JOINT NATURE CONSERVATION COMMITTEE

British Red Data Books
1 Vascular plants

3rd edition

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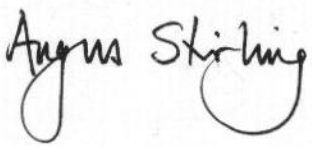
Foreword

It is now 20 years since the first edition of the vascular plants Red Data Book was published, and much has since changed, both in our natural heritage and our documentation of it. That book broke new ground in being the first document to draw attention in a systematic way to the likelihood of extinction of a substantial part of our native flora. Five years later a second edition was produced, with updated information. Yet both editions were very thin books, not because few plants were threatened but because we had so little information to draw on. The average species account was a mere six lines long! Now, 20 years on, with a wealth of autecological studies, targeted surveys, initiatives such as Plantlife's Back from the Brink project, Biodiversity Action Plans and so on, we are in a much better position to make informed scientific statements about the status of our most threatened plants. This has meant that the species accounts in the present book are not just longer but also packed with information distilled from the expertise of many British botanists over the past 20 years and more.

Indeed, readers will notice many differences between this book and its progenitors. As well as the much more detailed introductory section and species accounts, each species is also accompanied by a distribution map, with some species having an additional, more detailed, map. In respect of both text and maps the present book has much more in common with Stewart, Pearman & Preston's *Scarce plants in Britain*, published by the JNCC in 1994, than with the previous Red Data Books, and could in fact be regarded as a companion volume to that publication.

This is the second British Red Data Book to use the revised IUCN threat categories (the first covered lichens), which are based on more scientific criteria than the original categories, and I believe this has resulted in a much more accurate assessment of the degree of threat to each species. Although it is not always possible to apply the new categories to plants with the degree of precision one would expect for large mammals, because of the general lack of population viability analyses and the problem of determining just what constitutes an individual plant, the new system is undoubtedly a substantial improvement on the old one.

I would like to stress that this volume has been a collaborative effort between botanists in the statutory agencies, those in the voluntary societies and other non-governmental bodies and, principally, the host of individual botanists throughout Britain whose enthusiasm is so important for sustaining interest in our native plantlife and ensuring its conservation for future generations. The Editor, Martin Wigginton, is to be congratulated on synthesising such a disparate body of information into a coherent and valuable portrait of the current state of our most endangered plants; this work will continue to be useful to conservationists and botanists for many years to come.



Sir Angus Stirling
Chairman, Joint Nature Conservation Committee
December 1998

1 Introduction

Red Data Books play a crucial role in focusing attention on the plants and animals most in need of conservation action. Prior to this volume, there were four published Red Data Books (RDB) concerning the British flora. The first, in two editions (Perring & Farrell 1977, 1983), were of vascular plants, and these were the first national Red Data Books published for any European country. The other two are of stoneworts (Stewart & Church 1992) and lichens (Church *et al.* 1996). A Red Data Book of bryophytes is shortly to be published (Stewart & Church in prep.). The main objectives of the present volume are to provide a definitive statement on the current distribution and status of rare plants in Britain and to describe the recent changes and trends in the distribution and status of those species and the conservation measures taken to safeguard them.

The first and second editions of the British Red Data Book for vascular plants included those species, and a few subspecies, that occurred in Great Britain in one to fifteen 10 km x 10 km squares (hectads) of the Ordnance Survey national grid. This fifteen-grid-square threshold was established as the main selection criterion for defining a rare plant on the basis of a detailed investigation of the distribution of taxa in the British flora. This threshold was considered to provide an appropriate measure of rarity and was subsequently adopted by the Nature Conservancy Council (NCC) and non-government organisations as a national standard for plants and invertebrates. In the selection of species for inclusion in this edition, we have adopted the revised IUCN Criteria (described in Chapter 3), in which other aspects of rarity are considered, including decline, threat and population dynamics, in addition to distributional data. We have placed a greater emphasis on the status of species in a European or worldwide context, highlighting in the introductory chapters those for which Britain has a special responsibility. The following groups of species and subspecies are treated in this edition as 'Red Data Book' species:

- *Critically Endangered, Endangered, Vulnerable, Extinct* and *Extinct in the Wild* species and subspecies as defined by the revised IUCN criteria (i.e. nationally threatened = Red List species);
- non-Red List species in the revised IUCN categories *Lower Risk (Conservation Dependent), Lower Risk (Lower Risk (near threatened))* and *Data Deficient*;
- species and subspecies endemic to Britain;
- species included in Schedule 8 of the Wildlife & Countryside Act;
- species included in Annexes IIb and IVb of the European Community Habitats & Species Directive;
- other species threatened internationally, or for which Britain has a special responsibility.

The selection of taxa for inclusion is explained more fully in the chapters that follow.

A national Red Data Book is mainly concerned with species that are nationally threatened, and accounts of such species comprise the main bulk of this volume. They range from those that are endemic to Britain to those that are geographically widespread and common on a worldwide scale. There are a few endemic taxa that are not nationally rare but whose international importance is recognised by their inclusion in this volume. The international context is further explored in Chapter 4.

2 Production of the Red Data Book

2.1 Data sources and data gathering

The Biological Records Centre (BRC) at the Institute of Terrestrial Ecology, Monks Wood, holds the national database of single species records of all vascular plants, including the most complete historical record of Red Data Book species. This database is managed jointly by the Institute for Terrestrial Ecology (ITE) and the Joint Nature Conservation Committee (JNCC). In the mid-1980s the Nature Conservancy Council (NCC) became responsible for maintaining a computer database of rare plants, and this database came to hold the most complete set of post-1980 records. At the start of the current project in January 1993, the NCC database was transferred to the JNCC and was held on RECORDER, a data management system that is also widely used by voluntary bodies and individuals to hold locational species data. Because the NCC/JNCC database was incomplete at the time of transfer, a program of data verification and enhancement was begun. Mr R. Smith, Mr J. Farthing, Miss T. Sykes and Miss C. Minto were employed on short contracts over the next three years to verify existing data, to add new records and to document the occurrence of Red Data Book species in protected sites. The JNCC and BRC databases provided the initial bases for assessing the status of species and selecting those for inclusion in this volume. In 1996, following a wide-ranging review of its remit, the JNCC relinquished the responsibility for maintaining a rare plants database. All records from the JNCC were transferred to BRC at Monks Wood and will be incorporated into the national plants database held there.

Much of the data gathering was organised through the Botanical Society of the British Isles (BSBI), whose vice-county recorders represent one of the main sources of detailed information on the local distribution of the British flora. Print-outs from the JNCC database were sent to BSBI vice-county recorders, who checked the accuracy of existing data, amending where necessary, and provided additional and later records of RDB species at known sites from their own files. Some recorders and other BSBI members and local botanists undertook or organised fieldwork to obtain up-to-date information on the species in their particular areas. Nearly all BSBI vice-county recorders responded to requests for information, and many new records were received. The BSBI further organised a number of field meetings with the principal aim of obtaining information on particular species whose current status was uncertain. Known localities of *Polygala amarella* and some *Alchemilla* species were surveyed during a meeting in Yorkshire, and the very local species *Juncus mutabilis* and *J. capitatus* were specially sought during the meeting held on the Lizard peninsula, Cornwall. More general requests for records of rare species were published in issues of *BSBI News*, together with provisional lists of 'candidate' RDB species considered likely to be included in this volume. Some regional biological records centres, notably the Cornwall Biological Records Unit, provided information on their particular areas.

The JNCC commissioned surveys of a number of species for which up-to-date information was required. These were *Gentiana verna* and *Potentilla fruticosa* (G.G. & P.S. Graham), *Lotus angustissimus* (S.J. Leach), *Phleum phleoides*, *Silene otites* and *Thymus serpyllum* (Y. Leonard) and *Carex ornithopoda* (M. Porter & F.J. Roberts). Oxford University was commissioned to carry out an investigation of putative *Apium repens* populations at Port Meadow, and the Botanical Society of Scotland to survey some localities for Scottish montane species. Survey, monitoring and commissioned research carried out by and for English Nature (EN), Scottish Natural Heritage (SNH) and the Countryside Council for Wales (CCW) were sources of many new data on rare species, as also were their recovery programmes (or the equivalent) for threatened species. Staff of the country agencies also sent data on RDB species extracted from files held in local offices.

Data were culled from a wide range of published and unpublished sources, most of which are cited in the general bibliography or in individual species accounts. The most comprehensive collated information on the locations, habitats and populations of rare species in England and Wales is to be found in the series of county rare plant reports produced by the NCC and EN under the direction of L. Farrell between 1978 and 1993. The reports are cited in full in the bibliography: G. Beckett (1993), J. Blakemore (1979, 1980, 1981), G. Crompton (1974-1986), S. Everett (1988), R. FitzGerald (1988a-e, 1990a-d), Y. & D. Leonard (1991), V. Morgan (1987a-b, 1988a-b, 1989a-g) and I. Taylor (1987a-d, 1990a-f). The dissolution of the NCC into three country agencies intervened before such detailed surveys and reports could be produced for Scottish counties or regions, but the status of rare Scottish plants is being investigated and documented under the direction of C. Sydes, and species action plans compiled. Likewise, in Wales, similar investigations continue on rare species, much of which is carried out under the direction of A. Jones. Individual species files, which were maintained by L. Farrell in NCC and EN, and now held by JNCC, were valuable sources of locational and ecological data on species and sites in all three countries.

Plantlife reviews and monitoring reports of threatened species have provided much useful up-to-date information on populations, and also details of current and proposed management aimed at enhancing them. The National Trust for England & Wales, the National Trust for Scotland, and the Royal Society for the Protection of Birds provided information on rare plants occurring in their designated sites and areas. The main source of data on the occurrence and status of British RDB species outside Britain was the World Conservation Monitoring Centre (WCMC), which maintains a database of threatened species, compiled from a very wide range of sources, including national Red Data Books and lists.

2.2 Geographical scope

We follow the first and second editions of the British Red Data Book for vascular plants in confining the geographical coverage to Great Britain and the Isle of Man. As pointed out by Perring & Farrell (1983), it would be difficult to justify on phytogeographical grounds the preparation of a single list of threatened vascular plants for the United Kingdom as a whole, or for the United Kingdom and Ireland together. The vascular plant flora of the island of Ireland is considerably smaller than that of mainland Britain and differs substantially in the occurrence, distribution and status of species. For instance, many of Ireland's rare species are common in Britain and, conversely, some species occur in Ireland which are unknown in mainland Britain (Perring & Walters 1982; Perring 1996). These differences are reflected in the different priorities for the conservation of species adopted in the Republic of Ireland and in Northern Ireland, and, furthermore, different legislative frameworks provide for species protection in Ireland. An Irish Red Data Book for vascular plants (including Northern Ireland) was published a few years ago (Curtis & McGough 1988), and revisionary work covering both geopolitical parts of the island is currently underway. The Channel Islands are also excluded on phytogeographical as well as political grounds, their flora having a greater affinity with that of the nearby European mainland.

3 Species selection

3.1 Taxonomic scope

The aim has been to include all native or probably native threatened and near-threatened species and subspecies of vascular plants that occur in Britain. The distribution and status of these taxa is, for the most part, very well known. Plants of lower taxonomic rank, including varieties, forms, races, ecotypes and genetic variants, have been excluded (though a few are mentioned in some accounts of species) because in most cases their geographical distribution and ecology are inadequately known, or their taxonomy disputed. Thus, at the present time, the status of many of such taxa of lower rank cannot be determined.

Some apomictic groups are included, but, because our knowledge of them is uneven, different selection criteria have been applied to different genera. The distribution and status of species of *Alchemilla* and *Sorbus* are well known, and all rare species were described in the second edition of the vascular plants Red Data Book (Perring & Farrell 1983). The standard selection criteria have been applied to species in those two genera. Since the publication of the second edition, the occurrence and status of the larger, more 'difficult' apomictic genera, *Hieracium*, *Rubus* and *Taraxacum* have become better known, and despite some of their microspecies being rather unstable or ill-defined, it was nonetheless considered worthwhile highlighting some of their rarest taxa, if only to emphasise that their conservation value should not be disregarded. Because these groups are large, a different approach has been necessary. We list species of *Hieracium* that are thought to occur in five or fewer hectads, and provide a short list of species of *Rubus* and *Taraxacum* which specialists in these groups consider likely to be among the rarest in Britain. Of course, a severely restricted distribution does not necessarily imply a severe threat to a species. For example, many microspecies of *Rubus* have very restricted distributions (perhaps occurring in only a single hectad), but may be locally abundant in vigorous colonies and under little apparent threat in their particular localities. The recent revision of the *Limonium binervosum* aggregate (Stace & Ingrouille 1986) resulted in a large number of species and subspecies being newly described. Many of these appear to be very local and rare, although it is also probable that the status of many are inadequately known. However, since most of these new segregates are thought to be endemic to Britain, we considered that mention should made of all the species and subspecies currently thought to be rare.

Though it has not been possible to select taxa at a lower rank than subspecies for inclusion in this volume, their potential importance should not be overlooked. The loss of genetic variants or ecotypes might be detrimental to the long-term survival of a species, and represent genetic diversity and potential for evolution. Genetic aspects of conservation are discussed in section 5.4.

Taxonomy and nomenclature follows Kent (1992), except in very few instances where names used by other authorities are adopted, including *Asparagus prostratus* (Kay 1997), *Cochlearia atlantica* (Rich 1991) and *Diphasiastrum issleri* (Jermy *in litt.*).

3.2 Assessment of native status

In setting national priorities for species conservation, the greatest emphasis has always rightly been placed on those species which are native to Britain. In this book we treat as native those species which are presumed to have colonised Britain by natural means independent of human activity. Helpful discussions on the criteria for assessing native status are found, for example, in Webb (1985) and Preston (1986), and the status and distribution of plants deemed to be alien or probably so are given in Clement & Foster (1994) and Ryves *et al.* (1996).

Whilst the status of most species in the British flora is clear and undisputed, there has been much debate and disagreement over the status of others, and because the weighting of available evidence (sometimes conflicting) is a matter of personal judgement, there remains a divergence of opinion. For example, Webb (1985) gives a list of species accepted as native by Clapham *et al.* (1962) but which he (Webb) considered to be the clearest cases of non-native origin. Ten species on Webb's list of probable aliens are nationally rare, but of these ten, six are listed in Stace (1991) as native (*Centaurea cyanus, Echium plantagineum, Lavatera cretica, Muscari neglectum, Valerianella rimosa, Veronica triphyllos*), one as native in a single locality (*Eryngium campestre*), two as possibly native (*Melampyrum arvense* and *Lonicera xylosteum*), and only a single species (*Cynodon dactylon*) as probably introduced. Likewise, Clement & Foster (1994) and Ryves *et al.* (1996) differ from other authorities in their assessment of species: in the former, for example, *Iris spuria, Leucojum vernum* and *Matthiola incana* are accepted, with reservations, as native.

In selecting species for inclusion in the present volume, of the approximately 331 rare species first considered, 258 have been accepted as probably or certainly native, with thirteen subsequently re-assessed as nationally scarce and two as *Data Deficient*. A further 30 species, which were included in the second edition RDB, have been rejected as certain or almost certain introductions (Table 1). Their alien status is variously indicated - for example, by their distribution outside Britain, by their recent appearance in Britain or history of recording, or by the habitats which they occupy. Degrees of difficulty were presented by 30 other rare species whose claim to native status is doubtful, or at least has not been entirely unquestioned. For some of these (e.g. *Draba aizoides*), recent evidence points strongly to native status, whilst for others (e.g. *Cerastium brachypetalum*), non-native status seems very possible. It was particularly difficult to judge the status of species that could lay claim to be native in some of their sites, though certainly alien in others, examples of which are *Anisantha madritensis, Centaurea cyanus, Eryngium campestre* and *Lonicera xylosteum*. A special case is *Senecio cambrensis*, which is non-native in terms of its introduced parent, *S. squalidus*, but arose naturally through hybridisation with the native *S. vulgaris*. A list of questionably native species is shown in Table 2, and includes those which have been variously described as 'probably native', 'possibly native' and 'probably introduced'. Accounts of all of those species have been included in this volume. It is, of course, possible that some of our weeds of cultivation were introduced in ancient times (perhaps as far back as the Neolithic period), and whether some are truly native is probably unknowable. Where there is no clear opposing evidence, such species have been treated as native in this volume.

Table 1 Introduced species included in the 2nd ed. RDB but excluded from the 3rd ed. RDB

Alyssum alyssoides	*Leucojum vernum*
Anisantha tectorum	*Linaria supina*
Anthoxanthum aristatum	*Matthiola incana*
Campanula rapunculus	*Narcissus obvallaris*
Caucalis platycarpos	*Oenothera stricta*
Crocus vernus	*Paeonia mascula*
Cyclamen hederifolium	*Rorippa austriaca*
Equisetum ramosissimum	*Sagittaria rigida*
Galium spurium	*Schoenoplectus pungens*
Iris spuria	*Silene italica*
Iris versicolor	*Sisymbrium irio*
Isatis tinctoria	*Spartina alterniflora*
Juncus subulatus	*Tetragonolobus maritimus*
J. tenuis var. dudleyi	*Trifolium stellatum*
Ledum groenlandicum	*Veronica praecox*

Table 2 Species whose native status has been considered doubtful by some authorities

Adonis annua	*Echium plantagineum*
Alchemilla acutiloba	*Eryngium campestre*
A. subcrenata	*Homogyne alpina*
Althaea hirsuta	*Lavatera cretica*
Anisantha madritensis	*Limosella australis*
Bupleurum falcatum	*Lonicera xylosteum*
Centaurea calcitrapa	*Melampyrum arvense*
C. cyanus	*Muscari neglectum*
Cerastium brachypetalum	*Petrorhagia prolifera*
Chenopodium vulvaria	*Pulmonaria obscura*
Cotoneaster integerrimus	*Spergularia bocconei*
Crassula aquatica	*Tordylium maximum*
Cynodon dactylon	*Valerianella rimosa*
Draba aizoides	*Veronica triphyllos*
A. monticola	*Galium tricornutum*

3.3 The revised IUCN threat categories and selection criteria

The IUCN[1] Criteria for assigning threat status and category have been used in various forms in Red Data Books and Red Lists for thirty years. They are recognised internationally, provide a simple and readily understood method for highlighting species under threat, and are a means by which conservation priorities may be determined. In the original system, the categories *Endangered*, *Vulnerable*, and *Rare* were defined rather loosely and without quantitative qualifiers (Perring & Farrell 1983). Their application was, therefore, to a large extent a matter of subjective judgement, and it was not easy to apply them consistently within a taxonomic group or to make comparisons between groups of different organisms. The deficiencies of the old system had been recognised for some time, and in the mid-1980s proposals were made to replace it with one which could be more objectively and consistently applied. Finally in 1989, the IUCN's Species Survival Commission Steering Committee requested that a new set of criteria be developed to provide an objective framework for the classification of species according to their extinction risk. The aims of the revised criteria would be:

- to provide a system that could be applied consistently;
- to improve objectivity by providing clear guidance on how to evaluate the different factors which affect the risk of extinction
- to provide a system which will facilitate comparisons across widely different taxa
- to provide users of threatened species lists a better understanding of how individual species were classified.

The first, provisional, outline of the new system was published in Mace & Lande (1991). This was followed by a series of revisions, and the final version was adopted as the global standard by the IUCN Council in December 1994. The guidelines were recommended for use also at the national level. In 1995, the JNCC endorsed their use as the new national standard for Great Britain.

A brief outline of the revised IUCN criteria and their application is given below, but it is important that users of the new system refer to the published document (IUCN 1994), which fully explains it and contains many qualifying remarks. The definitions of the categories are given in Figure 1 and the hierarchical relationship of the categories in Figure 2.

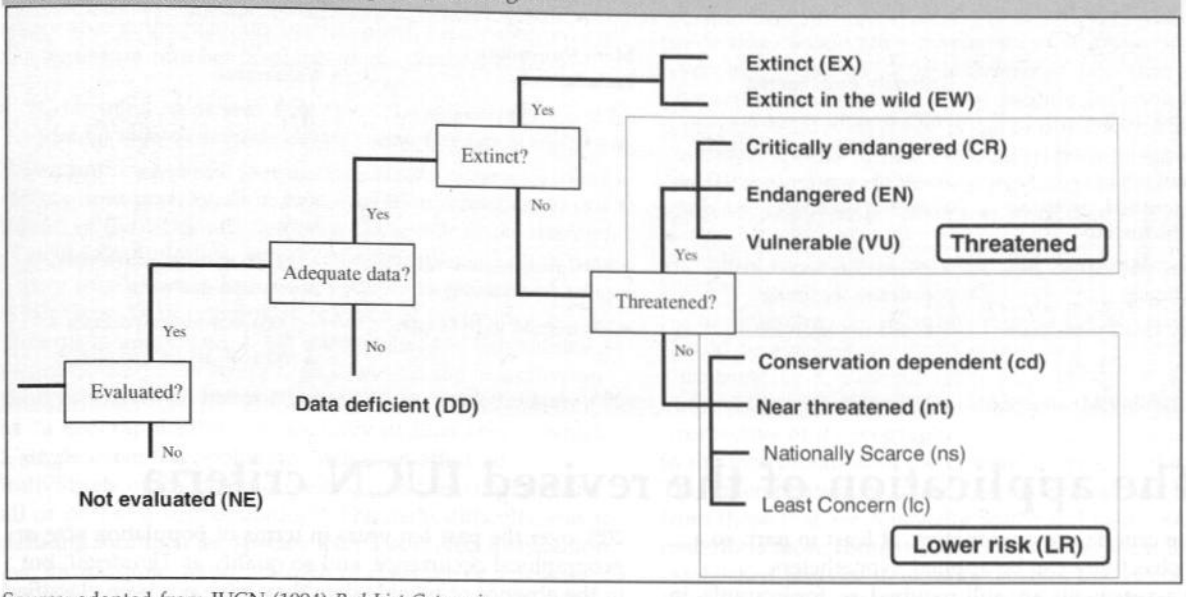
Figure 1 Definitions of IUCN threat categories (IUCN 1994)

Threat category	*Definition*
Extinct (EX)	A taxon is *Extinct* when there is no reasonable doubt that the last individual has died.
Extinct in the wild (EW)	A taxon is *Extinct* in the wild when it is known to survive only in cultivation, in captivity or as a naturalised population (or populations) well outside the past range. A taxon is presumed extinct in the wild when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual) throughout its range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and life form.
Critically Endangered (CR)	A taxon is critically endangered when it is facing an extremely high risk of extinction in the wild in the immediate future, as detailed by any of the criteria A to E*
Endangered (EN)	A taxon is *Endangered* when it is not *Critically Endangered* but is facing a very high risk of extinction in the wild in the near future, as defined by any of the criteria A to E*
Vulnerable (VU)	A taxon is *Vulnerable* when it is not *Critically Endangered* or *Endangered* but is facing a high risk of extinction in the wild in the medium term future, as defined by any of the criteria A to D*
Lower Risk (LR)	A taxon is Lower Risk when it has been evaluated but does not satisfy the criteria for any of the categories *Critically Endangered*, *Endangered* or *Vulnerable*. Taxa included in the Lower Risk category can be separated into three sub-categories.
Conservation Dependent (cd)	Taxa which are the focus of a continuing taxon-specific or habitat-specific conservation programme targeted towards the taxon in question, the cessation of which would result in the taxon qualifying for one of the threatened categories above within a period of five years.
Near Threatened (nt)	Taxa which do not qualify for *Lower Risk (conservation dependent)*, but which are close to qualifying for *Vulnerable*.
Least Concern (lc)	Taxa which do not qualify for *Lower Risk (conservation dependent)* or *Lower Risk (near threatened)*.
Data Deficient (DD)	A taxon is *Data Deficient* when there is inadequate information to make a direct or indirect assessment of its risk of extinction based on its distribution and/or population status. A taxon in this category may be well studied, and its biology well known, but appropriate data on abundance and/or distribution are lacking. *Data Deficient* is therefore not a category of threat or Lower Risk. Listing of taxa in this category indicates that more information is required and acknowledges the possibility that future research will show that a threatened category is appropriate.
Not Evaluated (NE)	A taxon is Not Evaluated when it has not been assessed against the criteria*.

Key: *see Appendix 1.

[1] now The World Conservation Union (WCU)

Figure 2 Hierarchical relationships of the categories



Source: adapted from IUCN (1994) *Red List Categories*.

Newly established categories are *Extinct in the wild* (EW), and *Critically Endangered* (CR). Whilst the names *Endangered* (EN) and *Vulnerable* (VU) have been maintained, they are now differently defined, and species in one of these threat categories in the old system will not necessarily be in the same category in the new. Most species deemed to be *'Rare'* in the old system have been assigned to the *Lower Risk (near threatened)* (LR(nt)) category in the new system, though on the basis of the new criteria some are now regarded as *Vulnerable*. The *Lower Risk (least concern)* (lc) subdivision of the *Lower Risk* category represents all other species, including the most widespread and ubiquitous.

At the national level, countries are permitted to refine the definitions for the Lower Risk categories and to define additional ones of their own. JNCC has established one extra category and two definitions as a national standard. The *Lower Risk (near threatened)* category is defined as - species occurring in 15 or fewer hectads, but which are not threatened (i.e. not qualifying as *Critically Endangered, Endangered* or *Vulnerable*). The *Nationally Scarce* category is defined as - species occurring in 16100 hectads, but which are not *Threatened, Lower Risk (near threatened)* or *Lower Risk (conservation dependent)*. Comments on the last category are included in the following section.

The revised criteria can be applied to any taxon at or below species level, and within any specified geographical area. However, the IUCN guidelines suggest that their application at regional or national levels (as opposed to global) are best used with two key pieces of information: the global status of the taxon, and the proportion of the global population or range that occurs within the region or nation. Thus, species endemic to Britain are treated as Red Data Book species, even though they may not qualify by the strict application of the criteria (see also chapter 4). More detailed guidelines for the use of national Red List categories are still being developed by IUCN to take account of the movement of organisms across national boundaries, especially highly mobile species such as birds.

Taxa listed as *Critically Endangered, Endangered* or *Vulnerable* are defined as Threatened (Red List) species. For each of these threat categories there is a set of five main criteria A-E (an additional sub-criterion for the *Vulnerable* category), any one of which qualifies a taxon for listing at that level of threat. The qualifying thresholds within the criteria A-E differ between threat categories. They are summarised in Table 3, and given in full in Appendix 1.

Species have been assigned to a threat category solely on the basis of their status in Great Britain, and without reference to their status outside this country. A full list of these species is given in Appendix 2, arranged in order of IUCN threat category, together with their qualifying criteria. Endemic species are discussed in 4.3. below.

Table 3 Summary of the thresholds of the IUCN Criteria

Criterion		Main thresholds		
		Critically Endangered	**Endangered**	**Vulnerable**
A.	Rapid decline	>80% over 10 yrs or 3 generations in past or future	>50% over 10 yrs or 3 generations in past or future	>20% over 10 yrs or 3 generations in past or future
B.	Small range – fragmented, declining or fluctuating	extent of occurrence <100 km^2 or area of occupancy <10 km^2	extent of occurrence <5,000 km^2 or area of occupancy <500 km^2	extent of occurrence <20,000 km^2 or area of occupancy <2,000 km^2
C.	Small population and declining	<250 mature individuals, population declining	<2,500 mature individuals, population declining	<10,000 mature individuals, population declining
D1.	Very small population	<50 mature individuals	<250 mature individuals	<1,000 mature individuals
D2.	Very small range			<100 km^2 or <5 locations
E.	Probability of extinction	>50% within 5 years	>20% within 20 years	>10% within 100 years

3.4 The application of the revised IUCN criteria

Most of the criteria are quantitative, at least in part, so a degree of objectivity can be applied. Nonetheless, subjective assessments are still required as, for example, in predicting future trends and judging the quality of the habitat. Since the criteria have been designed for global application and for a wide range of organisms, it is hardly to be expected that every one will always be appropriate to every taxonomic group or taxon. Thus, a taxon need not meet all the criteria A-E, but is allowed to qualify for a particular threat category on any single criterion. The guidelines emphasise that a precautionary principle should be adopted when assigning a taxon to a threat category, and this should be the arbiter in borderline cases. The threat assessment should be made on the basis of reasonable judgement, and it should be particularly noted that it is not the worst-case scenario which will determine the threat category to which the taxon will be assigned. Generally speaking, these new criteria have been relatively straightforward to apply, though some difficulties of interpretation remain; some of the problems encountered are mentioned below.

Criterion A. Rapid decline of population

A decline in the population of a species over a particular period may be readily determined in terms of numbers of individuals or range, and therefore assigning a species to a threat category should be relatively straightforward. However, because of the lack of consistency of baseline data, some subjective judgement has been required. Determining the causal factors for any future decline may be much less easy, particularly, for example, in determining the decline in the quality of the habitat, and the effects of hybridisation, of competitors or pollutants. Estimating past and future changes in our arable weed flora presented problems. Though it is clear that several species are in sharp decline, the lack of comprehensive data covering the past ten years (the period specified in criterion A) makes it uncertain whether they qualify as *Threatened*. *Scarce Plants in Britain* (Stewart *et al.* 1994) highlight some arable species, such as *Fumaria parviflora, Galeopsis angustifolia, Ranunculus arvensis, Scandix pecten-veneris* and *Torilis arvensis*, which have declined markedly. It is possible that some have declined at least 20% over the past ten years in terms of population size or geographical occurrence, and so qualify as *Threatened*, but in the absence of reliable data they have not been classified as such in this book.

Criterion B. Small range combined with fragmentation, decline or fluctuation

The criterion 'extent of occurrence' (definition in Appendix 1) has not been used in assessing the status of rare species in this book, as such estimates are meaningless in the present context. The 'area of occupancy' also presents problems of interpretation. It should be measured, according to the Guidelines, on grid squares "which are sufficiently small", and its size should be appropriate to the biological aspects of the taxon. This criterion is perhaps more appropriate to a mobile animal holding a territory or a 'home range' whose area can be measured. For a plant it is either much less easy to determine the area needed for its survival, or the area might be tiny in comparison. For simplicity, the 'area of occupancy' of the rare plants considered in this book has been interpreted in terms of hectads, which appears to be appropriate for a country the size of Britain. Thus, for example, under criterion B, a *Vulnerable* plant is one that occurs in twenty or fewer 10 km x 10 km grid squares and satisfies two of the three sub-criteria.

Criterion C. Small and declining population

This criterion includes thresholds of numbers of mature individuals (i.e. those that are capable of reproduction), and is generally readily applied where numbers are known. The definition of an 'individual' has been interpreted in this book to include clumps where single plants are difficult to define (for example, species with an underground rhizome which may interconnect what appear to be separate plants above ground, such as *Homogyne alpina, Lithospermum purpureocaeruleum*). For species whose populations naturally fluctuate, the definitions of the criteria state that the minimum population number should be used. However, this is a severe ruling for a plant species which may occur in vast numbers when the habitat is in an ideal condition, yet fall to near zero (though retaining a good seed-bank) when it

is not (e.g. *Filago pyramidata*). Much also depends on the interpretation of what is a 'natural' fluctuation. Therefore, reasonable judgement has been applied, rather than taking the minimum number of plants as the qualifying figure.

Criterion D. Very small or restricted population

No qualifiers are given in the *Critically Endangered* and *Endangered* categories; the population size alone will admit the taxon to criterion D irrespective of any decline or threat. In the *Vulnerable* category, D1 relates to the number of mature individuals, and D2 is applicable to a taxon with a very small population and a very restricted area of occupancy. As in criterion B, the area of occupancy is difficult to apply, and in D2 the threshold of the number of locations (normally fewer than five) was the key criterion used in this book. The IUCN guidelines defines a 'location' as "a geographically or ecologically distinct area in which a single event (e.g. pollution) will soon affect all individuals of the taxon present . . . and usually contains all or part of a subpopulation". The main difficulty was in defining locations for species with a scattered distribution (as, for example, along a length of coastline or across a range of hills), and again, some subjectivity was applied.

Criterion E. Population viability analysis (PVA)

This criterion invites a quantitative estimate of the percentage probability of extinction in the wild within a specified number of years. Such analysis should be explicit and based on the known life history and specified management options. Clearly this criterion can be applied only to well-studied organisms whose population dynamics and life histories are adequately known, and has not been applied to any plant in this book.

Conservation Dependent (cd) species

Many *Threatened* taxa are dependent upon regular and continuing conservation management, but this category is reserved for *Lower Risk (near threatened)* taxa that might very rapidly (within five years) become *Threatened* if such conservation action ceases. None of our *Lower Risk (near threatened)* species appears to qualify, though some of these species may, of course, be heading towards *Threatened* status through habitat change or neglect.

Threshold for 'Near Threatened' and 'Nationally Scarce' species

In assigning species to the revised IUCN categories, it should be emphasised that a species may qualify as *Threatened* (i.e. *Critically Endangered, Endangered or Vulnerable*) on the basis of its decline or other criteria, irrespective of its geographical occurrence (in grid squares, in the interpretation of the criteria adopted in this volume). The differentiation of *Lower Risk (near threatened)* species from those that are *Nationally Scarce* and *Lower Risk (least concern)* is more contentious. In this book, we follow established practice in defining species that occur in 16-100 hectads as *Nationally Scarce* unless they qualify as *Threatened*. Whilst this threshold has proved workable over many years, it is admittedly a coarse 'filter', and with the ever increasing availability of detailed locational data, a more refined system is now required. Pearman (1997) suggests many ways by which the definitions of a nationally rare and scarce species can be more precisely defined, based on their occurrence and frequency in smaller Ordnance Grid squares and ideally also on measures of population size. This points a useful way forward, and it is hoped that future Red Data Books will adopt a more refined system.

4 The international context

4.1 Legislation

An obligation to conserve certain species and habitats is laid upon the UK government by a number of international nature conservation conventions and directives. The most important ones that explicitly concern the protection of internationally important species that occur in the UK are the Bern Convention, the EC Habitats & Species Directive, the Ramsar Convention, the CITES Convention and the UN Convention on Biological Diversity.

The Bern Convention (*Council of Europe Convention No. 104 - convention on the conservation of European wildlife and natural habitats*) aims to conserve wild flora and fauna and their natural habitats. It incorporates the principle of sustainable development, and particular emphasis is given to endangered and vulnerable species, especially endemic ones. Appendix 1 of the Bern Convention lists plants requiring strict protection in the signatory states. Nine of the listed vascular plants occur in the wild in Britain (Table 4).

The main aims of the EC Habitats & Species Directive (*European Communities Directive 92/43/EEC, on the conservation of natural habitats and of wild fauna and flora*) were to establish, by the year 2000 at the latest, a network of protected areas in the member states, designed to maintain both the distribution and abundance of threatened species and habitats, and to confer overall protection for the most threatened European species. Annex IVb lists the plants requiring special protection, and Annex IIb lists the species for which protected areas must be designated. Annexes IIb and IVb list nine vascular plant species which occur in the wild in Britain. The Directive also requires, where it is deemed necessary, management of the exploitation of certain species (listed in Annex V). Under the Directive, member states will establish measures, including statutory measures, for the conservation of threatened habitats and species listed in the Annexes. The EU will designate a series of Special Areas of Conservation (SACs) to protect habitat types and species (listed in Annex II) considered to be of European Community interest and requiring conservation. Annex I includes 83 habitat types that occur in the UK, of which 22 are 'priority habitats' because of their Europe-wide rarity. The national network of SACs will contribute in a major way to the conservation of the British flora, including rare species. The protection of habitats in SACs may, of course, conserve nationally rare species other than those listed in the Annexes. For example, those occurring on wet heaths (*Erica ciliaris*), dry calcareous grassland (*Ophrys fuciflora, Orchis simia*), 'Mediterranean' temporary pools (*Cyperus fuscus, Mentha pulegium*), and alpine pioneer formations (*Carex microglochin*). The *Conservation (Natural Habitats etc.) Regulations 1994* came into force in response to the Directive and implements the Directive in GB.

The Ramsar Convention (*Convention on wetlands of international importance, especially as wildfowl habitat*) aims to stem the progressive encroachment on and loss of wetlands, which are broadly defined to include marsh, fen, peatland and water. Sites for designation may, through Article 2, be selected on the basis of their botany as well as other factors, which thus provides opportunity to conserve threatened or endemic wetland plants in designated sites.

The CITES Convention (*Convention on international trade in endangered species of wild fauna and flora*) regulates the international trade in species which are endangered or may become so unless their exploitation is controlled. The EC Regulation 3626/82 (as amended) implements CITES directly in the UK and other member states. Appendix I of CITES lists species whose trade is permitted only in exceptional circumstances (no UK vascular plant species are listed), and Appendix II lists species whose trade is subject to licensing (all orchids, and *Galanthus nivalis*). However, the EC Regulation 3626/82 treats all species of orchid as if they were listed on Appendix I (category C1).

The Convention on Biological Diversity, ratified by the UK government, was an important component of the 1992 United Nations Conference on Environment and Development (the 'Earth Summit') held in Rio de Janeiro. This commits the UK government, *inter alia*, to "develop national strategies, plans or programmes for the conservation and sustainable use of biological diversity". The first product of this commitment was the UK Biodiversity Action Plan, published in 1994, which contains a wide ranging review of our biological resources, and indicates the means by which they may be sustained and enhanced. The Plan outlines programmes and targets for the conservation of both habitats and species; for the latter, these include the preparation of Action Plans for globally threatened and endemic species, the development of a strategy for the *ex situ* conservation of genetic resources, and the preparation of guidelines on species translocations and reintroductions. Programmes for the conservation of habitats are also of key importance for the conservation of our rare and threatened plants.

Other international legislation, although not directly aimed at conserving threatened species, may nonetheless benefit rare plants indirectly by the protection of habitats. Examples include the World Heritage Convention and the EC Birds Directive, some of whose designated sites contain rare UK plants.

Vascular plants listed in international directives and conventions are shown in Table 4 and Appendix 3. Sixteen of the species covered by these international directives and conventions are *Threatened* in Britain (this includes ten orchids additional to *Cypripedium calceolus*). Recent research casts doubt on whether the snowdrop *Galanthus nivalis* is native anywhere in Britain.

Table 4 International obligations for the protection of UK vascular plant species

Species	*EC Habitats & Species Directive Annex*	*Bern Convention Appendix*	*CITES Appendix*	*Wildlife & Countryside Act (GB) Schedule*	*National IUCN threat category*
Apium repens	IIb, IVb	I		8	*Critically Endangered*
Cypripedium calceolus	IIb, IVb	I	II	8	*Critically Endangered*
Galanthus nivalis	Vb		II		*Least Concern*
Gentianella anglica	IIb, IVb	I		8	*Nationally Scarce*
Liparis loeselii	IIb, IVb	I	II	8	*Endangered*
Luronium natans	IIb, IVb	I		8	*Nationally Scarce*
Lycopodium sensu lato - all species	Vb				*Near Threatened/Nationally Scarce/ Least Concern*, according to species
Najas flexilis	IIb, IVb	I		8	*Nationally Scarce*
Orchidaceae (all orchids)	-		II	8 (11 species)	*Critically Endangered* to *Lower* Risk according to species
Rumex rupestris	IIb, IVb	I		8	*Endangered*
Ruscus aculeatus	Vb	-			*Least Concern*
Saxifraga hirculus	IIb, IVb	I		8	*Vulnerable*
Trichomanes speciosum	IIb, IVb	I		8	*Vulnerable*
Bromus interruptus		I			*Extinct in the Wild*
Spiranthes aestivalis	IVb	I	II		*Extinct*

4.2 International importance of the British flora

In comparison with many other European countries, particularly those bordering the Mediterranean, Britain has a relatively impoverished flora, only Ireland, the Low Countries and Scandinavian countries having fewer species. Kent (1992) lists some 1,300-1,400 native species and subspecies of ferns and seed-bearing plants, not including taxa in the large apomictic genera. However, because of our geographical position, the British flora combines north-west European, Lusitanian and Mediterranean elements, together with oceanic, arctic and alpine species.

Many European species are at the limit of their range in Britain, and thus many of our rare plants occur more abundantly in other parts of Europe. Nonetheless, this need not detract from their value in Britain. Species at or near the limit of their geographical range are close to their tolerance for environmental factors. They develop locally adapted populations (ecotypes) which may be genetically or physiologically distinct. Such ecotypes often occupy different ecological niches to those nearer the centre of the range. The need to conserve such diversity is readily apparent, and the importance of conserving the full extent of a species' natural range is also reflected in the new IUCN threat criteria, and is identified in the UK Biological Action Plan as a key objective in conserving biodiversity.

4.3 Endemic and near-endemic taxa, and other species of global concern in the British flora

From an international standpoint, the conservation of endemic taxa is clearly of the greatest importance, and should be the focus of priority action. Since they have such restricted distributions on a global scale they are, by definition, more threatened internationally than more cosmopolitan taxa. In Britain, the relative poverty of our vascular plant flora is matched by the few endemic taxa occurring here. Only about 25 species and subspecies are endemic to the UK and the Isle of Man, apart from the numerous endemic microspecies in *Euphrasia, Hieracium, Limonium, Rubus, Sorbus* and *Taraxacum*. Of these 25, two are extinct in the wild (*Bromus interruptus, Sagina boydii*), and the taxonomy of four others (*Alchemilla minima, Athyrium flexile, Calamagrostis scotica, Cochlearia atlantica*) is disputed. It is sobering to reflect that 71% of the UK endemic species are threatened or near-threatened.

Seventeen of the British endemic or near endemic species are nationally threatened or near-threatened, and accounts of such species are included in this book. The few other endemic species that are nationally scarce in Britain do not qualify for inclusion on the strict application of the IUCN criteria. However, the preamble to the Red List categories (IUCN 1994) advises that the global status category for a taxon should also be taken into consideration when applying the criteria at a national level. All taxa endemic to Britain are thus treated as 'Red Data Book' taxa. The following list of such taxa includes

Table 5 Species and subspecies endemic to the United Kingdom, Isle of Man and the Channel Islands*

Taxon	*Threatened* or *Lower Risk (near threatened)*	*Nationally Scarce*	*Occurrence*
Alchemilla minima	**VU**		**England**
Anthyllis vulneraria ssp. *corbierei*	VU		England, Channel Islands
Arenaria norvegica ssp. *anglica*	EN		England
Athyrium flexile	VU		Scotland
Bromus interruptus	EW		England
Calamagrostis scotica	VU		Scotland
Cerastium fontanum ssp. *scoticum*	VU		Scotland
Cerastium nigrescens	VU		Scotland
Cochlearia atlantica (?endemic)	DD		Scotland
Cochlearia micacea (?endemic)	LR-nt		Scotland
Coincya monensis ssp. *monensis*		LR-ns	England, Scotland, Wales, Isle of Man
Coincya wrightii	VU		England
Dactylorhiza majalis ssp. *cambrensis*		LR-ns	England, Scotland, Wales
Epipactis youngiana	EN		England, Scotland
Fumaria occidentalis	LR-nt		England
Gentianella amarella ssp. *septentrionalis*		LR-ns	England, Scotland
Gentianella anglica		LR-ns	England
Helianthemum canum ssp. *levigatum*	VU		England
Herniaria ciliolata ssp. *ciliolata*	LR-nt		England, Channel Islands
Herniaria ciliolata ssp. *subciliata*			Jersey
Linum perenne ssp. *anglicum*		LR-ns	England, Scotland
Pilosella flagellaris ssp. *bicapitata*	VU		Scotland
Primula scotica		LR-ns	Scotland
Sagina boydii	EW		Scotland
Scleranthus perennis ssp. *prostratus*	EN		England
Senecio cambrensis	LR-nt		England, Scotland, Wales
Tephroseris integrifolia ssp. *maritima*	VU		Wales
Ulmus plotii		LR-ns	England

Key: *not including the many microspecies of *Euphrasia, Hieracium, Limonium, Rubus, Sorbus* and *Taraxacum*. Note: *Cotoneaster integerrimus* from the Great Orme has recently been published as a new and endemic species, *C. cambricus* (Fryer & Hylmö 1994), but there are doubts as to its origin and whether it is distinct from continental stock.

seven endemics, and two non-endemics (*Luronium natans, Najas flexilis*) that are afforded special protection under the EC Habitats and Species Directive. The British endemic, *Gentianella anglica*, is also protected under that EC Directive, and under the Bern Convention.

British 'Red Data Book' taxa:

Coincya monensis ssp. *monensis*
Dactylorhiza majalis ssp. *cambrensis*
Gentianella amarella ssp. *septentrionalis*
Gentianella anglica
Linum perenne ssp. *anglicum*
Luronium natans
Najas flexilis
Primula scotica
Ulmus plotii

Accounts of these species (except for *Dactylorhiza majalis* ssp. *cambrensis* and *Gentianella amarella* ssp. *septentrionalis*) are given in Stewart *et al.* (1994). Conservation programmes should also take account of near-endemic taxa which are not threatened, and those for which Britain has a special responsibility because a high proportion of the world population occurs here. A list of such species, whilst not exhaustive, is given in Table 6.

The percentage of the world population occurring in Britain is an estimate based on available evidence, though this is often difficult to assess as the quality of data from other European countries is variable. For some countries (mainly northern European) there is a detailed and up-to-date record of the flora, but for others (especially eastern and southern European), data are decidedly patchy. Sources of information on the distributions of European species include Jalas & Suominen (1972 *et seq.*), Hultén & Fries (1986), regional atlases and Floras and unpublished data from WCMC. Cook (1983) describes the status of aquatic plants endemic to Europe, and detailed information is available for some European countries in published Red Data Books.

Some of the species listed in Table 6 are not uncommon in parts of their British range, and where there are large populations, a watching brief is perhaps all that is required. However, all these species are represented in some localities by small populations, sometimes comprising only a few individuals. Such endangered populations require positive conservation action if they are to stand any chance of longer term survival. The bluebell *Hyacinthoides non-scripta* is, of course, a celebrated species in Britain and something of a national icon. A high proportion of the world population of this north-west European species occurs in Britain and, though it is still widespread and locally common, it is under increasing threat from commercial exploitation.

Table 6 Select list of other species for which Britain has special responsibility

Taxon	*Threat category in Britain*	*Endemic to Europe*	*% of the world population* [1]	*Remarks*
Alopecurus borealis	LR-ns	No	?	In Europe occurs only in Britain and Svalbard
Carum verticillatum		Yes	25-50	
Deschampsia setacea	LR-ns	Yes	25-50	Threatened throughout its range
Dryopteris aemula		Yes	25-50	
Fumaria purpurea	LR-ns	Yes	?	Endemic to Britain, Ireland and the Channel Isles, perhaps declining
Hammarbya paludosa	LR-ns	No	?	Threatened throughout Europe
Hyacinthoides non-scripta		Yes	>50?	Under threat through commercial exploitation
Hymenophyllum tunbrigense		?	25-50	If taxonomically distinct from similar taxa in North America and elsewhere
Hymenophyllum wilsonii		Yes	25-50	
Oenanthe fluviatilis		Yes	25-50	Decreasing in Europe
Petroselinum segetum		Yes	25-50?	
Pilularia globulifera	LR-ns	Yes	25-50	Decreasing in much of mainland Europe
Ranunculus hederaceus		Yes	25-50	Decreasing in Europe

Key: [1] main source: UK Biodiversity Action Plan

5 Conservation

5.1 GB legislation

The first legislation directly providing significant protection to all wild plants was the Conservation of Wild Creatures and Wild Plants Act 1975. This Act made it an offence, except in certain circumstances, for any unauthorised person to uproot any wild plant, without reasonable excuse. The Act included a list of specially protected plants (Schedule 2), which it was an offence to pick, uproot or destroy, except as an incidental result of an operation carried out in accordance with good agricultural or forestry practice, or in certain other circumstances.

The law providing protection for plants was strengthened by the passing of the *Wildlife and Countryside Act* in 1981, which includes many sections which can be used to further the conservation of plants and their habitats. Under this Act, it remains an offence for an unauthorised person intentionally to uproot any wild plant. However, under section 13(1)a, the picking, destruction or removal of *any part* (including seed) of a specially protected (Schedule 8) plant was made unlawful, except where it could be shown that it was the incidental result of a lawful action and could not reasonably have been avoided. There are also additional restrictions on the sale of plants.

The *Wildlife and Countryside Act* (WCA) also tightened the criteria used for the selection of species for special protection (listed in Schedule 8), so that a plant can be added to the Schedule if it is in danger of extinction or likely to become so unless conservation measures are taken. In addition, species may be added in order to comply with international obligations, such as that conferred by European Union legislation. There are currently 110 species of vascular plant listed on Schedule 8 (see Appendix 3). There is a requirement under the WCA for the Secretary of State for the Environment, with advice from the statutory conservation agencies, to review the Schedule every five years, at which times recommendations may be made for species to be removed or added. The results of these quinquennial reviews could be seen as one measure of the effectiveness of conservation action. The Secretary of State can, however, add species to Schedule 8 at any time, not only at quinquennial reviews.

Rare plants also benefit from legislation providing for site safeguard and habitat protection. Other sections of the WCA provide for statutory designation and management of Sites of Special Scientific Interest (SSSI) and National and Marine Nature Reserves (NNR, MNR).

Rare plants may also benefit indirectly from other environmental legislation not specifically directed towards their conservation. Examples are the Natural Heritage (Scotland) Act, 1991, which enables SNH to enter into management agreements, the Environmental Protection Act, which seeks, *inter alia*, to control pollution and the release of genetically altered organisms, and Town & Country Planning Acts which control development.

5.2 Site protection

Populations of some threatened plants are safeguarded in Britain through the network of protected sites. The principal site designations are: Sites of Special Scientific Interest (SSSI), in which the appropriate statutory conservation agency can negotiate management agreements for the benefit of the wildlife; National Nature Reserves (NNR), which may be owned by one of the statutory agencies and which are managed specifically for nature conservation; Local Nature Reserves (LNR), managed by local authorities; and Special Areas of Conservation (SACs). The last is a designation soon to be brought into operation under the EC Habitats and Species Directive, and will contribute to the Natura 2000 site series, a network of 'elite' sites throughout Europe. The National Park network also provides some protection for important wildlife sites.

The series of non-statutory protected sites is also important for the conservation of threatened plants. National organisations such as the Royal Society for the Protection of Birds (RSPB), the National Trust and the National Trust for Scotland have extensive land holdings, which are managed primarily for the conservation of the wildlife they support, including many sites for threatened plants. The Ministry of Defence is an major landholder, and conservation management of its property is one of its responsibilities, in liaison with the country agencies. Plantlife owns some small nature reserves, mainly herb-rich meadows. At a local level, the Wildlife Trusts also manage substantial areas as nature reserves and some private landowners do the same. Of course, many of the areas owned and managed by these bodies are also SSSIs or NNRs.

Internationally, the Planta Europa network was established as a consortium of statutory and non-statutory organisations involved in plant conservation across Europe, including Plantlife, following the first European conference on the conservation of wild plants at Hyères, France, in 1995. Planta Europa is currently working on a Europe-wide list of Important Plant Areas (IPA), which is intended to feed into statutory site designations under international law such as the Natura 2000 series. In Britain, most of these may already receive some degree of protection through a statutory designation.

Designation of protected sites may, however, be of little value for ephemeral species, such as some of the arable weeds. Some of these species may be highly mobile, appearing at any particular location only when appropriate conditions prevail, and perhaps not remaining for very long. Less intensive management of the wider countryside, such as that provided under the various agricultural incentive schemes, may be more effective in conserving these species. Examples of these schemes, also mentioned below, include Environmentally Sensitive Areas (ESA) and the Countryside Stewardship scheme, both of which are administered by the Ministry of Agriculture, Fisheries and Food (MAFF).

5.3 Conservation

The conservation of wild flora in Britain during this century has mirrored the development of wildlife conservation overall, with the first steps involving purchase of nature reserves followed by the realisation of the need for specific management regimes to suit the needs of plants with different requirements. This in turn has led to more sophisticated assessments of the responses of different species to alternative management approaches and more detailed ecological studies of threatened plants.

Threats to plants are many and diverse, and are described, as far as they are known, in the individual species accounts. Habitat destruction through the loss of semi-natural areas to agriculture, forestry and urban development continues to threaten our rare plants, as do inappropriate management and neglect. Pollution, of all kinds, is an insidious and ever-present threat. Other, more local, threats include the invasion of semi-natural habitats by alien species such as *Rhododendron ponticum* and *Carpobrotus edulis*, and the increasing pressures from the 'leisure industry' leading to the loss of habitat, for example, to golf courses and coastal caravan sites. The importance of appropriate and continuing conservation management for many habitats and species can hardly be over-emphasised.

Grasslands have been particularly badly affected in recent decades, with about 97% of our semi-natural lowland grassland having been destroyed since 1932, either by ploughing, or by the application of artificial fertilisers and herbicides (Fuller 1987). Fenlands and other wetlands, along with the Red List plants they support, are affected by the lowering of the water table, a problem that is becoming more serious in areas such as East Anglia, now officially classified as 'semi-arid'. Large areas of ancient semi-natural woodland are now protected as nature reserves, but other areas remain unprotected and are always vulnerable to new commercial fashions in woodland management and changes in government policy on subsidies etc., any of which are potentially threatening to Red List plants.

Pollution, particularly nitrate pollution, is a serious problem for some species, causing an increased growth of common, nutrient-demanding, 'weedy' species at the expense of those species that thrive in conditions of low nutrient availability. This can affect whole habitats and wide areas, gradually contributing to the degeneration of heathland, for example. Although sulphur dioxide pollution has been reduced over the past two decades, other pollutants, such as the nitrogen oxides, primarily from vehicle emissions, have assumed a greater importance. Cutting harmful emissions from industry is a costly procedure, although the Government has committed itself to reducing the 1980 levels of sulphur dioxide by 80% by 2010 (Critical Loads Advisory Group 1995). The challenge of cutting emissions from vehicle exhausts is even more daunting, but it is an issue that is gradually becoming recognised as crucial for the health of the environment, though usually for reasons other than the well-being of plants!

Collecting by botanists, a factor that has in the past caused a catastrophic decline in some species (such as Killarney fern *Trichomanes speciosum*, which was severely depleted during the Victorian 'fern craze'), is now at a very low level and is not now generally considered a major threat. Most active botanists in Britain are also conservationists and are content with a photographic record of their finds, or a note on paper or in a database. There is a need to collect a rare plant only if there is doubt over the identity of a specimen, and this can normally be accommodated through collecting a minimal amount of material in a responsible way. Having said that, it would take only a single unscrupulous collector to wipe out some of the species covered in this book, so vigilance continues to be necessary.

Global warming is a likely, but at present unquantifiable, threat. It has hitherto often been assumed that as the mean global temperature rises, Britain will experience a warmer climate, with serious consequences for its alpine and snow-bed plants. However, such warming is by no means certain. Another possible scenario, for example, according to some experts, is a movement of the Gulf Stream southwards so that our climate becomes cooler and wetter. A continuing rise in sea-level seems certain, however, and this will have an impact on low coastal habitats and any nationally rare plants they support, including *Corrigiola litoralis* (on shingle) and *Petrorhagia nanteuilii* (on shingle and sand dunes).

Many actions have been, and are being, taken to counter the threats to our native flora, most notably the establishment of a network of protected sites (see above). Apart from designating and managing sites for nature conservation, the statutory agencies have a wider role in advising government, landowners and the public on nature conservation, including the conservation of threatened plants. English Nature's Species Recovery Programme, a programme of action for bringing threatened species back from the brink of extinction, has provided resources for addressing the problems faced by many of our most threatened plants. Similarly, SNH's Rare Plants Programme has addressed the same issues in Scotland, and CCW have their own programme of threatened plant conservation. More recently, other statutory bodies, such as the Environment Agency, have been drawn into the conservation of threatened plants, with the advent of the Biodiversity Action Plans (see below). Local Authorities have an important part to play in rare plant conservation, through local planning, organising surveys and designation and management of Local Nature Reserves.

The botanical societies have a particularly vital role in the conservation of threatened plants, as it is through them that specialist expertise is mobilised and the good-will of members put into practice. The Botanical Society of the British Isles is particularly strong in the field of recording and mapping. This is due in no small part to its system of

vice-county recorders, whereby a local botanist takes on responsibility for plant recording in a particular area. Local Floras are often the product of the efforts of vice-county recorders, usually supported by a small number of local enthusiasts, and remain the definitive sources of data for years or decades after their publication. Increasingly, vice-county recorders are keeping their botanical data on computerised databases.

The launch of Plantlife in 1989 heralded a new era in British plant conservation. Plantlife, with the aim of being to plants what the Royal Society for the Protection of Birds is to birds, has grown steadily and is now an important player in plant conservation both in the UK and abroad. Its main aims include carrying out ecological investigations of endangered species and undertaking practical conservation management at sites where they are declining or have recently disappeared. Emphasis is placed on four main groups of plants which are particularly threatened, namely:

- plants of ponds and commons, such as *Mentha pulegium* and *Pulicaria vulgaris;*
- Mediterranean' annuals - plants close to their northern limit, often of droughted soils in open habitats maintained by grazing, e.g. *Ajuga chamaepitys, Filago pyramidata;*
- plants of coppice, woodland rides and edges. Traditional coppice management is becoming rare, as are plants such as *Carex depauperata* and *Cynoglossum germanicum*, which are characteristic of coppiced woodland;
- other important plants under particular threat, such as the endemic *Gentianella anglica.*

Plantlife's 'Back from the Brink' initiative has directly addressed the conservation of certain species (for example *Damasonium alisma, Filago lutescens, Thlaspi perfoliatum*) that are in particularly grave danger of disappearing from our flora.

Other societies, such as the Wildflower Society and the RSPB, are also active in the conservation of rare species. The Wildlife Trusts and the National Trust are important in survey and protection of particular threatened species, as well as designating and managing nature reserves and other protected sites.

One of the messages highlighted by this Red Data Book is the importance of management for threatened plants *outside* nature reserves and other protected sites. For example, a number of threatened species are arable weeds or otherwise ephemeral species that are dependent on certain forms of management over a wide area rather than in a small specially protected area. It is clear, therefore, that land managers whose prime concern is other than with nature conservation may have a significant responsibility, in partnership with nature conservation bodies, to ensure the continuing survival of such species. MAFF has acknowledged this in the implementation of schemes such as ESA and Countryside Stewardship (inherited from the Countryside Commission), which enable land to be managed sympathetically for plants and other wildlife.

One particular international event has given species conservation a boost in recent years. At the Rio Earth Summit, the UK signed and ratified the Convention on Biodiversity. This has resulted in *Biodiversity: the UK Action Plan* (HMSO 1994) (UKBAP). New partnerships have developed between government departments and agencies, voluntary conservation organisations, business and the private sector, unlocking new sources of funds, with the new partnerships taking action under agreed plans for threatened species. One of the features of UKBAP is the production of lists of species 'of conservation concern'. These were subdivided into three: the 'short', 'middle' and 'long' lists. All short list species and many middle list species now have, or will have very soon, written action plans targeted specifically at the conservation of each species. The remainder of the species on the middle list and all those on the long list are targeted for lower level action or surveillance. The lists - essentially a means of determining conservation priorities - cover all taxonomic groups. Their composition was determined by considering, for each species, its status in Britain, its decline and its international importance. Action plans are not intended to be immutable. Both the individual plans and the composition of the lists will be reviewed at regular intervals and amended as necessary.

In addition to the species listed, thirty-seven habitats of conservation importance are listed in *The UK Action Plan*. Nearly all of these are of at least some importance for plants, including Red List species. Particularly important in the context of the conservation of threatened plants are broad-leaved and yew woodland, native pine woodland, calcareous grasslands, unimproved neutral grasslands, cereal field margins, fen, standing open water, rivers and streams, canals, montane habitats, maritime cliff and slope, sand dunes, coastal strandline and limestone pavement.

In response to the publication of *Biodiversity: the UK Action Plan*, a report (HMSO 1995) has been presented to Government from the Biodiversity Steering Group, a consortium of representatives from statutory conservation agencies, the voluntary conservation sector, Government Departments, industry and other bodies. This report contains costed action plans for 14 habitats, including fens, cereal field margins, native pine woods and limestone pavements, and also action plans for the conservation of 28 species of vascular plant. For example, the action plan for *Alisma gramineum* contains recommendations for, among other things, protecting it at its existing sites, restoration to its formerly occupied sites (either by appropriate habitat management or re-introduction), work on its water quality requirements and depositing seed in the National Seed Bank, run by Kew Gardens at Wakehurst Place.

Ex-situ techniques have an important part to play in the conservation of threatened plants. Whilst cultivation of wild stock or the cryogenic storage of seed is not a alternative to maintaining species *in situ*, these means of conserving genetic resources do provide important

insurance against potential loss due to unforeseen events. Populations of rare and endangered plants are maintained in many botanical gardens and provide a valuable resource for research into propagation, breeding systems and genetic typing. Small collections of rare plants are also maintained in many private gardens, having been established from seed or other parts collected from the wild under licence. Such collections are often important in preserving genetic stock from populations of plants that have subsequently become extinct at a particular locality. A recent example is *Filago gallica*, which became extinct in the wild, stock of native origin subsequently being discovered in a private garden, enabling it to be re-introduced to one of its former native sites. Plants in collections can, however, be exposed to hybridisation with related taxa, and genetic drift, leading to a much diminished value.

Outside Britain, many other European countries have produced or are producing Red Data Books for vascular plants. Together, these form a valuable body of information on the status of threatened plants internationally. The World Conservation Monitoring Centre (WCMC), based in Cambridge, takes a lead in collating information on plants worldwide, and is an important source of information on rare and threatened species internationally.

A key aspect of all the conservation initiatives mentioned above is co-operation and partnership and many such initiatives require co-ordinated input from a number of organisations and individuals. A good example of this is the co-operation between Plantlife and English Nature in implementing Species Recovery Programmes. Current initiatives in data collection and handling and the proposals for a National Biodiversity Network will become increasingly important as more people become involved in threatened plant conservation. A prerequisite for the successful conservation of our most threatened plants is the continuing involvement of amateur and professional specialists, local monitoring and surveillance of Red List species, and co-ordination at the national level. Such co-ordinated action can ensure the long-term survival of Britain's most threatened plants.

N. G. Hodgetts

5.4 Genetic aspects of rare plant conservation

Introduction

Genetic aspects of rare plant conservation have received relatively little attention until recently. There is now a growing realisation that biodiversity extends below the level of species, to include heritable variation between and within populations of the same species. Intraspecific variation may be expressed in qualitative or quantitative characters of a structural, physiological or biochemical nature, and only a small fraction has been formally recognised in infra-specific taxonomies. Conservation biologists are concerned that species may be losing genetic variation, primarily as a consequence of habitat decline and fragmentation, and that this genetic depletion may compromise their ability to evolve and adapt to changing environmental conditions (Falk & Holsinger 1991; Ellstrand & Elam 1993; Loeschke *et al.* 1994). Genetics also has considerable relevance to rare plant conservation as a technique for investigating various aspects of taxonomy, status and population biology of plants. This fundamental distinction between genetics as an investigative tool and as a component of biodiversity is maintained in the following synoptic account of recent work on genetic conservation in rare British vascular plants.

Genetics and biodiversity

Recent case studies on rare British plants have mostly involved population surveys of isoenzyme variation, occasionally supplemented by molecular analyses of the genetic material itself. These studies illustrate the wide diversity of ways in which genetic variation is distributed in vascular plants, particularly in relation to the breeding system. For example, John (1992) contrasted the regional patterning and high levels of heterozygosity in *Mibora minima*, which is wind-pollinated and outbreeding, with the local population differentiation and greater homozygosity found in *Gastridium ventricosum* and *Ononis reclinata*, both of which are autogamous inbreeders. Such fundamental differences in genetic make-up have important implications for rare plant conservation strategies, and genetic survey data can help assessments of priorities for population persistence.

Although vascular plants are polymorphic at an average of 50% of their isoenzyme loci (Hamrick *et al.* 1991), genetic screening has occasionally failed to reveal variation within or between the sampled populations, as in the case of the Welsh populations of *Liparis loeselii*, *Gentianella uliginosa* and *Eleocharis parvula* studied by Kay & John (1995). Similarly, very little variation was detected by isoenzyme and DNA analysis in the British endemic *Primula scotica* (Glover & Abbot 1995). However, a subsequent study of *P. scotica* found high levels of variation in quantitative morphological characters, both between and within populations (Ennos *et al.* 1997). This raises important and as yet not fully resolved questions about the extent to which variation detected at the molecular level is representative of biometric traits of potentially greater adaptive significance.

Conservation of genetic diversity is likely to be a particular priority in species with global population concentrations in Britain, but may also be important in geographically peripheral populations of internationally widespread species. For example, the Snowdonia corrie populations of *Lloydia serotina* are genetically divergent from populations in the French Alps and North American Rockies (B.Jones in prep.). Similarly, the Gower populations of *Draba aizoides* are clearly differentiated from their continental counterparts (John 1992). Lesica & Allendorf (1995) concluded that geographically marginal

populations are potentially important sites for future speciation events and therefore have high value for biodiversity conservation.

A central tenet of population genetic theory is that small, isolated populations tend to lose genetic variation and decline in fitness due to genetic drift and inbreeding depression. The extent to which these processes occur in natural populations has been investigated in Dutch material of *Salvia pratensis*. Small populations were found to contain lower levels of variation in isoenzyme and phenotypic characters than large populations, as predicted by genetic theory (Treuren *et al.* 1991; Ouborg *et al.* 1991). However, there was no significant correlation between population size and various fitness attributes, probably because population contraction had taken place relatively recently and inbreeding effects had yet to be fully realised (Ouborg & Treuren 1995). Further work has focused on modelling the effects of inbreeding depression on demographic characteristics and population viability (Ouborg & Treuren 1997).

Genetics as an investigative tool

Genetic studies have provided important insights into conservation-relevant aspects of the biology of rare species. In the context of plant taxonomy, DNA analysis was used recently to confirm the occurrence of putative *Apium repens* alongside a phenotypically similar variant of *A. nodiflorum* at the former's only extant British locality (Grassly *et al.* 1996). Similarly, genetic screening can aid assessments of the extent to which populations have been 'contaminated' by hybridisation with allied taxa, as in the case study of *Cirsium tuberosum*, which crosses with *C. acaule*, reported by Kay & John (1994). Assessments of native or introduced status can also be examined using genetic techniques, and in *Luronium natans* genetic inter-relationships corroborate the notion that populations in eutrophic lowland watercourses are recently derived from native colonies in upland oligotrophic lake systems (Kay *et al.* in prep.).

The gene pool of a species may also provide important information on its evolutionary origins or population structure. For example, studies of isoenzyme and chloroplast DNA variation in *Senecio cambrensis* have provided evidence for the independent origins and subsequent genetic diversification of this endemic polyploid hybrid derivative of *S. vulgaris* and *S. squalidus* in Wales and Scotland (Ashton & Abbott 1992; Harris & Ingram 1992). DNA analysis has similarly been valuable in elucidating the clonal structure of British populations of the self-incompatible *Pyrus cordata*, with important implications for its species recovery plan (Jackson *et al.* 1997).

Conclusions

Notwithstanding our inadequate understanding of the importance of hereditary factors in extinction, sufficient case studies have been compiled on the British flora to illustrate the relevance of genetics for nature conservation. Genetics has an important role to play in both traditional and progressive approaches to conserving rare vascular plants (Stevens & Blackstock 1997). Representation and maintenance of genetic variation are important considerations in conservation site selection and *ex situ* procedures, and Gray (1997) has emphasised the need to protect populations across their full range of ecological variation. Conversely, problems of crossing and competition need to be assessed in species recovery programmes, and Kay (1993; Kay & John 1997) has cautioned against translocations of inappropriate genotypes which may lead to disruption of locally adapted genotypes or distortion of long-established patterns of genetic variation. With an increasingly interventionist stance being adopted by conservationists towards the end of the 20th century, genetic considerations are likely to play a prominent role in the conservation strategies of the next millennium.

D. Stevens