3 ALIENS IN THE BRITISH FLORA

3.1 SOURCES OF DATA

Two lists of alien species were available, derived from Stace's (1991) *New flora of the British Isles* and Kent's (1992) *List of vascular plants of the British Isles*. Stace's flora excludes microspecies in the genera *Hieracium*, *Rubus* and *Taraxacum*, but includes many garden plants, crop plants and exotic trees that rarely if ever escape into the wild. Kent's list includes microspecies but excludes plants that are not to some extent naturalized.

For the purposes of the present study, the basic list of aliens has been derived from Kent (1992). It includes all species signified by an asterisk as introduced, excluding microspecies in the genera *Hieracium*, *Rubus* and *Taraxacum*. For some enumerations, a few species native to Ireland but introduced to Britain were added. No attempt was made to distinguish species naturalized in Scotland but not England. Such species, being northern in tendency, are most unlikely to increase aggressively in a warmer climate.

An additional list of species was derived from a database of taxa in *Flora Europaea*. This database, prepared under the supervision of Prof. V.K. Heywood, has been revised and extended at the Royal Botanic Garden by R.J. Pankhurst. For each species, the *Flora Europaea* name and synonyms are given, together with a list of countries in which the species occurs. For each country, the entry in the database is a numerical code, specifying whether the species is native, naturalized or cultivated there.

3.2 CATEGORIES OF ALIENS INTERPRETED BY *FLORA EUROPAEA*

The *Flora Europaea* database can be used to distinguish species that are native to Europe from those that are exotic. It can also be used to distinguish species with differing geographical tendencies. For example, no species occurring in Finland can be frost-sensitive and no species occurring in the Balearic Islands can be an arctic-alpine. This is illustrated by the table of temperature limits for the *Flora Europaea* regions, which are mostly countries (Table 3.1).

These data have been used to derive overall temperature indicator values for species. The algorithm used to derive temperature indicator values is given in Appendix 1. Essentially, the indicator value is an analogue of growing degree days for each species. Temperature indicator values were used to divide species into "cold" and "warm" groups (Appendix 1).

The species fell into categories indicated in Table 3.2. The numbers could be reduced appreciably, to a total perhaps 1000, by removal of hybrids, subspecies and duplicated names (especially names of species with infraspecific taxa). Nevertheless, the overall numbers give an indication of the proportions overall.

Table 3.1. Climate normals for *Flora Europaea* regions. Values are minima and maxima taken over the area of the region. Regions with high mountains, such as Italy, have a much larger range than those, such as Denmark, that lack them.

Country		Jan mean daily minimum T (°C)		Jul mean daily maximum T (°C)		Precipitation (mm)	
Name	Abbr	Min	Max	Min	Max	Min	Max
Albania	Al	-14.0	5.0	12.2	31.2	1029.2	1996.5
Austria	Au	-21.7	-3.4	8.8	27.1	615.3	2203.5
Azores	Az	.9	10.6	15.4	25.1	717.4	1024.0
Belgium	Be	-4.1	.9	19.3	24.3	695.8	945.9
Balearic	Ba	-1.3	7.2	21.3	29.8	468.0	724.4
Britain	Br	-6.7	6.0	9.4	22.1	449.2	2762.1
Bulgaria	Bu	-15.8	.8	14.8	31.4	484.6	1006.9
Corsica	Co	-8.6	5.4	13.6	27.6	629.6	1087.4
Crete	Cr	-2.2	9.6	18.9	30.7	530.4	807.1
Czechosl	Cz	-19.4	-3.5	11.5	27.4	557.6	1031.1
Denmark	De	-3.7	-1.2	18.1	20.6	566.1	1059.6
Faeroes	Fa	-1.1	1.0	9.5	11.6	1526.1	1662.5
Finland	Fi	-26.4	-4.5	.1	22.0	420.0	723.3
France	Fr	-23.7	5.5	1.0	30.2	637.5	1739.0
Germany	Ge	-19.6	-.4	6.6	25.8	476.9	1871.5
Greece	Gr	-13.2	8.6	12.1	33.9	398.9	1604.2
Ireland	Hb	-2.1	4.7	12.9	19.7	870.1	1533.9
Switzerl	He	-23.5	-3.2	7.8	28.1	980.0	2203.5
Nethrlnd	Ho	-3.6	1.1	18.4	23.1	667.5	813.0
Spain	Hs	-13.9	9.6	12.5	36.0	281.9	1854.5
Hungary	Hu	-16.1	-4.5	16.6	28.2	513.3	917.2
Iceland	Is	-14.3	.0	1.1	15.4	450.8	1556.2
Italy	It	-23.7	7.4	-.6	30.5	485.5	2203.5
Yugoslav	Ju	-15.3	3.8	12.7	31.8	525.7	1996.5
Portugal	Lu	-4.1	10.6	18.8	33.5	446.2	1729.5
Norway	No	-26.7	1.0	-6.0	21.7	294.0	2534.4
Poland	Po	-19.4	-2.7	9.1	25.8	507.8	950.1
Romania	Ro	-19.0	-1.4	12.8	30.4	436.2	1179.7
Russia N	RsN	-36.6	-10.5	-2.2	23.9	389.3	903.9
Baltics	RsB	-11.7	-4.1	15.6	23.2	559.3	718.5
Russia C	RsC	-29.7	-7.1	7.8	30.4	320.1	847.7
Russia W	RsW	-19.7	-1.1	14.8	33.4	117.4	1171.7
Crimea	RsK	-8.9	-2.3	22.2	28.8	383.8	848.8
Russia E	RsE	-17.9	-3.3	14.5	29.1	365.0	1256.2
Sardinia	Sa	-1.0	6.6	26.1	33.7	560.9	826.2
Svalbard	Sv	-31.2	-5.8	-14.5	10.9	138.1	774.2
Sicily	Si	-8.4	10.0	14.6	33.0	448.1	810.9
Sweden	Su	-27.8	-1.5	-4.2	22.1	462.1	1440.1
Turkey	Tu	-5.6	1.8	23.7	31.1	603.5	807.2

Table 3.2. Numbers of species (from Kent's list) introduced to Britain, classified according to temperature value (TIV °C) and native status in *Flora Europaea* (FE). The category "Unknown" for the temperature indication arises where the species is either not recorded in FE or it is recorded but is nowhere native or naturalized.

Temperature indication	European native	Exotic	Not in FE	Total
Warm (TIV >= 5.4)	216	64	-	280
Cold (TIV <= 5.3)	248	225	-	473
Unknown	-	44	279	323
TOTAL	464	333	279	1076

3.3 ALIENS RECORDED IN THE BSBI MONITORING SCHEME

A valuable indication of the present frequency of aliens is provided by the BSBI Monitoring Scheme (Rich & Woodruff, 1990). This survey, conducted during 1987-1988, is intended as the baseline survey for future monitoring of the British and Irish flora. The sampling scheme for the survey was to take a one-in-nine systematic sample of the 10-km squares, and within these to sample 3 out of the 25 constituent 2-km squares (tetrads). In this way, a proportion 1/75 of the total area of the British Isles was surveyed.

Frequency in the Monitoring Scheme 10-km squares, being based on a standardized survey, is a good indication of the extent to which an alien is present in the countryside. In the event, about 200 aliens were recorded in 10 or more squares. For these, information on habitat and origin were extracted from Stace (1991) and other sources, notably Clapham, Tutin & Warburg (1962) and personal experience in the field.

The resulting list (Appendix 2) gives information on the following attributes.

Species	Species name, abbreviated for 23 letters
LF	Life form (with height if a phanerophyte)
Orig	Area of origin
D	D signifies a canopy dominant
T	T signifies a species forming thickets
L	L signifies a species occurring in late-successional communities

S	S signifies a species reproducing by seed in the wild in Britain
W	W signifies a species that is found in wild habitats of nature conservation interest
Habitat	Brief specification of habitat (mostly from Stace (1991).
Brit	Number of 10-km squares in Britain
Eng	Number of 10-km squares in England
Sco	Number of 10-km squares in Scotland
Ire	Number of 10-km squares in Ireland

The ten most frequent species (Table 3.3) give an impression of the characteristics of the list as a whole.

Table 3.3. The twenty most frequent species in the BSBI Monitoring Scheme. The columns are defined in the text of Section 3.3.

Species	LF	Orig	D	T	L	S	W	Habitat	Brit	Eng	Sco	Ire
Matricaria discoidea	Th	NEAs	-	-	-	S	W	Waste, tilled	286	165	93	97
Acer pseudoplatanus	P35m	CEur	D	-	L	S	W	Woods, hedges	279	167	85	102
Aegopodium podagraria	Hv	CEur	-	T	-	S	W	Waste, hedge	254	155	73	73
Veronica persica	Th	SWAs	-	-	-	S	-	Tilled, waste	215	153	36	57
Aesculus hippocastanum	P39m	SEur	D	-	-	S	-	Rough, grass	210	145	43	50
Epilobium ciliatum	H	NAm	-	-	-	S	W	Waste, cult	203	138	41	17
Symphoricarpos albus	P 2m	WNAm	D	T	L	S	W	Woods, hedges	194	133	40	71
Fallopia japonica	Hv	EAs	D	T	-	-	W	Waste, rivers	194	121	46	64
Veronica filiformis	Hv	Turk	-	-	-	-	-	Lawns, paths	188	127	42	26
Rhododendron ponticum	P 5m	SEur	D	T	L	S	W	Woods, moorland	185	107	55	44
Cymbalaria muralis	Hv	CSEu	-	-	-	S	W	Walls, rocks	184	131	31	40
Larix decidua	P46m	CEur	D	-	-	S	-	Woods, us plnted	170	108	44	11
Calystegia silvatica	Hv	SEur	-	T	-	S	-	Waste, hedges	162	135	8	17
Lolium multiflorum	Th	SEur	-	-	-	S	-	Rough, waste	154	123	19	27
Prunus domestica	P 8m	SWAs	D	T	-	S	-	Hedges, scrub	149	114	16	30
Trifolium hybridum	H	Eur	-	-	-	S	-	Rough, grass	147	104	26	9
Armoracia rusticana	Hv	WAs	D	T	-	-	-	Rough, wayside	141	126	4	4
Castanea sativa	P35m	SEur	D	-	L	S	W	Woods	139	106	18	2
Pentaglottis sempervire	H	SWEu	-	-	-	S	-	Waysides, banks	136	100	22	3
Avena fatua	Th	Eur	-	-	-	S	-	Tilled	135	110	14	3

A notable feature of the list is that many of the species do not occur in habitats of nature conservation interest, or, if they do, then they occur in low quantity and in a way that does not threaten native species. In addition, some of them, not perhaps from among the twenty most frequent, show a northern distribution and would not be expected to respond favourable to climate change.

3.4 A MEASURE OF INVASION THREAT

In order to take account of these differences, a score was constructed, which better reflects the invasion threat of a species. The formula for the score is avowedly rather arbitrary and could no doubt be improved. However, it serves to make the criterion of selection more explicit.

Using the attributes in Table 3.3 and Appendix 2, the following scoring system was applied.

Simple threat score (STS) is calculated by scoring for each of the following attributes and taking a sum:-

Canopy dominant (column D), score 1
Thicket-former (column T), score 1
Late-successional communities (column L), score 1
Reproduces by seed in the Britain (column S), score 1
Occurs in wild places (column W), score 2
Reproduces by seed and occurs in the wild (S & W) score 1
Number of squares in England $\geq$ 30 and <90 score 1
Number of squares in England $\geq$ 90 score 2
Number of squares in Ireland $\geq$ 10 and <20 score 1
Number of squares in Ireland $\geq$ 20 score 2.

The purpose of this scoring system is mainly to identify species that have aggressive characteristics in the wild and which are common enough to pose a threat to nature conservation. The emphasis on Ireland results from the scenarios discussed in Chapter 2. In particular, the climate of cluster 2 will resemble a present Irish climate in the year 2050.

Scottish avoidance score (SAS) is calculated by scoring

$$SAS = 100 * (1 - \text{Number of squares in Scotland} / \text{number in Britain + Ireland})$$

A species absent from Scotland scores SAS=100. A species confined in Britain and Ireland to Scotland scores SAS=0.

Finally, the species invasion score (SIS) is calculated by the formula

$$SIS = STS * SAS / 100.$$

3.5 A GROUP OF POTENTIALLY THREATENING ALIENS

On the basis of the species invasion scores, the 204 aliens listed in Appendix 2 were divided into three categories.

1. Species with SIS < 3.0 (Appendix 3); these were deemed not to pose an immediate threat, although some of them could increase in the future.
2. Species with SIS $\geq$ 3.0 which for various reasons do not pose a threat (Table 3.4).
3. Species with SIS $\geq$ 3.0 which are thought likely to pose a threat; the 'top 50' (Table 3.5).

The reasons for including a species in Table 3.4 were: scarce in natural habitats, dependent on planting, climatically northern, uncompetitive annual or biennial. All of these characteristics were included in SIS, but the species selection was, even so, not ideal.

One species, *Azolla filiculoides*, has been added to Table 3.5. It has a relatively low value of SIS, but this is because of its failure to reproduce by seed. This attribute is not relevant in a free-floating aquatic.

3.6 ALIENS WITH A SOUTHERN DISTRIBUTION

The list of potentially threatening aliens (Table 3.5) is based on species that are at present frequent in the British Isles. Given that future climates for much of Britain will resemble those at present experienced in southwest England and the atlantic coasts of France and Spain, it is necessary to consider species which are not at present especially common but which might increase in future.

An attempt to derive a suitable list from *Flora Europaea* is described in Section 3.2. It was a little disappointing, probably because the occurrence of species in countries is a very coarse indication of their habitat. Several countries, notably Italy and Spain, include environments ranging from high alpine to some of the hottest in Europe.

An unmechanized approach to the problem was therefore adopted. This consisted of a systematic search through the pages of Stace (1991), noting down species that appeared likely to increase in future. These are listed in Appendix 4, together with their life form, family, habitat and country of origin. Using personal knowledge, combined with a scrutiny of the floras of Scilly (Lousley, 1971), Guernsey (McClintock, 1975, 1987) and Jersey (Le Sueur, 1984), a subset of these species was selected, which (a) did not occur in the present "top 50" and (b) were thought to be particularly likely to increase. In all a list of 73 species was selected (Table 3.6)

Because of the great subjectivity in the method of selection, this list cannot be justified as well as the "top 50" in Table 3.5. However, it should contain most of those aliens that are at present not very frequent and which are likely to increase in a warmer Britain.

Table 3.4. Species with invasion score > 3.0 which were deemed not to threaten sites of nature conservation interest. Columns are as follows: SIS Species invasion score, STS Simple threat score, SAS Scottish avoidance score, D Canopy dominant, T Forming thickets, L Occurs in late-successional communities, S Reproduces by seed in GB, W sometimes found in wild places. The number of 10-km squares where it was found during the BSBI Monitoring Scheme are also given: GB number of squares in Britain, En number of squares in England, Sc number of squares in Scotland and Ir number of squares in Ireland.

Species	SIS	STS	SAS	D	T	L	S	W	GB	En	Sc	Ir
Brassica rapa	6.7	7	95	-	-	-	S	W	95	67	9	57
Prunus domestica	6.4	7	92	D	T	-	S	-	149	114	16	30
Matricaria discoidea	6.1	8	76	-	-	-	S	W	286	165	93	97
Epilobium ciliatum	5.7	7	82	-	-	-	S	W	203	138	41	17
Aesculus hippocastanum	5.0	6	84	D	-	-	S	-	210	145	43	50
Crepis vesicaria	5.0	5	100	-	-	-	S	-	116	101	0	20
Foeniculum vulgare	5.0	5	100	-	-	-	S	W	51	45	0	2
Galanthus nivalis	5.0	6	84	-	-	-	S	W	134	94	23	2
Antirrhinum majus	4.9	5	99	-	-	-	S	W	57	46	1	5
Euphorbia esula agg.	4.8	5	95	-	-	L	S	W	17	16	1	0
Sanguisorba minor subsp	4.7	5	93	-	-	L	S	W	13	11	1	0
Lilium martagon	4.7	5	93	-	-	L	S	W	14	13	1	0
Lolium multiflorum	4.5	5	90	-	-	-	S	-	154	123	19	27
Veronica persica	4.3	5	87	-	-	-	S	-	215	153	36	57
Sorbus intermedia	4.2	5	83	-	-	-	S	W	45	35	8	0
Tellima grandiflora	4.0	5	80	-	-	L	S	W	10	8	2	0
Lonicera nitida	4.0	4	100	-	T	-	-	-	36	30	0	26
Impatiens capensis	4.0	4	100	-	-	-	S	W	19	19	0	0
Geranium phaeum	4.0	4	100	-	-	-	S	W	12	9	0	2
Erigeron karvinskianus	4.0	4	100	-	-	-	S	W	10	9	0	1
Diplotaxis tenuifolia	4.0	4	100	-	-	-	S	W	23	20	0	0
Armoracia rusticana	3.9	4	98	D	T	-	-	-	141	126	4	4
Larix decidua	3.8	5	76	D	-	-	S	-	170	108	44	11
Barbarea intermedia	3.8	5	75	-	-	-	S	W	43	22	15	16
Vicia sativa subsp.sege	3.8	4	96	-	-	-	S	W	23	14	1	2
Prunus cerasus	3.8	4	96	-	-	L	S	-	27	19	2	20
Oxalis articulata	3.8	4	95	-	-	-	S	W	20	19	1	0
Lobularia maritima	3.8	4	94	-	-	-	S	W	30	23	2	1
Ligustrum ovalifolium	3.8	4	94	-	T	-	-	-	114	91	8	11
Pinus contorta	3.7	6	62	D	T	-	S	W	22	7	12	9
Arabis caucasica	3.7	4	92	-	-	-	S	W	12	8	1	0
Myrrhis odorata	3.6	6	60	-	-	-	S	W	88	41	40	11
Lysichiton americanus	3.4	4	86	-	-	-	S	W	11	8	2	3
Hesperis matronalis	3.4	4	86	-	-	-	S	-	120	85	22	35
Veronica filiformis	3.2	4	81	-	-	-	-	-	188	127	42	26
Epilobium brunnescens	3.2	6	54	-	-	-	S	W	88	16	58	38
Picea abies	3.0	4	75	D	-	L	S	-	102	63	27	5
Juglans regia	3.0	3	100	D	-	-	S	-	41	38	0	0

Table 3.5. Species with invasion score > 3.0 which may threaten sites of nature conservation interest in a future warmed climate. Columns are labelled as in Table 3.4.

Species	SIS	STS	SAS	D	T	L	S	W	GB	En	Sc	Ir
Symphoricarpos albus	9.4	11	85	D	T	L	S	W	194	133	40	71
Impatiens glandulifera	9.1	10	91	D	T	-	S	W	131	104	14	20
Rhododendron ponticum	8.4	11	76	D	T	L	S	W	185	107	55	44
Prunus laurocerasus	7.9	9	88	D	T	L	S	W	86	63	12	12
Smyrnium olusatrum	7.9	8	99	-	T	-	S	W	49	38	1	26
Acer pseudoplatanus	7.8	10	78	D	-	L	S	W	279	167	85	102
Sedum album	7.4	8	93	-	-	-	S	W	122	92	12	39
Aegopodium podagraria	7.0	9	78	-	T	-	S	W	254	155	73	73
Elodea canadensis	7.0	8	88	D	T	-	-	W	128	95	20	27
Castanea sativa	7.0	8	88	D	-	L	S	W	139	106	18	2
Cymbalaria muralis	7.0	8	87	-	-	-	S	W	184	131	31	40
Quercus ilex	6.9	7	98	D	-	L	S	W	50	46	1	0
Claytonia perfoliata	6.7	7	95	-	T	L	S	W	34	31	2	0
Fallopia japonica	6.6	8	83	D	T	-	-	W	194	121	46	64
Quercus cerris	6.5	7	93	D	-	L	S	W	102	86	8	3
Mahonia aquifolium	6.4	7	91	-	T	L	S	W	63	52	6	0
Pinus nigra	6.3	7	90	D	T	-	S	W	63	49	7	1
Buddleja davidii	6.2	7	88	D	-	-	S	W	114	83	16	12
Lathyrus latifolius	6.0	6	100	-	T	-	S	W	42	41	0	0
Acer platanoides	5.9	7	84	D	-	L	S	W	119	89	20	2
Centranthus ruber	5.9	6	99	-	-	-	S	W	89	72	2	16
Heracleum mantegazzianu	5.2	7	74	D	T	-	S	W	61	42	18	8
Quercus rubra	5.0	5	100	D	-	-	S	W	16	12	0	1
Vinca major	4.9	5	98	-	T	L	-	W	85	70	2	7
Crocosmia x crocosmiifl	4.8	6	80	-	T	-	-	W	99	48	33	62
Sedum rupestre	4.8	5	96	-	-	-	S	W	70	53	3	3
Calystegia silvatica	4.8	5	96	-	T	-	S	-	162	135	8	17
Populus x canescens	4.8	5	95	D	T	-	-	W	72	65	4	6
Erysimum cheiri	4.7	5	94	-	-	-	S	W	44	33	3	5
Impatiens parviflora	4.5	5	90	-	-	L	S	W	28	25	3	0
Populus alba	4.4	5	89	D	T	-	-	W	96	75	11	4
Eranthis hyemalis	4.4	5	89	-	-	L	S	W	27	24	3	0
Campanula rapunculoides	4.4	5	89	-	-	L	S	W	18	16	2	0
Leycesteria formosa	4.4	5	88	-	-	L	S	W	11	9	2	5
Hyacinthoides hispanica	4.4	5	88	-	-	-	S	W	76	57	10	4
Gaultheria shallon	4.3	6	72	-	T	L	S	W	14	10	4	0
Vinca minor	4.3	5	85	-	T	L	-	W	83	60	13	2
Senecio cineraria	4.0	4	100	-	-	-	S	W	10	10	0	0
Allium triquetrum	4.0	4	100	-	-	-	S	W	16	14	0	4
Petasites fragrans	3.9	4	97	-	T	-	-	-	94	78	5	44
Elodea nuttallii	3.7	4	93	-	T	-	-	W	39	35	3	0
Doronicum pardalianches	3.5	5	69	-	-	L	S	W	48	26	15	0
Claytonia sibirica	3.4	6	56	-	T	-	S	W	90	42	41	2
Cornus sericea	3.4	4	84	-	T	L	-	W	15	10	3	3
Juncus tenuis	3.4	5	68	-	-	-	S	W	81	40	29	8
Lupinus arboreus	3.2	4	79	-	-	-	S	W	23	17	5	0
Fallopia sachalinensis	3.2	4	80	D	T	-	-	W	23	17	5	1
Robinia pseudoacacia	3.0	3	100	D	T	-	-	-	31	30	0	0
Crassula helmsii	3.0	3	100	-	T	-	-	W	13	13	0	0
Azolla filiculoides	2.0	2	100	-	-	-	-	W	20	20	0	0

Table 3.6. Selected list of southern species, which are thought likely to increase in future. Many of these are already common in the Channel Islands and Scilly. The 73 species are listed by life form and ordered by family.

1 Therophytes (annuals)
Ranunc Ranunculus muricatus
Amaran Amaranthus deflexus
Portul Portulaca oleracea
Crucif Coronopus didymus
Crucif Diplotaxis muralis
Crucif Erysimum cheiranthoides
Euphor Mercurialis annua
Oxalid Oxalis stricta
Solana Datura stramonium
Solana Nicandra physalodes
Boragi Amsinckia lycopsoides
Boragi Amsinckia micrantha
Compos Conyza sumatrensis
Compos Senecio squalidus
Gramin Anisantha madritensis
Gramin Cynosurus echinatus
Gramin Lagurus ovatus
Gramin Setaria viridis

2 Biennials
Legumi Melilotus altissimus
Legumi Melilotus officinalis
Onagra Oenothera stricta

3 Geophytes
Oxalid Oxalis latifolia
Oxalid Oxalis pes-caprae
Liliac Allium neapolitanum
Liliac Allium roseum
Liliac Nectaroscordum siculum
Iridac Gladiolus communis

4 Hemicryptophytes
Crucif Diplotaxis tenuifolia
Halora Gunnera tinctoria
Onagra Epilobium pedunculare
Umbell Foeniculum vulgare
Umbell Hydrocotyle moschata
Umbell Hydrocotyle novae-zeela
Boragi Pentaglottis sempervire
Labiat Melissa officinalis
Scroph Antirrhinum majus
Lentib Pinguicula grandiflora
Juncac Juncus planifolius
Juncac Juncus subulatus
Gramin Agrostis castellana
Gramin Cynodon dactylon
Gramin Dactylis polygama
Gramin Paspalum distichum
Gramin Polypogon viridis

5 Chamaephytes
Selagi Selaginella kraussiana
Urtica Soleirolia soleirolii
Aizoac Carpobrotus edulis
Aizoac Carpobrotus glaucescens
Aizoac Disphyma crassifolium
Ericac Daboecia cantabrica
Oxalid Oxalis corniculata
Labiat Thymus vulgaris
Compos Erigeron karvinskianus
Compos Otanthus maritimus

6 Phanerophytes
Pinace Pinus pinaster
Pinace Pinus radiata
Laurac Laurus nobilis
Aizoac Lampranthus falciformis
Aizoac Oscularia deltoides
Chenop Atriplex halimus
Polygo Muehlenbeckia complexa
Ericac Arbutus unedo
Ericac Erica lusitanica
Pittos Pittosporum crassifoliu
Rosace Cotoneaster horizontali
Rosace Cotoneaster integrifoli
Rosace Prunus lusitanica
Legumi Genista hispanica
Legumi Spartium junceum
Myrtac Leptospermum scoparium
Umbell Bupleurum fruticosum
Caprif Viburnum tinus
Gramin Pseudosasa japonica

4 ALIENS IN THE FLORA OF NEARBY EUROPEAN COUNTRIES

Given that the climate is expected to become warmer, the question naturally arises of whether there are plants in nearby European countries which have characteristics that would be expected of invaders.

A list of species present in Belgium, Germany and the Netherlands but not listed by Stace (1991) was assembled from the *Flora Europaea* database. Relatively few plants in this list appear to be likely invaders, and it is not reproduced here. Several species with southern tendencies also occur in France, notably the trees *Acer monspessulanum* and *Quercus pubescens*, the subshrub *Fumana procumbens* and the annual *Heliotropium europaeum*. Growing as they do in Germany, these are not markedly atlantic species, and are therefore not especially likely to be favoured by future British climates. In particular, summer warmth and drought are likely to be more favourable to them than the mild winters that are predicted for the future. Only if the summers become markedly drier would they be favoured.

Most of the species that have established in the Netherlands (Weeda, 1987) are familiar enough from Britain. The most successfully established woody plants in the Netherlands are *Acer pseudoplatanus* and *Sambucus racemosa*. Both of these are European species, but are more common in northern Britain than in the south, and therefore are not likely to respond favourably to climate warming. *Amelanchier lamarckii*, *Prunus serotina* and *Quercus rubra*, all from North America, are widely planted and sometimes naturalized, but they have not become abundant except where they have been planted. While these species have not become abundant far away from their point of introduction, *Aronia x prunifolia*, also with North American parentage is a suckering shrub of peat bogs, which regenerates by seed in the wild. However, this is a plant that can be expected to increase under the present climate and which would not be particularly favoured by warming. Stace (1991) suggests that both its parents are likely to increase in the British Isles.

The Atlantic flora of Europe has been considered in detail by Dupont (1962). Dupont (1990) has also mapped a proportion of the French flora. There are a number of plants that might, from their French distribution, be expected to be suited to future climates in Britain (Table 4.1).

It is notable that *Acer monspessulanus* and *Quercus pubescens* occur in this region as well as in Germany, suggesting that some genotypes of these species should be adapted to future climates in Britain. Most of these plants are characteristic of dry hills or dunes. Only *Peucedanum lancifolium* is a plant of wet ground.

Table 4.1 Species not naturalized in Britain but occurring in atlantic France (data from Dupont, 1990)

Acer monspessulanus	Similar distr to Quercus pubescens
Cistus salvifolius	Siliceous rocks
Ephedra distachya	Steppic, mainly SE Eur, on Bret dunes
Erica scoparia	Mediterranean atlantic
Helichrysum stoechas	Dry grassland, dunes, rocks, to Bret
Potentilla montana	Acid sands
Quercus pubescens	Calcicolous at northern limit
Quercus pyrenaica	Sunloving siliceous
Peucedanum lancifolium	Boggy places, Bretagne
Pseudarrhenatherum longifolium	Abundant, pinewoods, heaths in Landes, rare Bretagne

It has not been possible, within the scope of this study, to make a detailed examination of the flora of northern Spain. This flora (see, for example, Mayor & Diaz, 1977) is similar to that of Britain. Apart from species that are already well known from the Irish flora (*Arbutus unedo, Daboecia cantabrica, Erica mackaiana*), there are only a few, such as *Erica lusitanica*, that appear likely to spread in Britain in future.

5 HABITATS UNDER THREAT

5.1 SPECIES ALREADY FREQUENT IN ENGLAND

In an attempt to clarify habitat preferences, the list of 50 common aliens that are likely to thrive in a warmer England has been classified by life form and habitat (Appendix 5; Table 5.1). This list has been strongly selected for species characteristic of permanent late-successional habitats. Thus it is hardly surprising to find that hedges and woods are the most frequent habitats.

Table 5.1. Habitat preferences of the top 50 species already well established in England. For details of the species considered, refer to Appendix 6. Habitats (columns) are grouped and labelled with initial letters as follows.

Tillage **H**orticulture **G**arden **W**aste **T**ransport
Dune and shingle **S**altmarsh
Coast rock **W**alls **I**nland rock
Lawn **U**nmanaged grass **P**ermanent grass **T**rack **B**ank
Stream **W**etland **B**og **H**eath **S**hrub **H**edge **W**ood

	T	H	G	W	T	D	S	C	W	I	L	U	P	T	B	S	W	B	H	S	H	W
Therophyte	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	1	.	.	.	2	3
Biennial	.	.	.	1	.	.	.	1	.	.	.	.	.	.	1	1	1	.	.	.	1	1
Geophyte	.	1	3	.	.	.	.	.	.	.	.	.	.	.	2	1	1	.	.	.	2	3
Hemicryptophyte	.	.	3	3	3	.	.	4	2	4	.	.	.	1	4	3	.	.	1	.	5	4
Chamaephyte	.	.	.	.	.	.	.	2	1	1	.	.	.	.	2	.	.	.	.	.	2	2
Phanerophyte	.	.	2	.	1	3	.	2	1	1	.	.	.	.	.	.	.	1	3	8	7	15
Hydrophyte	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	4	.	.	.	.	.
Total	.	1	8	4	4	3	.	9	4	6	.	.	.	1	10	10	7	1	4	8	19	28

Of greater interest are the remaining habitats, in order of preference:-

Banks	10
Streamsides	10
Coastal rocks	9
Shrubland	8
Garden	8.

Banks are especially characteristic of clonally spreading hemicryptophytes and chamaephytes, notably *Aegopodium podagraria*, *Fallopia* spp., *Petasites fragrans* and *Vinca* spp. To a lesser extent they support geophytes, in the form of *Allium triquetrum* and *Crocosmia x crocosmiiflora*, and the monocarpic *Claytonia sibirica* and *Smyrnium olusatrum*.

Streamsides and river banks are typically rather open habitats and therefore are likely to be invasible. The relatively high score for streams and rivers is partly due to the inclusion of four water-plants. Streambanks also support clonal hemicryptophytes, including several of those characteristic of other banks. Monocarpic plants are perhaps fewer, although *Heracleum mantegazzianum* and *Impatiens glandulifera* have attracted much attention.

Coastal rocks and coastal undercliffs support a wide variety of species, including the hemicryptophytes *Centranthus ruber*, *Lathyrus latifolius* and *Sedum* spp. When cliffs fall, invasion by woody species is often rapid. *Quercus ilex* is invading coastal undercliffs in several places on the south coast of England, and the shrub *Buddleja davidii* also takes advantage of open habitats.

Shrublands in Britain are generally a seral stage between grassland or open ground and woodland. Admittedly, *Rhododendron ponticum* forms dense shrubby thickets, but most of the invaders of this habitat are essentially woodland species.

Another rather ill-defined habitat is that of gardens. Almost all the common aliens can sometimes be found in gardens. Indeed, the great majority of them are still regularly cultivated for ornament. The main exceptions are *Aegopodium podagraria* (of which a variegated form is often cultivated), *Calystegia sylvatica*, *Claytonia* spp., *Cymbalaria muralis* and *Juncus tenuis*. Only the last of these was not deliberately introduced, either for human consumption (*A. podagraria*) or for ornament.

5.2 SPECIES EXPECTED TO BECOME FREQUENT IN FUTURE

A similar analysis was made for the selected list (Appendix 6; Table 3.6) of species that are currently not frequent but which are expected to increase. The detailed ascription of these species to habitats is made in Appendix 6 and the results are summarized in Table 5.2.

In this list, with no prior selection for permanent habitats, the habitat preferences are totally different. The most frequent in descending order are:-

Waste places	32
Coastal rock	12
Walls	12
Dune	9
Horticulture	8
Shrub	7.

Table 5.2. Numbers of species thought likely to increase in a warmer climate, grouped by habitat. For details of the species considered, refer to Appendix 5. Habitats (columns) are grouped and labelled with initial letters as follows.

Tillage **H**orticulture **G**arden **W**aste **T**ransport
Dune and shingle **S**altmarsh
Coast rock **W**alls **I**nland rock
Lawn **U**nmanaged grass **P**ermanent grass **T**rack **B**ank
Stream **W**etland **B**og **H**eath **S**hrub **H**edge **W**ood

	T	H	G	W	T	D	S	C	W	I	L	U	P	T	B	S	W	B	H	S	H	W
Therophyte	3	6	1	14	.	2	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Biennial	.	.	.	2	.	1	.	1	.	.	.	2	.	.	.	.	.	.	.	.	.	.
Geophyte	.	2	1	6	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	1
Hemicryptophyte	.	.	.	7	1	.	1	.	2	1	4	1	1	2	.	2	1	1	1	.	2	1
Chamaephyte	.	.	1	1	.	4	.	3	4	.	1	.	.	.	4	.	.	.	1	.	.	.
Phanerophyte	.	.	.	2	3	1	1	7	4	2	.	.	.	.	2	.	.	.	3	7	1	2
Total	3	8	3	32	4	9	2	12	10	3	5	3	1	2	6	2	1	1	5	7	5	4

Waste places are by far the most important alien habitat in the list, particularly for monocarpic plants (annuals and biennials) and geophytes. Among the geophytes, the genera *Allium* and *Oxalis* are especially notable. Several species of these genera other than those listed in Appendix 6 could also become common (Appendix 4). The large number of annuals and biennials is exactly what would be expected from the disturbed and open character of waste places.

Coastal rocks and undercliffs are another major habitat for potential aliens. Several alien species are already threatening the habitat in southern Britain. In particular, *Carpobrotus edulis* forms large mats over cliffs in southwest England, and two other Aizoaceae, *C. glaucescens* and *Disphyma crassifolium* are also potentially smothering (Preston & Sell 1989). On limestone rocks, invasive *Cotoneaster* species can compete with valued indigenous flora, notably with *C. integerrimus* on the Orme peninsula. They are a potential threat in England.

Other phanerophytes that may become established on coastal rocks and undercliffs are generally less threatening. *Muehlenbeckia complexa* and *Pittosporum crassifolium* may become more widespread in southwest England. They are, however, perhaps no more likely to damage cliff habitat than indigenous shrubs such as *Prunus spinosa*.

The occupation of walls by aliens has no relevance to nature conservation unless these species then escape into natural habitats, notably inland rocks.

Dunes, on the other hand are of great conservation interest, and are often subject to invasion by aliens. Annuals such as *Cynosurus echinatus* and *Lagurus ovatus*, and biennials such as *Oenothera* spp. do not convert open habitat to closed vegetation and do not threaten dune communities. At the other extreme, *Pinus* spp. can rapidly invade ungrazed dunes and convert them to woodland. Climate warming will not essentially affect this process, although it may affect the species of invasive pine, making *P. pinaster* a more successful invader. Dunes are also potentially affected by Aizoaceae, notably *Carpobrotus edulis*; however, it is palatable to rabbits (Preston & Sell 1989) and may well be capable of being controlled by other grazing animals.

Horticultural land figures as an major alien habitat because of the importance of horticulture in Scilly and the Channel Islands. Geophytes are particularly notable; the common mediterranean weed, *Gladiolus communis*, occurs in bulbfields, as do many species of the genera *Allium* and *Oxalis*. There are also a wide variety of annuals, but these are no more threatening than the existing weed flora.

Shrubland, indicated as a habitat, is not specifically threatened. Native shrublands are almost always seral, nd the indication of shrubland as a habitat is mainly a reflection of the fact that there are numerous potentially invasive shrubs, for example *Arbutus unedo*, *Laurus nobilis*, *Leptospermum scoparium*, *Prunus lusitanica* and *Viburnum tinus*. These are all evergreen species, and represent a life form that can be expected to increase.

Heathland is a strongly threatened type of community under the current climate. Climate warming should not increase the threat. Indeed, many interesting heathlands exist in the atlantic zone of France and Spain. In a warmer climate they may be subject to an increased frequency of fires, but the basic threat, of conversion to shrubland and woodland will remain the same.

6 DISPERSAL OF POTENTIALLY INVASIVE SPECIES

The large majority of the aliens that have entered Britain were introduced by gardeners. Activities of gardeners continue to disperse them near to human habitation. Other major influences are deliberate planting, often of shrubs for pheasant cover, and transport of seeds and other propagules in mud and on the wheels of cars.

It has been observed above that almost all of the 50 species already frequent in England (Appendix 5; Table 3.5) are regularly cultivated in gardens, or (*Aegopodium* and *Fallopia*) occur as garden weeds. *Juncus tenuis*, with very small and presumably long-lived seeds is clearly moved about in mud on car wheels.

None of these species will therefore experience any difficulty with long-distance dispersal. Gardeners will see to that. The problem, if any, is medium-distance dispersal. Here, the main distinction is between plants that rely almost entirely on clonal spread on land (*Cornus sericea*, *Fallopia* spp., *Petasites fragrans*, *Populus* spp., *Robinia pseudoacacia*, *Vinca* spp.) and species that can reproduce by seed or spread clonally between water bodies. The clonal spreaders can threaten interesting wooded bottomlands and, locally, duneland; but they will not threaten more remote habitats.

Of the species that are relatively infrequent but likely to spread in future, those that are particularly characteristic of waste places (Appendix 6) are potentially ubiquitous. A small number of these may also spread to more natural habitats, notably duneland and streambanks. However, because most of these species are not likely to enter mature woodland or permanent grassland, the medium-distance dispersal problem hardly arises.

On the sea-coast, particularly, there is a wide variety of dispersal agents, so that sea-cliffs are notably invasible. A particularly interesting case is that of *Carpobrotus edulis* spreading to new coastal sites. Although seedlings have been observed in the wild, a major agent of dispersal is gulls, which collect fragments for nesting material.

Perhaps the most likely species to experience dispersal difficulties are those of heathland, notably *Erica* spp. and *Daboecia cantabrica*. The heathland resource is highly fragmented. These species may not be able to reach many new sites unless (as is quite likely) they are deliberately planted in the wild.

7 CONCLUSIONS AND RECOMMENDATIONS

7.1 ANALOGUE CLIMATES

Although climates of southern England will be different from those experienced anywhere in Britain today, there is no evidence that they will be markedly unlike climates currently experienced in the Channel Islands, Brittany, southwest France and northwest Spain. The future climate of northern England will resemble the present climate of the southwest.

7.2 THE RESPONSE OF THE FLORA

Species with the potential to increase as a result of climate change are mostly those that are already common in those regions. If they are not already present in Britain, at least in gardens, then they are unlikely to colonize naturally in less than a century.

Gardens will remain the major source of alien immigration. Aliens imported in bird seed and wool, although very numerous in British lists, rarely become established. If they do so, it is chiefly on disturbed ground in the region of towns and docks. Such plants have little potential to invade native habitats other than cliffs, dunes, shingle and strandlines.

There are remarkably few aliens that appear likely to form the canopy of established woods. In existing woodland, some increase of *Castanea sativa*, *Quercus cerris*, *Q. ilex* and *Q. rubra* could be expected. However, *C. sativa* is compromised by disease and is currently decreasing in southern Europe. It will probably persist where planted but will not prove to be an aggressive invader. The same applies to the oaks. They are not subject to debilitating disease, but nevertheless show little tendency to increase within established woodland. Only on rocky south-facing slopes is major change at all likely. Here, conditions for *Q. ilex* may be very suitable, so that it will become an established canopy tree. However, it is interesting to note that in southern Europe, *Q. ilex* is favoured by disturbance, so that, with decreasing human pressure, it is being replaced widely by *Q. pubescens* (Reille & Pons 1992). As *Q. pubescens* is scarcely planted in England, its place on dry slopes could be taken by *Q. cerris*.

Aliens in the understorey of established woods are much more numerous, particularly as planted species often form thickets that increase clonally. On acid soils, *Rhododendron ponticum* will remain a major nature conservation problem. The physiognomically similar *Prunus laurocerasus* is likely also to increase. It is often birdsown in relatively remote sites and is not a calcifuge. Particularly threatened are wooded bottomlands, where clonal plants such as *Cornus sericea*, *Pseudosasa japonica* and *Symphoricarpos albus* can form dense thickets. However, with the sole exception of *P. laurocerasus*, there is no reason to expect any additional invasion as a result of climate change.

There are remarkably few perennial grasses or species of grassland that are expected to invade in a warmer climate. *Agrostis castellana* and *Cynodon dactylon* will increase in lawns and in waste places. *A. castellana* may perhaps increase in semi-natural grasslands, but is so similar to native species of *Agrostis* that its presence would be obvious only to the specialist. Effectively, the grassland habitat is not threatened by invaders. Very locally, grassland is being invaded by *Quercus ilex* and *Viburnum tinus* (Shepherd 1990). However, this is essentially an example of woodland and scrub invasion, a process that can proceed independently of climate change.

Heathland will not experience any new threats as a result of climate warming. It will, no doubt, continue to decrease in extent; but this will be the result of changes in land management and possibly of nitrogen deposition. Indeed, additional heathland species could well be regarded as a prospect for introduction to the wild if the climate becomes suitable for them.

A complete contrast is provided by the more invasible habitats such as coastal and inland cliffs, dunes and strandlines. Here, a large number of species will invade and increase. Many of the potential invaders are similar to species that are already present; they will not alter the essential character of the communities they invade. Indeed, a few, such as *Otanthus maritimus*, have in the past been present as British natives.

Much the largest threat to these habitats from aliens is from species that smother the substrate, notably from *Carpobrotus edulis* on the coast, and perhaps from *Cotoneaster* species inland.

7.3 CONTROL MEASURES

It is clear from what has been written above that control measures against alien invaders are not generally required. Indeed, although aliens such as *Acer pseudoplatanus* and *Rhododendron ponticum* are already well established in semi-natural habitats, the prospect of climate warming should not make the problem worse. This is because there are few potential invaders of closed vegetation available to increase. One of the main threats is the planting of clonally spreading exotics in bottomlands and private woodlands. In sites with high heritage value, these should be destroyed. Where elimination is impossible, such species could sometimes be contained by a local *cordon sanitaire*.

Any attempt to keep aliens away from coasts and rocks would be doomed to failure. On coasts, there are many sources of introduction. In particular, aliens escape from gardens and become established on walls. From these they spread to semi-natural habitats.

The main danger to natural vegetation on coasts is smothering by aggressive herbs and shrubs. Small uncompetitive coastal plants are often at risk, and Preston

(1988) recommends that stretches of valuable coastline on Guernsey should be maintained as a *Carpobrotus*-free zone. Because of the inaccessibility of many cliffs, the plant can never be eliminated completely. Indeed, such are its powers of survival as fragments that it is almost impossible to eliminate once established (Frost 1987).

Part of the problem arises from the fact that many cliffs are ungrazed. On dunes and slopes, grazing livestock provide the best method of maintaining good habitat. Almost all the deleterious effects of aliens are due to invasion by highly competitive species, and these can usually kept under control by grazing.

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