Which vascular plants are found at the northern or southern edges of their European range in the British Isles?

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ABSTRACT

The northern and southern limits of the European distributions of native vascular plants in the British Isles are summarised. Of 1346 species considered, 279 reach their absolute northern limits in the British Isles and a further 167 at equivalent latitudes (45º–60º N) elsewhere in Europe. A particularly high proportion of Mediterranean-Atlantic species in the British Isles reach their absolute northern limits here, and a higher proportion of Southern-temperate than Temperate species do so. By contrast, only 35 species are at their absolute southern limits in our area, with a further 7 extending south to equivalent latitudes (50º–60º N) elsewhere. The low southern limit totals reflect the presence of most northern species on high mountains in southern Europe. The range-edge species are listed, but the lists must be regarded as provisional as there are some difficulties in using the secondary sources on which they are based, the most serious being the problem of distinguishing native from introduced occurrences. Some 49% of threatened members of the British flora are at or near their northern or southern European limits in the British Isles. If Continental and Hyperoceanic species are also considered as species at the edge of their range, this figure increases to 64%. The increase is almost entirely due to the addition of many Continental species, which in Britain appear to be an especially threatened group.

KEYWORDS: continental, distribution, major biome, Mediterranean-Atlantic, threat.

INTRODUCTION

Populations of plants at or near the edge of their distributional range are of great interest. In such situations plants may become increasingly restricted in their habitat requirements, and these restrictions can offer considerable insights into the factors which limit the total distribution. Marginal populations (especially of annual species) may also fluctuate greatly in size from year to year, and this also provides evidence of ecologically limiting factors. They are sometimes genetically depauperate compared to core populations, or genetically adapted to specialised local environments. Marginal populations are especially interesting if the distribution of a species is changing, as they will often be the first ones to show the change. Global warming is widely anticipated in the next few decades and can, for example, be expected to result in a retreat of some species from the southern edge of their ranges accompanied by an expansion northwards. The conservation of species at the edge of their range has often been discussed, with some authors arguing that these populations should be safeguarded because of their intrinsic interest, whereas others caution against concentrating on the conservation of small, marginal populations of species which are more abundant elsewhere.

In view of the general interest of edge-of-range populations, it is perhaps surprising that there is no easy way of identifying species which are at the edge of their range in the British Isles. This paper aims to fill this gap. Some species, especially those in the Mediterranean-Atlantic and Submediterranean-Subatlantic floristic elements such as *Parietaria judaica*, *Polystichum setiferum* (Fig. 1) and *Umbilicus rupestris*, have northern European limits which run diagonally from north-west to south-east Europe, and there is normally little doubt whether or not these reach their absolute northern limit in Britain. However, the northern limit of other species such as *Hydrilla verticillata*, *Rumex conglomeratus* and *Salsola kali* (Fig. 2) runs approximately west-east, and these may extend north to essentially the same latitude in several European countries. It is difficult to identify the precise location of their absolute northern limit, both because much of the available information is insufficiently precise geographically, and because the absolute limit may easily be extended by the discovery of new populations. In this paper, therefore, I have listed the species which reach their northern and southern European limits as native species *either* in the British Isles itself *or* at similar latitudes elsewhere in Europe.

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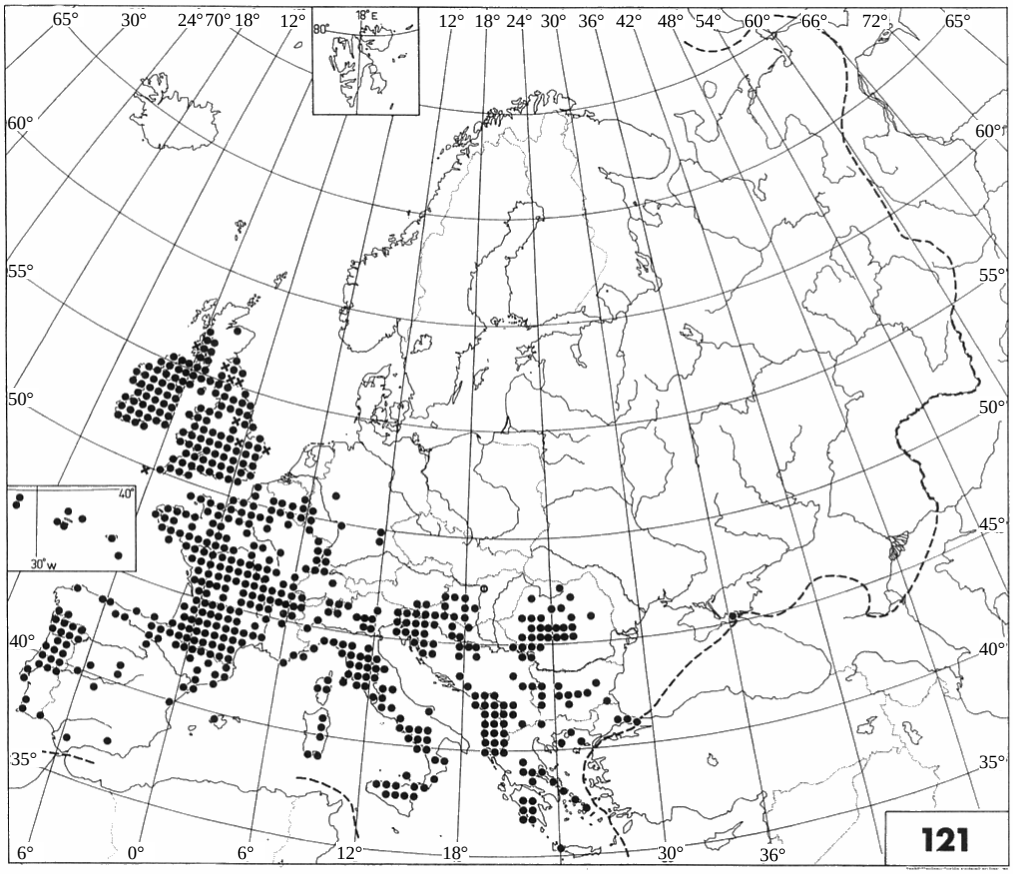

FIGURE 1. The distribution of *Polystichum setiferum* in Europe (Jalas & Suominen 1972). This Submediterranean-Subatlantic species has a northern limit running NW–SE and is clearly at its northern European limit in the British Isles.

IDENTIFYING THE EUROPEAN RANGES OF BRITISH AND IRISH SPECIES

SPECIES CONSIDERED

My aim has been to assess the European distributional limits of all the native species of the British Isles, with the exception of the microspecies of *Hieracium*, *Rubus* and *Taraxacum*. Species which are endemic to the British Isles or are confined in Europe to our area are excluded for the obvious reason that they have no wider European distribution, and infraspecific taxa have not been considered. Taxonomy and nomenclature usually follow Stace (1997) and the species considered are those treated by Preston, Pearman & Dines (2002) as native or doubtfully native ('native or alien'). In a few cases I have departed from these sources to take account of recently published work or to exclude species with distributions which are not sufficiently well understood for their limits to be assessed. *Asparagus officinalis* subsp. *prostratus* is treated as a species, *A. prostratus*, following Kay, Davies & Rich (2001), and two species added to the flora since 1997, the native *Carex salina* (Dean *et al*. 2005) and the apparently native *Cystopteris diaphana* (Murphy & Rumsey 2005), have been considered. *Cystopteris alpina* has been restored to the British list by Rumsey (2003), although it is now believed to be extinct. Segregates in the *Callitriche hamulata*, *Arctium minus*, *Erophila verna*, *Salicornia europaea*, *S. procumbens* and *Utricularia intermedia* complexes and the species *Carex recta*, *Cystopteris dickieana*, *Dactylorhiza lapponica*, *D. majalis* and *D. traunsteineri* have not been considered because

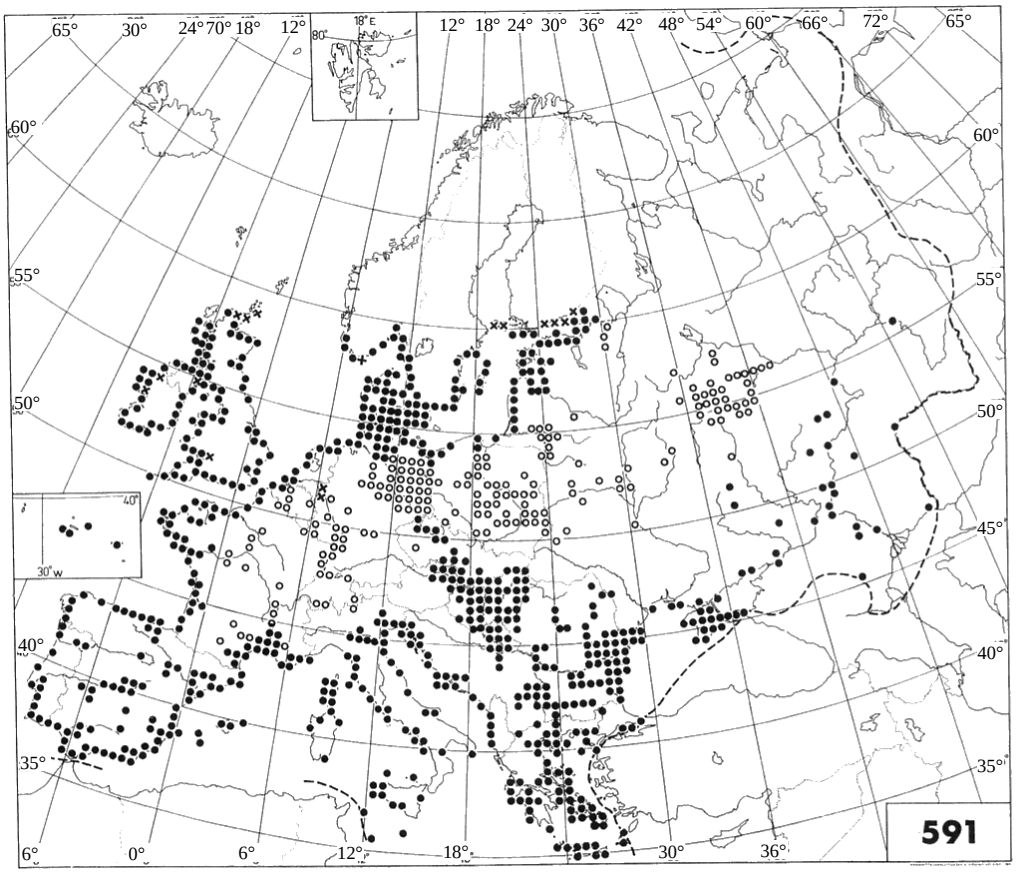

FIGURE 2. The distribution of *Salsola kali* in Europe (Jalas & Suominen 1980). The symbols 'x' and '+' denote 'probably extinct' and 'extinct' respectively, and occurrences as an established alien are shown by open circles. This Eurosiberian Southern-temperate species reaches its northern limit at similar latitudes in Scotland, Norway, Sweden, Finland and Russia.

of doubts about their taxonomic status, distributional uncertainties or because recent taxonomic revisions have reduced them to endemic status. *Viola odorata* and the doubtfully native *Onobrychis viciifolia* and *Ribes rubrum* have also been excluded as their native ranges are so confused by introductions that the northern and southern limits cannot be assigned to the latitudinal bands specified below. *Valerianella eriocarpa*, considered a neophyte by Preston *et al*. (2002), is treated as doubtfully native following a reassessment of its status (Pearman & Edwards 2002). *Symphytum tuberosum* is also treated as doubtfully native; it was considered native, with reservations, by Preston *et al*. (2002) but, as Braithwaite, Ellis & Preston (2006) suggest, it is "much more likely to be a neophyte".

SOURCES OF DISTRIBUTIONAL DATA

In compiling information on the distributional limits of species, I have drawn on published distribution maps, especially those of *Atlas Florae Europaeae* (Jalas & Suominen 1972–1994; Jalas, Suominen & Lampinen 1996; Jalas *et al*. 1999; Kurtto, Lampinen & Junikka 2004) or, for the majority of taxa not yet covered by this *Atlas*, the maps compiled by Hultén & Fries (1986). For plants covered in neither of these works, I have consulted Meusel, Jäger & Weinert (1965), Meusel *et al*. (1978) and Meusel & Jäger (1992) for central European species, and Bolòs & Vigo (1984–2001), who map many southern European species, as well as Tutin *et al*. (1968–1980, 1993). For more detailed information on the distribution of species in countries in the same latitudinal

TABLE 1. SUMMARY OF MAJOR BIOME CATEGORIES (PRESTON & HILL 1997)

Name	Explanation
Arctic-montane	Main distribution in the tundra or above the tree-line in temperate mountains.
Boreo-arctic Montane	In both the tundra and the coniferous forest zones.
Wide-boreal	Extends from the temperate zone to the tundra.
Boreal-montane	Main distribution in the coniferous forest zone.
Boreo-temperate	In both the coniferous and the broadleaf forest zones.
Wide-temperate	Extends from the Mediterranean zone to the coniferous forest zone.
Temperate	Main distribution in the broadleaf forest zone.
Southern-temperate	In both the Mediterranean region and the broadleaf forest zones.
Mediterranean-Atlantic	In the Mediterranean region, and extending north into the broadleaf forest zone in western Europe. Submediterranean-Subatlantic and Mediterranean-montane species are included here.

band as the British Isles, useful sources include Hultén (1971), Mossberg & Stenberg (2003) and Jonsell (2000, 2001) for the Nordic countries, Mennema, Quené-Boterenbrood & Plate (1980, 1985) and van der Meijden, Plate & Weeda (1989) for the Netherlands, Haeupler & Schönfelder (1988) and Benkert, Fukarek & Korsch (1996) for Germany, Institut Floristique Franco-Belge (1978–2001) for Belgium and northern France and Dupont (1962) for species of the Atlantic zone. The native ranges of species in Britain are taken from Preston *et al*. (2002), with additional information from local floras such as Graham (1988), Scott & Palmer (1987) and Swan (1993).

Distributional limits are analysed below in relation to the major biome categories defined by Preston & Hill (1997), Preston *et al*. (2002) and Hill, Preston & Roy (2004) (Table 1). Of the three species recently added to the flora, *Carex salina* and *Cystopteris alpina* have been treated as European Boreo-arctic Montane and *C. diaphana* as Suboceanic Southern-temperate.

CLASSIFICATION OF NORTHERN AND SOUTHERN LIMITS

The above sources were used to classify the northern European limit of the species considered into five latitudinal bands: 45º–50º N, 50º–55º N, 55º–60º N, 60º–65º N and >65º N. Similarly, the southern limits of species were classified into the bands <45º N, 45º–50º N, 50º–55º N and 55º–60º N. Almost all the land area of the British Isles falls within the 50º–55º and 55º–60º bands (Figs 1–2). The only parts of the British Isles south of 50º N are the Channel Islands, the Isles of Scilly and the southern part of the Lizard peninsula; Shetland alone extends north of 60º N. (None of the species considered has a southern limit in the 60º–65º band, which would imply growing as a native in Shetland but descending no further south in Britain.) The 55º N line of latitude very approximately separates Ireland, Wales and England to the south from Scotland to the north. Thus plants occurring as natives in the British Isles and reaching their northern limits in Europe between 45º and 60º are usually close to their northern limits here, even if they do not reach their absolute European limit in these islands. Similarly most plants extending south to latitudes between 50º and 60º are close to their southern limits in Britain. Species extending south to 45º–50º are not necessarily close to their southern limits in the British Isles as they may extend almost 5º further south; by contrast, a native of the British Isles which reaches its northern limit between 45º and 50º must be near its limit in our area. In addition to allocating the limits of species to these latitudinal bands, I have tried to identify the plants reaching their absolute northern and southern limits in our area. In determining species limits, all recorded native sites are considered, including those at which the species has become extinct in recent times.

The data on distributional limits are summarised in this paper, and species at or near their northern or southern limits in the British Isles are listed in Appendix 1 and 2. The full data have been added to the PLANTATT database (Hill *et al*. 2004) and can be downloaded from the Biological Records Centre website (www.brc.ac.uk).

TABLE 2. NORTHERN EUROPEAN LIMITS OF NATIVE SPECIES IN RELATION TO THEIR OCCURRENCE IN MAJOR BIOMES

Major biome	Number of species at N limit in latitudinal band					Total
	45°–50°	50°–55°	55°–60°	60°–65°	>65°	
Arctic-montane		1*	3*		75	4*+75
Boreo-arctic Montane			1*	1	39	1*+40
Wide-boreal					19	19
Boreal-montane			7*	5	86	7*+91
Boreo-temperate			1*+1	8	212	1*+221
Wide-temperate					33	33
Temperate	2*+1	30*+11	39*+82	5*+192	141	76*+427
Southern-temperate	3*+1	43*+19	37*+38	5*+50	37	88*+145
Mediterranean-Atlantic	3*+1	67*+2	31*+11	1		101*+15
Unknown			1*		1	1*+1
Total	8*+3	141*+32	120*+132	10*+257	643	279*+1067

*The askerisked figures are the number of British species at their absolute northern limit in the British Isles.

RANGE LIMITS IN RELATION TO OCCURRENCE IN MAJOR BIOMES

The northern limits of native species are summarised in Table 2. In all 279 of the 1346 species considered (21%) reach their absolute northern limits in the British Isles, and a further 167 (12%) extend north to equivalent latitudes (45°–60° N) in mainland Europe. These species are listed in Appendix 1. Almost all the species of northern biomes, and the widespread species, extend to latitudes north of 65°. A small number of Arctic-montane and Boreal-montane species occur at the northern edge of their range in Britain, these being Alpine species which are absent from the Arctic, e.g. the Arctic-montane *Minuartia recurva*, *M. sedoides* and *Myosotis alpestris*, the doubtfully native Boreo-arctic Montane *Homogyne alpina* and the Boreal-montane *Meum athamanticum*, *Oxytropis halleri* and *Viola lutea*. *Thlaspi caerulescens* extends north to Scotland as a native, but is very widely naturalised in the Nordic area (Jalas *et al*. 1996) and *Myosotis stolonifera* occurs in the mountains of the Iberian peninsula and the hills of northern England and southern Scotland. Plants of the Temperate and Southern biomes show an obvious tendency to reach their northern limits further south.

Of the species reaching their northern European limits between 45° and 60° N, there is a clear increase in the percentage occurring at their absolute limit in Britain from Temperate (43%) through Southern-temperate (59%) to the Mediterranean-Atlantic (88%) major biome categories. This presumably reflects the fact that Temperate species may be able to extend further north in mainland Europe because of the warmer continental summers, whereas the Mediterranean-Atlantic species require milder winters and are therefore likely to extend further north in the oceanic west of Europe. The difference between Temperate and Southern-temperate species on the one hand and Mediterranean-Atlantic species on the other is almost inevitable in view of the definition of the major biome categories, as the Mediterranean-Atlantic plants differ from the Temperate and Southern-temperate species in occurring further north in the Atlantic zone of western Europe than they do further east.

There is a rather unexpected trend for a greater proportion of species reaching their northern limit between 50° and 55° N in Europe to have their absolute limit in the British Isles compared to those which extend north into the 55°–60° N band. In the southerly latitudinal band 82% of species reach their northern limits in the British Isles, compared to 48% of those in the northerly band, a highly significant difference ($p<0{\cdot}001$). This difference holds within all three of the predominant major biome categories. For Temperate species 73% of the 50°–55° species are at their northern limit here compared with 32% for the 55°–60° plants ($p<0{\cdot}001$); the equivalent figures for Southern-temperate species are 69% vs 49% ($p<0{\cdot}05$) and for Mediterranean-Atlantic species 97% vs 74% ($p<0{\cdot}001$). Most of the (rather few) species in

the 50°–55° zone which reach their absolute limits outside the British Isles extend further north in Germany. The larger group reaching their northern limits outside our area in the 55°–60° zone include many at their northern limits in Denmark or Sweden, smaller numbers in Norway or in the eastern Baltic (including the Baltic states and Baltic Russia) and very few species reaching their limits further east in Russia. The reasons for this shift in northern limits to continental Europe for the more northerly species are not entirely obvious, and the fact that many species have become naturalised after they have been introduced to sites north of their native limits suggests that these reasons are unlikely to be simple. Factors to be considered include differences in the proportion of the total land area in each latitudinal band which lies in the British Isles and the range of climates and habitats provided in southern Britain and Ireland compared to northern Britain. The contrast between the climate of S.W. Ireland and East Anglia in the 50°–55° zone is much greater than the climatic extremes within the northern zone. Another factor is almost certainly the paucity of lowland, calcareous habitats in much of Scotland. Ellenberg R values, which indicate pH preferences from extreme calcifuge (R = 1) to calcicole (R = 9, see Hill *et al*. 2004) can been used to identify the number of marked calcicoles at their absolute limits in Britain and elsewhere in Europe (Table 3). A few species with R = 8–9 are halophytes rather than calcicoles but they do not greatly affect the percentages in Table 3. The overall proportion of calcicoles is higher for the species with northern limits between 50° and 55° than for those with limits between 55° and 60° N ($p<0{\cdot}05$), not unexpectedly in view of the fact that acidic habitats predominate in the Boreal zone. More relevantly, the proportion of calcicoles amongst the species reaching their absolute limits in Britain is significantly lower in the northerly band than in the southerly band ($p<0{\cdot}001$). The calcicoles occurring at their northern limits between 55° and 60° N in continental Europe include a small but well-known group of species which extend north to the calcareous islands of Öland and Gotland in the Baltic (e.g. *Aster linosyris*, *Helianthemum oelandicum*, *Orchis laxiflora*, *Potamogeton coloratus*).

Whereas there is a clear relationship between major biome categories and northern limits, there is no such relationship with southern limits (Table 4). The majority of species in all major biome categories extend south to southern Europe (<45° N). This reflects the presence of high mountains at southern latitudes in Europe, and hence the availability of habitats above the tree-line. A few Arctic and Boreal species are absent from the southern European mountains, and these represent the majority of species which attain their southern limits in the British Isles. Only 35 species are at their absolute southern limits in our area and a further 7 extend south to equivalent latitudes (50°–60°) in mainland Europe (Appendix 2). The high proportion of these species which are at their absolute southern limit in the British Isles is noteworthy, and indeed all 15 species extending south to between 55° and 60° are at their absolute limit here. There is in fact little high ground in Europe between 50° and 60°, so montane species which extend south to the British Isles but not to the mountains of central Europe are likely to be at their absolute southern limits here.

ARE THREATENED PLANTS IN BRITAIN MAINLY PLANTS AT THE EDGE OF THEIR RANGE?

IUCN threat categories for British species have recently been revised (Cheffings & Farrell 2005). Table 5 summarises the number of threatened species in Britain which are close to their northern or southern limits. Only the species covered in this paper are included in Table 5; other Red Listed species (notably archaeophytes, endemics, plants confined to the British Isles in Europe and infraspecific taxa) are excluded from consideration. I have used the term ‘threatened species’ to include those classified as Extinct, Extinct in the Wild, Critically Endangered, Endangered, Vulnerable and Near Threatened in the Red List. Of the threatened species considered, almost half (49%) are at or near their northern or southern limits. Although this is a higher percentage than the equivalent figure (36%) for species in our flora as a whole, it is clear that many species at the limits of their latitudinal range are not threatened, and that many threatened species have a very broad latitudinal range in Europe.

It might be argued that some threatened (and non-threatened) species are at their western and eastern limits in our area. In general, western limits are of little interest to British and Irish

TABLE 3. ELLENBERG R VALUES OF SPECIES REACHING THEIR NORTHERN EUROPEAN LIMITS BETWEEN 50° AND 60° N

Northern limit	No. of species	Ellenberg R values		
		Range	Mean	% calcicoles (R = 8–9)
50°–55° N, absolute limit in Britain	140†	1–9	6·4	31
50°–55° N, absolute limit elsewhere	32	4–9	6·8	44
55°–60° N, absolute limit in Britain	120	2–9	6·0	12
55°–60° N, absolute limit elsewhere	131†	2–9	6·7	30

† These totals each exclude one species for which an Ellenberg R value has not been allocated.

TABLE 4. SOUTHERN EUROPEAN LIMITS OF NATIVE SPECIES IN RELATION TO THEIR OCCURRENCE IN MAJOR BIOMES

Major biome	Number of species at S limit in latitudinal band				Total
	<45°	45°–50°	50°–55°	55°–60°	
Arctic-montane	53	7	5*+1	13*	18*+61
Boreo-arctic Montane	29	3	6*+2	1*	7*+34
Wide-boreal	17	2			19
Boreal-montane	78	8	8*+3	1*	9*+89
Boreo-temperate	216	1*+5			1*+221
Wide-temperate	33				33
Temperate	491	12			503
Southern-temperate	232		1		233
Mediterranean-Atlantic	116				116
Unknown	1	1			3
Total	1266	1*+38	19*+7	15*	35*+1311

*The asterisked figures are the number of British species at their absolute southern limit in the British Isles.

botanists, as the British Isles are at the western fringe of Europe. All our species approach their western limits here. Whether or not one of our common species reaches its absolute western European limit in the British Isles therefore depends on whether it occurs on the Atlantic islands of Iceland and the Azores (the only parts of Europe as defined by *Flora Europaea* that are further west than western Ireland) and on the exact details of its distribution in the British Isles, western France and the Iberian peninsula. Although the details of its distribution in the western fringes will be determined by its ecology, the relevant ecological factors will include dispersal mechanisms and habitat preferences which are unlikely to act together to make 'presence at its absolute western limit in Britain' a useful piece of information about the species. Species which reach a western European limit in eastern Britain are perhaps more clearly at their western limit here, and the more extreme examples are identified as 'Continental' species by Preston & Hill (1997). One small group of species, the 'Hyperoceanic' species, have such western distributions in Europe that they are close to their *eastern* limits in Britain, and these are listed by Preston & Hill (1999).

If the Continental and Hyperoceanic species as well as those close to their northern and southern limits are considered, the percentage of threatened species which are at or near the edge of their range increases from 49% to 64%. This is almost entirely due to the addition of substantial number of Continental species which have a broad latitudinal range but are threatened in Britain. Only a single threatened Hyperoceanic plant is not at either its northern

TABLE 5. EUROPEAN LIMITS OF NATIVE SPECIES IN RELATION TO THEIR IUCN RED LIST CATEGORY (CHEFFINGS & FARRELL 2005)

Red List category	No. species at northern limit in British Isles	No. species at northern limit between 45° and 60° N elsewhere in Europe	No. species at southern limit in British Isles	No. species at southern limit between 50° and 60° N elsewhere in Europe	No. of additional hyperoceanic or continental species	*Total no. of species at or near range limits*	No. species extending north of 60° and south of 50° in Europe and neither hyperoceanic nor continental	Total
Extinct	2 (17%)	3 (25%)		1 (8%)	1 (8%)	*7 (58%)*	5 (42%)	12
Critically endangered	3 (19%)	7 (44%)			5 (31%)	*15 (94%)*	1 (6%)	16
Endangered	9 (17%)	14 (26%)	2 (4%)	1 (2%)	10 (19%)	*36 (68%)*	17 (32%)	53
Vulnerable	36 (26%)	22 (16%)	8 (6%)		19 (14%)	*85 (62%)*	51 (38%)	136
Near threatened	19 (25%)	14 (18%)	3 (4%)	1 (1%)	8 (10%)	*45 (58%)*	32 (42%)	77
Total threatened	*69 (24%)*	*60 (21%)*	*13(4%)*	*3 (1%)*	*43 (15%)*	*188 (64%)*	*106 (36%)*	*294*
Least concern	187 (18%)	100 (10%)	17 (2%)	3 (<1%)	26 (3%)	*333 (33%)*	676 (67%)	1009
Data deficient	3 (27%)		5 (46%)			*8 (73%)*	3 (27%)	11
Not classified*	20 (62%)	7 (22%)				*27 (84%)*	5 (16%)	32
Total	279 (21%)	167 (12%)	35 (3%)	6 (<1%)	69 (5%)	*556 (41%)*	790 (59%)	1346

The percentages relate to the totals in each Red List category. Rows and columns in italics are subtotals. *Hydrilla verticillata* reaches both its northern and southern limits between 50° and 60° in mainland Europe. To avoid double-counting, it is included in the northern but not the southern limit totals.
*These species were not classified as they are restricted to those parts of the British Isles outside Great Britain, were included by Cheffings & Farrell (2005) in the 'Waiting List' or are amongst the species I have excluded from consideration in this paper for other reasons.

or southern limit, the Near Threatened *Hymenophyllum wilsonii*. This highlights the threat to Continental species in Britain, a group first discussed in detail by Walters (1953). Of the 88 species which are listed by Preston & Hill (1997) as Continental and considered in this paper, 86 occur in Great Britain and of these 54 (63%) are listed as Extinct (2), Critically Endangered (7), Endangered (12), Vulnerable (22) or Near Threatened (11) by Cheffings & Farrell (2005).

DISCUSSION

LIMITATIONS OF THE SOURCES

The user of secondary sources to identify the limits of the native range of species in Europe is confronted by three major problems. Was the information presented taxonomically accurate at the time of publication, and has it been superseded by subsequent taxonomic revision? Are native records distinguished from alien (including casual) occurrences? Do sources such as small-scale distribution maps provide sufficient geographical precision? All these are serious problems. To a great extent, however, users are in the hands of their sources. It is clearly impractical to investigate the European distribution of all native British species individually, and even if one did there is no likelihood that the result would be any better than the published compilations. By maintaining a semi-critical approach to the sources one can attempt to identify potential problems and check one source against another. Outlying localities on small-scale European maps can be checked against national floras and atlases, for example. These publications can also be used to provide more precise details of the limits of species than are apparent on small-scale maps. More critical accounts of the distribution of some species are available in monographic works. The greatest problem is the identification of native ranges. Even if the native range is known to the local observer, it may not be clear to a compiler working elsewhere in Europe or the compiler may choose not to distinguish alien occurrences on the map. Outlying northern localities on many of the maps compiled by Hultén & Fries (1986), for example, represent introduced or even casual occurrences. In the cases of Scandinavian records, these maps can be checked against Mossberg & Stenberg's (2003) maps and national and regional floras. However, there are limits to the number of such checks which are either possible or practical in a reasonable time-scale.

The interpretation of the native ranges of British and Irish species is that of Preston *et al*. (2002). The problems associated with assessing native ranges in Britain, which to a large extent reflect those associated with the wider problem in Europe as a whole, are discussed briefly on pp. 10–11 of that work.

For the above reasons, the lists provided in this paper are provisional. I hope that specialists in individual species or genera will be able to review the assessments and correct them where necessary. The lists will also need revision in the light of the critical reviews of the distribution and native or introduced status of Nordic plants which will become available as further volumes of *Flora Nordica* are published.

POTENTIAL USEFULNESS OF INFORMATION ON DISTRIBUTIONAL LIMITS

This paper has been prepared with several potential uses in mind. Authors of local Floras can use the lists in Appendix 1 and 2 in conjunction with the maps in Preston *et al*. (2002) to identify those species at their northern or southern limits in their area. The lists could also be used in planning scientific studies that compare populations of species at the edge of their range with those in a more central position. The information on individual species may also be useful in assessing the extent to which edge-of-range populations are conserved in protected sites.

However, one of the main aims of this compilation is to provide a further 'plant attribute' to be used in interpreting the observed changes in the British and Irish flora. Even a simplified version of Preston & Hill's (1997) major biome categories correlated surprisingly well with the changes detected in several Broad Habitats by the BSBI 'Local change' survey (Braithwaite *et al*. 2006). Information on the northern limits is potentially useful, although it may not always prove to be as informative as the classification by major biome categories. The latter summarise the overall range of a species and disregard outlying occurrences, whereas by definition the distributional limits are governed by the outlying occurrences. At outlying localities a population may be dependant on a very specialised microhabitat, or the plants may be relictual, dating from a different climatic

period. Although such relict populations persist they may, in the extreme case of some long-lived species, no longer even be capable of sexual reproduction in the current climatic regime. Once maps such as those published in *Atlas Florae Europaeae* are available for all species it will be possible to use numerical methods to summarise range boundaries, with rules to determine whether or not disjunct localities should be treated as outliers, but at present such maps are available for only a minority of European species. Information on the southern limits of species is much less informative than that on northern limits as, unlike major biome categories, it fails to take into account the altitudinal range of species.

The current interest in the effects of climate change has led to an increasing concentration of research on the behaviour of populations at the edge of their range. It is clear from the results presented here that British and Irish botanists are ideally placed to study the behaviour in the years to come of species at the northern edge of their European ranges. This is surely an area in which the B.S.B.I. could develop one of those "really impressive examples of botanical co-operation in which the amateur and professional talent of our Society is used with great effect" (Walters 1975).

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APPENDIX 1. SPECIES AT OR NEAR THE NORTHERN EDGE OF THEIR NATIVE EUROPEAN RANGE IN THE BRITISH ISLES

Native British species which have their northern European limits in the latitudinal bands 45–50º N, 50–55º N and 55–60º N are listed in this section. Species are asterisked if the absolute limit is reached in the British Isles, but not if it they reach their northern limit at the same latitude in our area and in other European countries or if the precise northern limit is obscured by introductions.

The following additional annotations are used:

§ Doubtfully native
(1) Confined as a native in the British Isles to the Channel Islands
(2) Confined as a native in the British Isles to Ireland
(3) Limit(s) of native range particularly confused by introductions (this also applies to doubtfully native taxa)

SPECIES WITH NORTHERN EUROPEAN LIMITS BETWEEN 45º N AND 50º N

Anogramma leptophylla* (1)
Armeria arenaria (1)
Exaculum pusillum* (1)
Festuca armoricana (1)
Festuca huonii* (1)
Limonium auriculae-ursifolium* (1)
Limonium normannicum* (1)
Myosotis sicula* (1)
Ophioglossum lusitanicum*
Ornithopus pinnatus*
Ranunculus paludosus (1)

SPECIES WITH NORTHERN EUROPEAN LIMITS BETWEEN 50º N AND 55º N

Aceras anthropophorum*
Aconitum napellus§*
Adiantum capillus-veneris*
Agrostis curtisii*
Ajuga chamaepitys§
Allium sphaerocephalon§
Alopecurus bulbosus
Anagallis arvensis (3)
Arabis scabra*
Arbutus unedo* (2)
Arum italicum*
Asparagus prostratus
Asperula cynanchica*
Asplenium onopteris* (2)
Atropa belladonna* (3)
Brassica oleracea§*
Bromopsis erecta*
Bunium bulbocastanum
Bupleurum baldense*
Buxus sempervirens* (3)
Callitriche truncata*
Carex humilis
Centaurium scilloides*
Centaurium tenuiflorum*
Cirsium eriophorum*
Cirsium tuberosum
Clematis vitalba (3)
Clinopodium ascendens*
Clinopodium calamintha*
Clinopodium menthifolium
Colchicum autumnale*
Corrigiola litoralis
Crassula tillaea*
Cynodon dactylon§
Cynoglossum germanicum*
Cyperus longus*
Cystopteris diaphana*
Daboecia cantabrica* (2)
Damasonium alisma*
Daphne laureola*
Dianthus gratianopolitanus
Draba aizoides*
Epilobium lanceolatum* (3)
Erica ciliaris*
Erica erigena* (2)
Erica vagans*
Erodium maritimum*
Euphorbia amygdaloides*
Euphorbia peplis*
Euphorbia serrulata§
Festuca longifolia*
Frankenia laevis*
Gagea bohemica
Galium constrictum*
Galium parisiense§*
Gastridium ventricosum§*
Gaudinia fragilis§*
Gentianella germanica
Geranium purpureum*
Geranium rotundifolium*
Gladiolus illyricus*
Gnaphalium luteoalbum§
Helianthemum apenninum*
Helleborus foetidus*
Helleborus viridis§*
Herniaria ciliolata*
Himantoglossum hircinum*
Hippocrepis comosa*

Hypericum linariifolium*
Hypericum undulatum*
Iberis amara*
Inula crithmoides*
Iris foetidissima*
Isoetes histrix*
Juncus acutus*
Koeleria vallesiana*
Lactuca saligna*
Lathyrus aphaca§*
Lathyrus nissolia*
Leucojum aestivum*
Limonium bellidifolium*
Limonium binervosum*
Linum bienne*
Lithospermum purpureocaeruleum*
Lobelia urens*
Lotus angustissimus
Lotus subbiflorus*
Ludwigia palustris
Luzula forsteri*
Matthiola sinuata§*
Medicago arabica*
Medicago polymorpha*
Melittis melissophyllum
Mentha pulegium*
Mentha suaveolens* (3)
Mibora minima*
Milium vernale (1)
Minuartia hybrida*
Minuartia recurva* (2)
Muscari neglectum§*
Neotinea maculata*
Oenanthe pimpinelloides*
Oenanthe silaifolia*
Ononis reclinata*
Ophrys fuciflora
Ophrys sphegodes*
Orchis simia*
Ornithogalum pyrenaicum*
Otanthus maritimus*
Petrorhagia nanteuilii*
Petroselinum segetum*
Peucedanum officinale
Physospermum cornubiense
Pinguicula grandiflora* (2)
Poa infirma*
Polycarpon tetraphyllum§*
Polygala calcarea*
Polygonum maritimum*
Polypogon monspeliensis*
Potamogeton nodosus
Puccinellia fasciculata*
Pulmonaria longifolia*
Pyrus cordata§*
Ranunculus parviflorus*
Ranunculus tripartitus
Romulea columnae*
Rosa stylosa*
Rubia peregrina*
Rumex pulcher*
Rumex rupestris*
Ruscus aculeatus*
Salicornia pusilla*
Saxifraga hirsuta* (2)
Schoenoplectus pungens§
Schoenoplectus triqueter
Scilla autumnalis*
Scirpoides holoschoenus
Sedum forsterianum*
Serapias parviflora §*
Sibthorpia europaea*
Simethis planifolia* (2)
Sison amomum*
Sorbus aria*
Sorbus domestica*
Spartina maritima*
Spiranthes aestivalis
Stachys germanica*
Suaeda vera*
Tamus communis*
Thesium humifusum*
Thlaspi perfoliatum
Trifolium bocconei*
Trifolium glomeratum*
Trifolium incarnatum *
Trifolium occidentale*
Trifolium ochroleucon*
Trifolium ornithopodioides*
Trifolium squamosum*
Trifolium strictum*
Trifolium subterraneum*
Trifolium suffocatum*
Trinia glauca*
Tuberaria guttata*
Ulex minor*
Ulmus procera§*
Valerianella eriocarpa§*
Verbascum pulverulentum§*
Viburnum lantana*
Vicia bithynica*
Vicia parviflora*
Viola kitaibeliana
Viola lactea*
Vulpia ciliata*

SPECIES WITH NORTHERN EUROPEAN LIMITS BETWEEN 55º N AND 60º N

Acer campestre*
Alisma gramineum
Alisma lanceolatum
Althaea officinalis
Anacamptis pyramidalis
Anthriscus caucalis
Aphanes arvensis*
Apium graveolens
Apium inundatum*
Apium nodiflorum*
Apium repens
Aquilegia vulgaris* (3)
Arum maculatum
Asplenium obovatum*
Aster linosyris
Atriplex laciniata*
Atriplex pedunculata
Atriplex portulacoides
Baldellia ranunculoides
Berberis vulgaris§
Beta vulgaris
Blackstonia perfoliata*
Brassica nigra§*
Bromus commutatus*
Bromus racemosus
Bryonia dioica*
Bupleurum tenuissimum
Callitriche obtusangula*
Calystegia soldanella*
Carduus nutans
Carduus tenuiflorus*
Carex davalliana
Carex depauperata*
Carex divisa*
Carex divulsa
Carex laevigata*
Carex pendula*
Carex punctata
Carex strigosa
Carex trinervis
Carpinus betulus
Carum verticillatum*
Catapodium marinum*
Catapodium rigidum*
Cephalanthera damasonium
Cerastium glomeratum (3)
Ceratophyllum submersum
Ceterach officinarum
Chaerophyllum temulum*
Chamaemelum nobile*
Chenopodium chenopodioides
Cicendia filiformis
Cirsium acaule
Cirsium dissectum*
Cochlearia anglica
Cochlearia pyrenaica*
Coincya monensis*
Corynephorus canescens
Crataegus laevigata
Crepis biennis
Crepis capillaris (3)
Crepis mollis
Crithmum maritimum*
Cruciata laevipes*
Cuscuta epithymum (3)
Cyperus fuscus
Cytisus scoparius* (3)
Dactylorhiza praetermissa
Dianthus armeria
Dipsacus fullonum§*
Dipsacus pilosus
Dryopteris aemula*
Dryopteris oreades*
Dryopteris remota*
Dryopteris submontana*
Elytrigia atherica
Epilobium hirsutum
Epipactis leptochila*
Epipactis phyllanthes
Epipactis purpurata
Equisetum telmateia*
Erica mackaiana*
Erodium lebelii*
Euonymus europaeus
Euphorbia hyberna*
Euphorbia paralias*
Euphorbia portlandica*
Euphrasia tetraquetra*
Festuca filiformis
Festuca lemanii§*
Filago lutescens§
Filago minima
Filago vulgaris*
Fritillaria meleagris§
Fumaria bastardii*
Fumaria capreolata*
Genista anglica*
Genista pilosa
Genista tinctoria
Glaucium flavum
Groenlandia densa
Helianthemum oelandicum
Homogyne alpina§*
Hordeum marinum*
Hordeum secalinum
Hornungia petraea
Hyacinthoides non-scripta*
Hydrilla verticillata
Hymenophyllum tunbrigense*
Hypericum androsaemum*

Hypericum elodes*
Hypericum humifusum
Hypericum tetrapterum*
Hypochaeris glabra
Illecebrum verticillatum*
Inula conyzae*
Isolepis cernua*
Juncus foliosus*
Juncus inflexus*
Juncus maritimus*
Juncus pygmaeus
Juncus subnodulosus
Koeleria macrantha*
Lactuca virosa*
Lamiastrum galeobdolon
Lavatera arborea*
Leontodon saxatilis*
Lepidium heterophyllum*
Lepidium latifolium (3)
Limonium humile
Limonium vulgare
Lotus glaber
Lotus pedunculatus
Luronium natans
Lysimachia nummularia (3)
Malva moschata* (3)
Marrubium vulgare (3)
Meconopsis cambrica*
Medicago minima
Meum athamanticum*
Minuartia sedoides*
Moenchia erecta*
Myosotis alpestris*
Myosotis stolonifera*
Myosotis sylvatica (3)
Narcissus pseudonarcissus*
Oenanthe crocata*
Oenanthe fistulosa
Oenanthe fluviatilis
Oenanthe lachenalii*
Ononis spinosa
Ophrys apifera*
Orchis laxiflora
Orchis morio
Orchis purpurea
Orchis ustulata
Ornithopus perpusillus*
Orobanche alba
Orobanche artemisiae-campestris
Orobanche caryophyllacea
Orobanche elatior
Orobanche hederae*
Orobanche minor (3)
Orobanche purpurea
Orobanche rapum-genistae*
Orobanche reticulata
Oxytropis halleri*
Parapholis incurva*
Parapholis strigosa
Parentucellia viscosa*
Parietaria judaica*
Petasites hybridus (3)
Phleum arenarium
Phyteuma orbiculare
Pinguicula lusitanica*
Poa bulbosa
Polypodium cambricum*
Polypodium interjectum
Polystichum setiferum*
Potamogeton acutifolius
Potamogeton coloratus
Potamogeton trichoides
Potentilla rupestris
Potentilla sterilis*
Primula elatior
Puccinellia rupestris*
Pulicaria dysenterica*
Pulicaria vulgaris
Ranunculus fluitans*
Ranunculus omiophyllus*
Ranunculus ophioglossifolius
Ranunculus sardous§
Raphanus raphanistrum*
Reseda lutea§*
Rorippa microphylla *
Rorippa nasturtium-aquaticum *
Rosa agrestis
Rosa arvensis*
Rosa micrantha
Rosa rubiginosa
Rosa tomentosa
Rumex conglomeratus*
Rumex palustris
Sagina apetala*
Salix purpurea (3)
Salvia pratensis§
Salvia verbenaca*
Sanguisorba minor (3)
Sarcocornia perennis*
Saxifraga spathularis*
Scabiosa columbaria
Scrophularia auriculata*
Scrophularia umbrosa
Scutellaria minor*
Seriphidium maritimum
Sherardia arvensis (3)
Silaum silaus
Silene conica*
Silene otites
Sonchus palustris
Sorbus torminalis
Spergularia rupicola*

Spiranthes spiralis
Stellaria neglecta*
Stellaria pallida
Symphytum tuberosum§*
Teesdalia nudicaulis
Teucrium scordium
Teucrium scorodonia*
Thlaspi caerulescens*
Tilia platyphyllos
Torilis nodosa*
Trichomanes speciosum*
Trifolium campestre
Trifolium micranthum
Trifolium scabrum*
Trifolium striatum
Trisetum flavescens (3)
Ulex europaeus*
Ulex gallii*
Ulmus minor
Umbilicus rupestris*
Valeriana dioica
Verbascum lychnitis
Veronica catenata
Veronica montana*
Vicia lutea*
Viola lutea*
Vulpia bromoides (3)
Vulpia fasciculata*
Wahlenbergia hederacea*
Wolffia arrhiza

SPECIES WITH NORTHERN EUROPEAN LIMITS BETWEEN 60º N AND 65º N AND NORTHERNMOST OCCURRENCES IN THE BRITISH ISLES

These species reach their northern European limits north of 60º in Shetland, although *Aphanes australis* is only doubtfully native there (Scott & Palmer 1987). There are 257 other native British species that reach their northern limit in the 60–65º latitudinal band elsewhere in Europe.

Aira caryophyllea*
Aphanes australis*
Deschampsia setacea*
Eleogiton fluitans*
Eryngium maritimum*
Glyceria declinata*
Isolepis setacea*
Radiola linoides*
Ranunculus hederaceus*
Schoenus nigricans*

APPENDIX 2. SPECIES AT OR NEAR THE SOUTHERN EDGE OF THEIR NATIVE EUROPEAN RANGE IN THE BRITISH ISLES

Native British species which have their southern European limits in the latitudinal bands 55–60º N, 50–55º N and 45–50º N are listed in this section. Species are asterisked if the absolute limit is reached in the British Isles, but not if it they reach their southern limit at the same latitude in our area and in other European countries.

§ Doubtfully native
(3) Limit(s) of native range particularly confused by introductions (this also applies to doubtfully native taxa)

SPECIES WITH SOUTHERN EUROPEAN LIMITS BETWEEN 55º N AND 60º N

Artemisia norvegica*
Carex rariflora*
Carex salina*
Carex saxatilis*
Diapensia lapponica*
Erigeron borealis*
Euphrasia foulaensis*
Koenigia islandica*
Luzula arcuata*
Minuartia rubella*
Sagina nivalis*
Salix arbuscula*
Salix lanata*
Salix myrsinites*
Saxifraga rivularis*

SPECIES WITH SOUTHERN EUROPEAN LIMITS BETWEEN 50º N AND 55º N

Alchemilla wichurae
Alopecurus borealis*
Arenaria norvegica*
Atriplex longipes*
Atriplex praecox*
Blysmus rufus
Carex aquatilis*
Cerastium arcticum*
Cornus suecica
Dactylorhiza purpurella*
Euphrasia frigida*
Euphrasia ostenfeldii*
Euphrasia scottica*
Festuca vivipara*
Galium sterneri*

Hydrilla verticillata
Juncus balticus
Ligusticum scoticum*
Mertensia maritima*
Polygonum boreale*
Rubus arcticus
Salix phylicifolia*
Saxifraga cespitosa*
Saxifraga hypnoides*
Saxifraga nivalis
Sorbus rupicola*

SPECIES WITH SOUTHERN EUROPEAN LIMITS BETWEEN 45° N AND 50° N

As explained in the text, these species are not necessarily close to their southern limit in the British Isles, but as the list is so short it is included for completeness.

Arabis petraea
Atriplex glabriuscula
Calamagrostis purpurea
Calamagrostis stricta
Callitriche hermaphroditica
Carex magellanica
Carex maritima
Carex norvegica
Carex pauciflora
Centaurium littorale
Cochlearia officinalis
Crassula aquatica
Dactylorhiza praetermissa
Draba norvegica
Euphrasia arctica
Euphrasia confusa*
Euphrasia tetraquetra
Festuca armoricana
Festuca huonii
Festuca longifolia
Gentianella uliginosa
Juncus biglumis
Juncus castaneus
Leymus arenarius
Limonium humile
Limonium normannicum
Luzula pallidula
Minuartia stricta
Najas flexilis
Oenanthe fluviatilis
Poa humilis
Potamogeton rutilus
Ribes spicatum
Rubus chamaemorus
Salicornia pusilla
Saxifraga hirculus
Saxifraga rosacea
Tephroseris palustris
Thymus serpyllum