The Inventory of Seminatural Grasslands in Estonia 1999-2000.* Tartu: Estonian Fund for Nature & Royal Dutch Society for Nature Conservation.
PAAL, J., 1997. *Eesti taimkatte kasvukohatüüpide klassifikatsion.* Tallinn: Tartu Ül kooli Botaanika ja Ökoloogia Instituut.
PAAL, J., 2004. *"Loodusdirektiivi" Elupaigatüüpide Käsiraamat.* Tallinn: Eesti Keskkonnaministerium.
PAAL, J., 2004. *Euroopas väärtustatud Elupaigad Eesti.* Tallinn: Eesti Keskkonnaministerium.
DEVILLERS, P. & DEVILLERS-TERSCHUREN, J., 2002. *Application & development of the Palaearctic habitat classification: Baltic States.* Strasbourg: Council of Europe.

Finland

VAINIO,M, KAKALAINEN, H., ALANEN, A. & PYKALA, J., 2001. *Traditional rural biotopes in Finland.* Helsinki: Finnish Environment Institute.

France

BENSETTITI, F., BOULLET, V., CHAVAUDRET-LABORIE, C & DENIAUD, J., 2005. *Cahiers d'habitats Natura 2000.* Paris: La Documentation française.
And, for example, for one region and organised by alliance: Bournerias, M., Arnal, G. & Bock, C (2001). *Guide des Groupements vegetaux de la region Parisienne.* Paris: Belin.

Germany

SSSYMANK, A. et al., 1998. *Das europäische Schutzgebietssyetm NATURA2000.* Bonn: Bundesamt für Naturschutz.
BALZER,S. & SSYMANK,A., 2005. *Natura 2000 in Deutschland.* Bonn: Bundesamt für Naturschutz
and, for about 10 Länder, for example, BENTLER, H. & BEUTLER, D., 2002. *Naturschutz und Landschaftspflege in Brandenburg.* Potsdam: Landesumweltsamt Brandenburg Abt. Naturschutz.

Greece

Οδηγος Παρακολογουθησης Τυπη Οικοτοπωη & Φυτικων Ειδων
(DIMOPOULOS, P., BERGMEIER, E., THEODOROPOULOS, K., FISCHER, P & TSIAFOULI, M., 2006. *Monitoring Guide for habitat Types and Plant species in the Natura 2000 sites of Greece.* University of Ioannina & Hellenic Ministry for the Environment, Physical Planning & Public Works. Agrinio. With English summary)

Hungary

BORHIDI, A. & ANTAL, S., 1999. *Vörös Könyv: Magyarország Növénytársulásairól* Volumes 1 & 2. Budapest: Természet BÚVÁR Alapítvary Kiadó.

Iceland

DEVILLERS, P. & DEVILLERS-TERSCHUREN, J., 2002. *Application & development of the Palaearctic habitat classification: Iceland.* Strasbourg: Council of Europe.

Ireland
FOSSIT, J., 2000. *A Classification of Irish Habitats.* Dublin: The Heritage Council

Italy
MINELLI, A. (undated). *Italian Habitats.* Volumes 1-15. Udine: Ministerio dell'Ambiente e della Tutela del territorio & Museo Friulano di Storia Naturale.

Latvia
KABUCIS, I., 2000. *Biotopu rokasgrâmata: Eiropas Savienības aizsargājamie biotope Latvijā.* Riga: Latvijas Dabas Fonds.
DEVILLERS, P. & DEVILLERS-TERSCHUREN, J. (2002). *Application & development of the Palaearctic habitat classification: Baltic States.* Strasbourg: Council of Europe.

Lithuania
RAŠOMAVIČIUS, V. (editor), 2001. *Europines Svarbos Buveines Lietuvoje.* Vilnius: Botanikos institutes.
DEVILLERS, P. & DEVILLERS-TERSCHUREN, J., 2002. *Application & development of the Palaearctic habitat classification: Baltic States.* Strasbourg: Council of Europe.

Malta
DEVILLERS, P. & DEVILLERS-TERSCHUREN, J., 2001. *Application & development of the Palaearctic habitat classification: Malta.* Strasbourg: Council of Europe.

Netherlands
JANSSEN, J. & SCHAMINÉE, J.H.J., 2003. *Habitattypen.* Utrecht: KNNV Uitgeverij.

Norway
FREMSTAD, E., 1997. *Vegetatsjonstyper I Norge*. Trondheim: Norsk Institutt for natursforskning.
FREMSTAD, E., 2002. *Natura 2000 in Norway* on http://www.ntnu.no/vmuseet/botavd/Nat2000iN.pdf

Poland
HERBICHA, J., 2004. *Poradniki ochrony siedlisk I gatunkow Natura 2000 – podręcznik metodyczny.* Volumes 1-9. Warszawa: Ministerstwo Środowiska ul Wawelska.

Portugal
http://www.icn.pt/psrn2000/caract habitat.htm
and for the maps http://www.icn.pt/psrn2000/cartog habitat.htm

Romania
DONITĂ, N., POPESCU, A., PAUCĂ-COMĂNESCU, M., MIHĂILESCU. & BIRIŞ, I-A., 2005. *Habitatele din România.* Bucuresti: Editura Tehnică Silvică

Slovakia
SEFFER, J., LASÁK, R., GALVANÉK, D. & STANOVA, V., 2002. *Grasslands of Slovakia.* Bratiuslava: Daphne.
VICENÍKOVÁ, A. & POLÁK, P., 2003. Európsky významné biotopy NA SLOVENSKU. Bratislava: Daphne Institute of Applied Ecology.

Slovenia
KALIGARIC, M., SELIŠKAR, A. & VEEN, P., 2003. *Grasslands of Slovenia*. Ljubljana: Royal Dutch society for Nature Conzervation & Society for Natural History in Slovenia.
DEVILLERS, P. & DEVILLERS-TERSCHUREN, J., 2002. *Application & development of the Palaearctic habitat classification: Slovenia.* Strasbourg: Council of Europe.

Spain
MORILLO-FERNANDEZ, C., 2003. Manual de Interpretación de los Hábitats de Espanã, Vols 1 & 2. Madrid: Tragsa, Ministerio de Medio Ambiente.
Maps of the Natura 2000 habitats are available from the Banco de Datos de la Biodiversidad, Gran Vía de San Francisco 2, 28005, Madrid and via http://www.mma.es/portal/secciones/bidiversidad/banco_datos/contacyo/index.htm.

Sweden
PÅHLSSON, L., 1994. *Vegetationstype I Norden.* Copenhagen: Nordisk Ministeraad.

Switzerland
DELARZE, R., GONSETH, Y. & GALLAND, P., 1998. *Guide des Milieux naturels de Suisse.* Lausanne: Delacaux et Niestlé.

Ukraine
DEVILLERS, P. & DEVILLERS-TERSCHUREN, J., 2002. *Application & development of the Palaearctic habitat classification: Ukraine.* Strasbourg: Council of Europe.

United Kingdom
JACKSON, D.L. & MCLEOD,C.R., 2002. Handbook on the UK status of EC Habitats Directive interest features: provisional data on the UK distribution and extent of Annex I habitats and the UK distribution and population size of Annex II species. *JNCC Report 312.* Peterborough: Joint Nature Conservation Committee.