Rare Arable Flowers in the Oxford Heights

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Summary

From 1996 to 1998, rare arable plants were surveyed within 290 fields from 37 farms in the Oxford Heights. Twenty-one target species were recorded from a list of 51 arable flower species which are thought to be rare or to have declined in Oxfordshire. In general, arable plant species have declined in the area in recent years, with species such as corn chamomile (*Anthemis arvensis*) and corn buttercup (*Ranunculus arvensis*) now very rare indeed. The sandy soils supported the richest arable plant communities and many target species were entirely restricted to this soil type. The crop types most favourable to rare arable flowers were spring crops. The conservation of rare arable flowers is discussed in relation to the findings of the research.

Declines in Rare Arable Flowers

Many of our beautiful farmland flowers have declined dramatically in recent years. Some of these like pheasant's-eye (*Adonis annua*) have never been particularly widespread, but others like cornflower (*Centaurea cyanus*) which were once very common throughout Britain, are now restricted to only a handful of sites. Phil Wilson, Britain's leading arable plant expert, gives a detailed account of the reasons for the declines in his 1992 British Wildlife article (Wilson 1992). Most of the changes have taken place since 1945. During this time farming has become much more intensive: monoculture has replaced traditional mixed farming systems; crops are now autumn rather than spring sown; crops are sown and harvested earlier; fertilizers and chemical pesticide applications have increased hugely; field boundaries have been removed; cereal strains are being developed to grow at higher densities. The arable flora has evolved to grow in close association with arable crops over thousands of years. However, the changes in farming practices during the last 50 or so years have been so rapid that many arable plant species have been unable to keep pace.

Rare Arable Plant Surveys in Oxfordshire

In 1995, a number of concerned botanists and agriculturists in Oxfordshire set up the Rare Arable Flora Group, which aimed to raise the profile and promote the conservation of rare arable flowers. The Group quickly recognised that many arable plant records were at least 10-20 years old. Consequently, the Northmoor Trust, with funding support from English Nature, began surveys of rare arable plants in order to find out their current status. Rather than trying to cover the whole county, attention was focused on hotspot areas which were known to have had a rich arable flora in the past.

The first target area was the corallian limestone ridge of the Oxford Heights, corresponding to the section of the Midvale Ridge Natural Area falling within the adjoining Prime Biodiversity Area (Figure 1). This paper reports the findings from field-by-field surveys of rare arable flowers in the Oxford Heights, undertaken from 1996 to 1998. Full survey reports are given in Hunt (1996), Sutcliffe (1997) and Kay and Gregory (1998).

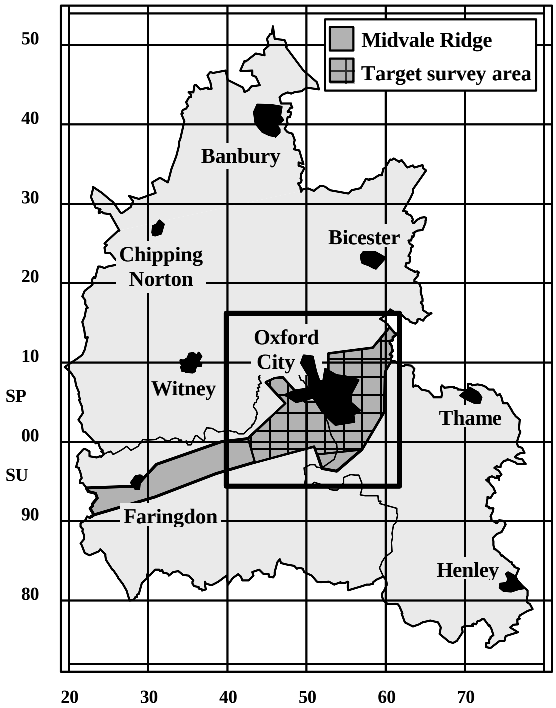

Figure 1. The modern county of Oxfordshire showing the Midvale Ridge Natural Area (shaded), with the target survey area (the 'Oxford Heights') shown hashed. Key towns and the city of Oxford are shown to aid orientation.

Species chosen for the survey

The Rare Arable Flora Group drew up a list of 51 arable plant species to be recorded during the survey (Table 1 in the Appendix). The list is split into two. Part A contains 31 species, which are thought to be rare in Oxfordshire (some may even be extinct) or are known to have declined in the county over the past 50 years. It includes species which are Nationally Scarce (found in only 16-100 of the 10 km grid squares in the UK) (Stewart *et al.* 1994) or listed in the Red Data Book, which documents British species that are considered rare or vulnerable (Wigginton 1999). Part B contains 20 species which are considered to be of slightly lower conservation priority in Oxfordshire. It includes species like the fluellens (*Kickxia* sp.) and Venus's-looking-glass (*Legousia hybrida*) which although not rare, are thought to be less common than they used to be. Seventeen species from both List A and List B are included in the UK Biodiversity Action Plan (UK BAP), which identifies species that have globally important populations occurring within Britain (Anon 1995, Anon 1998).

Field Methods

Permission was obtained from landowners before any survey work was carried out. At each farm, the margins of all arable fields were then walked, looking specifically for the 51 species from the target list (Table 1 in the Appendix). Our sampling was mostly restricted to the field edges (within the outer 6 m of the field), because this is where the uncommon species tend to be found (Wilson and Aebischer 1995), although a special effort was made to search likely areas, for example field corners which supported a less dense crop. All the surveys were completed between early May and early August. Sites visited early in the season were often re-visited later on in order to check the identity of species.

Where species from the target list were found, a record was made of the margins on which they were growing. Abundance was scored on a scale of 1-5 (rare to common). (After the first year, an estimate of the number of individuals was also given e.g. 10-20 individuals; 50-100 individuals).

A note was made of the crop type of each field, and soil type was obtained from British Geological Survey maps (solid and drift editions).

Data Analysis

Canonical ordination techniques are mathematical techniques which help us to detect relations between species and their environment. We used canonical correspondence analysis (CCA) to examine the relationships between target species and soil and crop types using the computer programme CANOCO (ter Braak 1987). The three soil types, sand, limestone soils and clay, and the three crop types, winter-sown crops, spring-sown crops and set-aside were considered as factors which were thought to affect the distribution of target species. Since many species occurred on a low number of sites, it was necessary to include the 'down-weighting rare species' option in the computer programme, to make the analysis more meaningful. Monte-Carlo randomisation tests were undertaken to assess the statistical significance of the effect of crop and soil types on rare plant communities.

Our findings

A total of 290 fields from 37 farms were surveyed covering the bulk of the target survey area (Figure 2). In general farmers had no objection to the surveys (of the 42 farmers contacted, only five refused to give us permission to survey their land), and some showed an active interest in the work.

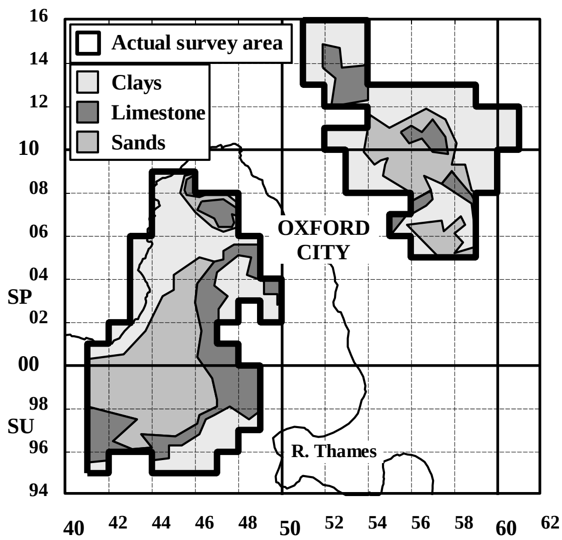

Figure 2: Simplified soil map of the Oxford Heights, showing broad soil types. The bold line indicates the actual areas surveyed within the Oxford Heights target survey area (shown in Figure 1)

(a) Target species

Table 2 (in the Appendix) shows the 21 target species found during the survey (out of a total of 51 target species), including the number of farms, the number of 1 km grid squares and a rough estimation of their abundance throughout the survey area.

A few species were found to be frequent throughout the target area, particularly small-flowered crane's-bill (*Geranium pusillum*), bugloss (*Anchusa arvensis*) and prickly poppy (*Papaver argemone*). Some species were faring better than might have been expected, such as the Nationally Scarce grass, dense silky-bent (*Apera interrupta*), recorded from 14 fields (Table 2 in the Appendix; Figure 3). This was previously known from only a handful of sites in the area (Bowen 1968; Killick *et al.* 1998). Shepherd's-needle (*Scandix pecten-veneris*), another Nationally Scarce species thought to be very rare in the area, was recorded from six fields (Figure 4).

Figure 3. The grass, dense silky-bent (*Apera interrupta*) was recorded from a surprisingly high number of fields in the study area. This species has probably been under-recorded in the past.

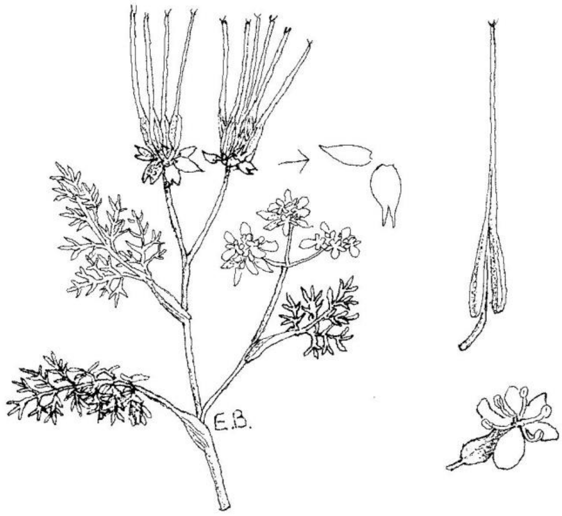

Figure 4. Shepherd's-needle (*Scandix pecten-veneris*), so named for its long, splayed seed-cases, is one of the few target species which appears to have increased in the area recently.

However, several target species were found to be very rare indeed, for instance corn chamomile (*Anthemis arvensis*) (Figure 5), and corn buttercup (*Ranunculus arvensis*), both recorded from only one field. Others, although not rare, were less common than we might have hoped. For example, corn marigold (*Chrysanthemum segetum*) (Figure 6) which used to be frequent in the Oxford Heights (Bowen 1968; Killick *et al.* 1998), was recorded from only 5% of the fields in this survey.

Figure 5. Corn chamomile (*Anthemis arvensis*) is now very rare indeed in the Oxford Heights. The flowers and leaves are fragrant.

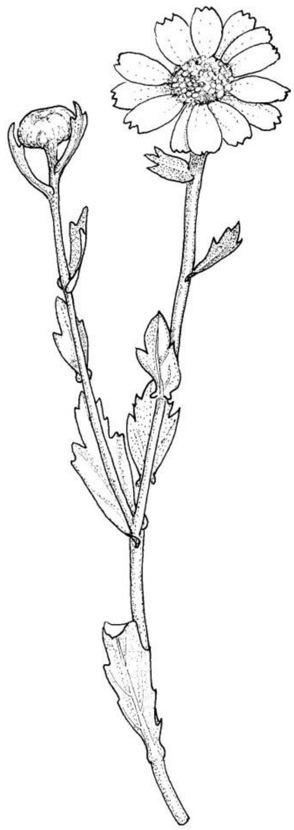

Figure 6: Corn marigold (*Chrysanthemum segetum*), which used to be frequent in the Oxford Heights, has declined in recent years. The flowers are a striking bright yellow colour.

(b) Species richness and distribution in relation to soils and crops

Soils

The soils in the study area ranged from the free-draining sands and limestone soils of the Midvale Ridge to the clays and alluvial deposits on lower ground. Figure 2 gives a simplified distribution of the soil types. The sands of the Midvale Ridge were found to support the highest number of target species with a maximum of nine species recorded per 1 km square (Figure 7). Many species were recorded exclusively from the sands, for example bugloss (distribution map shown in Figure 8) and dense silky-bent (distribution map shown in Figure 9). Other species such as round-leaved fluellen (*Kickxia spuria*) (Figure 10) were recorded from the heavier soil types.

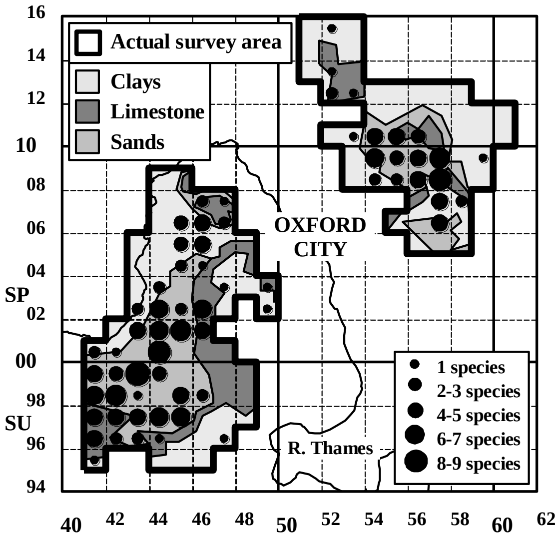

Figure 7. Number of target species recorded per 1km square with the actual survey area (in total 21 target species were recorded)

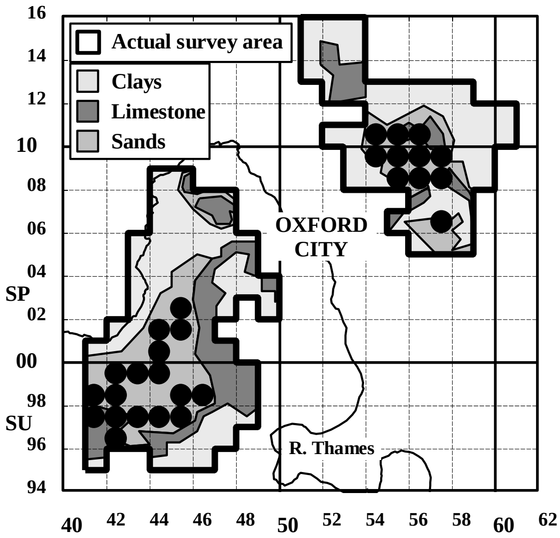

Figure 8. The distribution of bugloss (*Anchusa arvensis*) shows a strong association with the sands of the corallian ridge

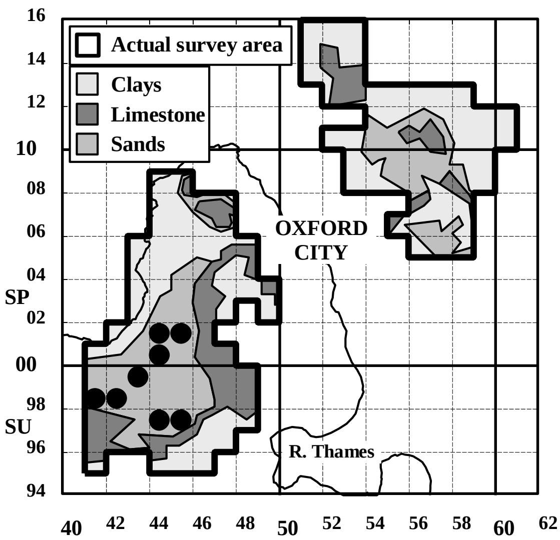

Figure 9. Dense silky-bent (*Apera interrupta*) was found to be frequent on the sandy soils in the west of the survey area

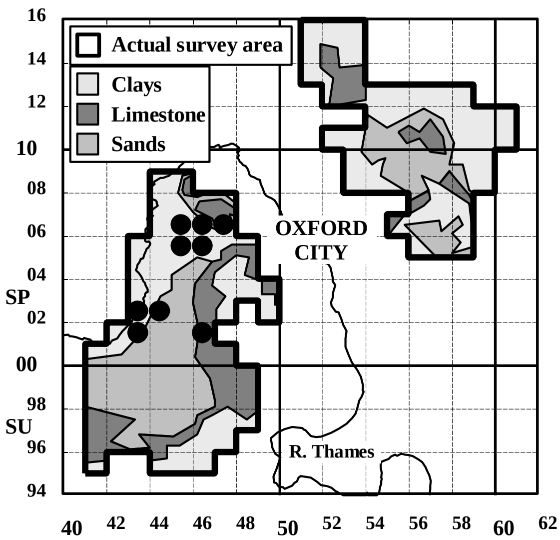

Figure 10. Round-leaved fluellen (*Kickxia spuria*) is characteristic of heavier soils such as those of the Oxford Clays

The main relations between target species and soil and crop types is given in the CCA ordination diagram of Figure11. Soils (the environmental factors with long arrows) are shown to be more important in influencing the community variation than crop types (which have short arrows). Species associated with clay soils such as round-leaved fluellen and sharp-leaved fluellen (*Kickxia elatine*) lie close to the right hand of the diagram. Species associated with limestone soils such as Venus's-looking-glass and field madder (*Sherardia arvensis*) lie to the top of the diagram. Species associated with sandy soils such as dense silky-bent, corn spurrey (*Spergula arvensis*) and bugloss are clustered slightly to the left of the centre. Statistical tests (Monte-Carlo permutation tests) showed that all three soil types had a highly significant effect on rare plant communities (p=0.005).

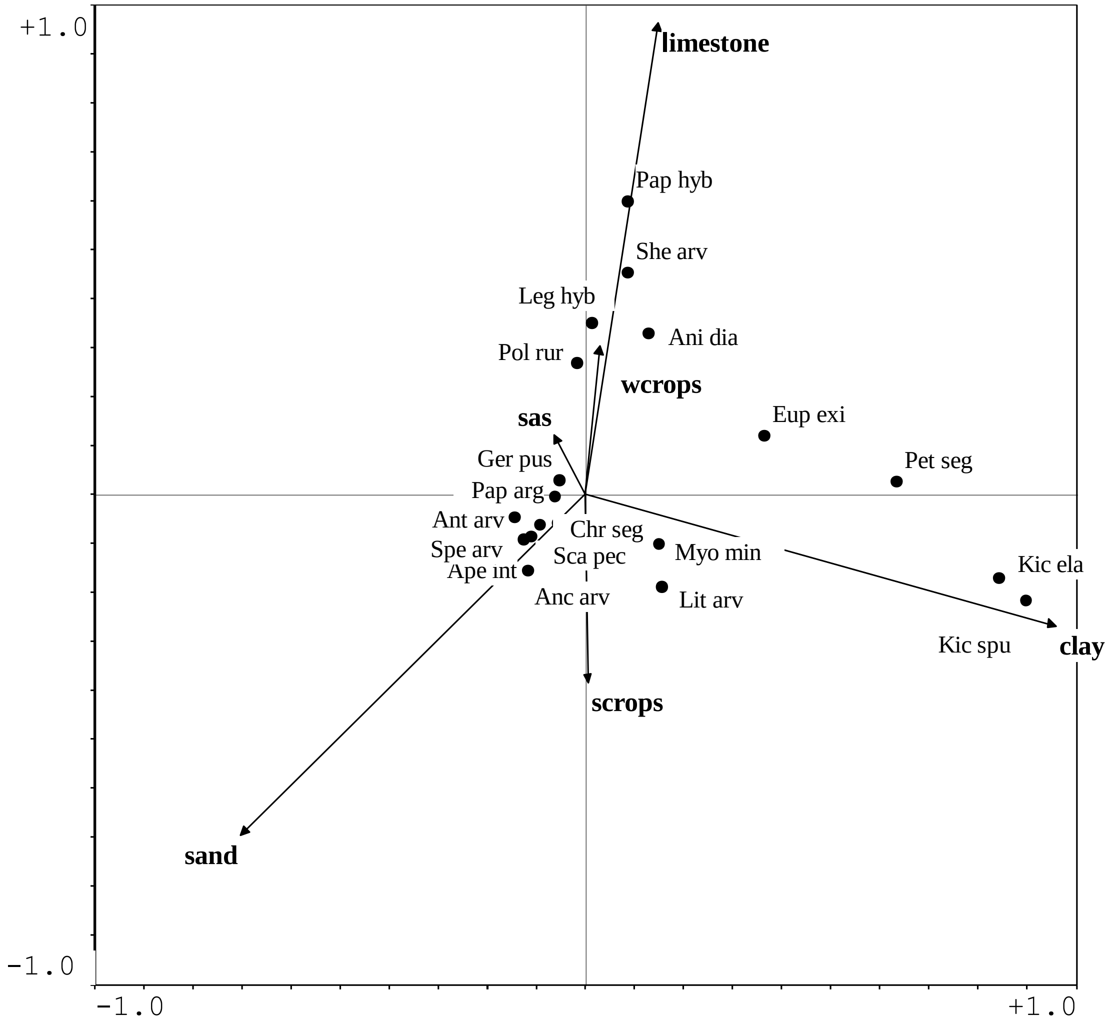

Figure 11: A canonical ordination diagram showing target species in relation to soils and crop types.

Soils: limestone, sand and clay

Crop types: wcrops =winter-sown crops; scrops = spring-sown crops; sas = set-aside

Target species are given as shortened latin names e.g. Anc arv = *Anchusa arvensis* (bugloss)

Crop types

Figure 12 shows the mean number of target species recorded from different crop types. In general spring crops, in particular spring cereals, supported high numbers of target species. Winter crops, in comparison, supported a low number of target species. The number of target species recorded from set-aside fields varied greatly from field to field, depending on how well the sward had developed and whether or not the field had been sprayed with herbicides. A few set-aside fields were very rich in arable flowers; the single record for corn chamomile was from a set-aside field (Table 2 in the Appendix) (although it is possible that this came in with grass seed and is not of local provenance).

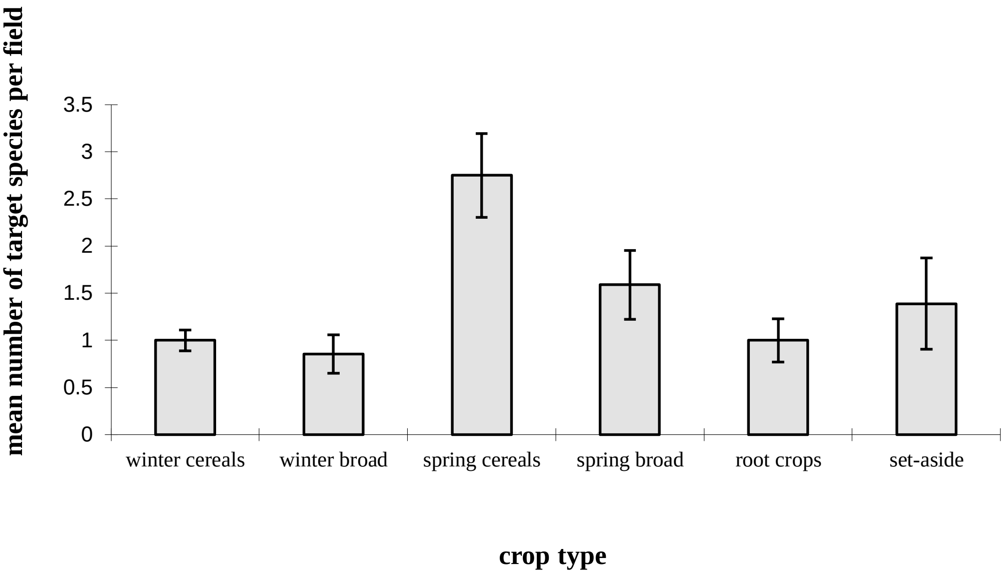

Figure 12: Mean number of target species found in each crop type. The error bars represent the standard error of the mean, and 'n' the number of fields in each crop type.

Most target species were recorded from both spring-sown and winter-sown crops (Table 2). A few occurred only in winter-sown crops e.g. corn parsley (*Petroselinum segetum*) and mousetail (*Myosurus minimus*). Statistical tests (Monte-Carlo permutation tests) showed that crop types did not have a significant effect on rare plant communities (spring crops p= 0.05; winter crops p = 0.09; set-aside p = 0.39).

General Discussion

Status and distribution of rare arable plants

A field-by-field survey of this kind provides up-to-date arable plant records for the area. Of course the records will not be exhaustive. A major problem is that many species are sporadic and their abundance varies greatly from year to year depending on many factors including crop type, weather and the nature and efficiency of herbicide and nitrogen applications. Therefore, the plants recorded during one season may not give a very accurate reflection of the real population size and some species might be missed altogether. A survey spanning three years will give a better idea of the rare arable plant distribution and abundance in the survey area. However, even in a three year study there is no doubt that some species, including those that complete their life-cycles very early in the season (e.g. mousetail) or very late (e.g. red hemp-nettle, *Galeopsis angustifolia*) will be under-estimated. A discussion of the merits and shortfalls of field-by field surveys like this, and other survey approaches is given in Kay (in press).

A few arable plant species were found to be frequent in the Oxford Heights but many of the target species were recorded from a low number of sites, or not at all. Although it is not easy to quantify any changes, comparison with Oxfordshire and Berkshire County Flora records and other historical accounts[1] gives an indication of recent changes in the arable flora (Bowen 1968; Hunt 1996; Killick *et al.* 1998).

One or two species were doing better than might have been expected, for instance dense silky-bent which was found to be frequent in the western part of the study area. This species is otherwise largely confined to East Anglia (Stewart *et al.* 1994). It seems unlikely that dense silky-bent has expanded its range in the county and it is more likely that this species has been under-recorded. Killick *et al.* (1998) noted that grasses were probably an under-recorded group within Oxfordshire. Shepherd's-needle, on the other hand, may be showing a real increase in the area. Stubble burning is thought to have contributed towards the decline of shepherd's-needle in the past (Killick *et al.* 1998), and it is possible that the recent ban in stubble burning has enabled shepherd's-needle to recover.

However, there is no doubt that the majority of target species have declined in both distribution and abundance even in recent years. Some, like corn marigold, are not yet rare in the area, but have shown worrying declines. Others, like corn chamomile, have always been uncommon in the area, but are now very rare indeed. Of even greater concern are those species which had been recorded from the Oxford Heights in the last 20-40 years (Bowen 1968; Killick *et al.* 1998) but were not recorded at all during these surveys, nor by those undertaken by Hunt (1996). Examples include weasel's-snout (*Misopates orontium*), night-flowering catchfly (*Silene noctiflora*) and narrow-fruited cornsalad (*Valerianella dentata*).[2] Declines in the latter two species have also been observed within other parts of Oxfordshire (Sutcliffe and Kay 2000) and elsewhere in England (Rich and Woodruff 1996).

Species distribution in relation to crops and soils

The well-drained sandy soils of the Midvale Ridge supported the most target species and many of them were entirely restricted to this soil type. The ordination diagram confirms the importance of soil type for influencing rare plant community composition. The differences in weed communities between heavy and light soils have already been established and species distributions according to soil type were generally in line with other reports (e.g. Salisbury 1961; Bowen 1968; Wilson 1990; Killick *et al.* 1998). There were some exceptions. For example shepherd's-needle (*Scandix pecten-veneris*), which is generally associated with heavy soils, was recorded entirely from sandy soils in this survey. Both fluellen species were recorded from the heavier soil types in this survey although there are reports of sharp-leaved fluellen, in particular, occurring on light, well-drained soils.

It is well known that arable weed floras differ substantially depending on the season of cultivation (e.g. Chancellor 1985; Wilson 1992; Critchley *et al.* 1999), and it is

[1] Lynn Hunt collated historical records from the last 150 years for rare arable plant species in the Oxford Heights and re-visited the sites in 1996. The historical records additional to those in the county floras are listed in Table 1 and the 1996 records are given in Hunt (1996).

[2] In the year following this study (1999), narrow-fruited corn-salad turned up in the study area at Sheepstead Fen (John Killick, pers. comm.)

perhaps surprising that crop type did not significantly affect arable plant community composition. However, many of the species recorded from this survey were able to survive in a range of crop types and it is likely that the data analysis is insufficiently sensitive to detect differences in abundance of species in different crops. In addition, we did not record the crop types within the full crop rotation. It has been shown that previous cropping will affect the arable weed species composition (e.g. Wilson 1990; Critchley 1994).

Spring crops, in particular spring cereals, were found to support higher numbers of target species than winter crops. Spring crops tend to be good for arable flowers because they are sprayed less often, they are harvested later - giving plants a chance to set seed - and they are generally lower and less dense. It is true that many of Britain's rarest arable plant species such as corn buttercup and spreading hedge-parsley (*Torilis arvensis*) are associated with winter-sown crops (Wilson 1992). However there has been a shift from spring-sown to winter-sown cereals in recent years (Wilson 1992) and inclusion of spring sown crops in the rotation will benefit a wide range of rare arable plant species.

A few set-aside fields were very rich in target species, but in general we recorded a low number of target species from set-aside fields. There are two main reasons for this. Firstly, there is normally an obligation for farmers to remove 'green cover' in the summer, usually with herbicides. Secondly, in long-term set-aside a closed sward quickly develops on all but the thinnest soils. However, there is potential for rotational set-aside to bring about benefits to wildlife including scarce arable flowers (Firbank and Wilson 1995; Sotherton 1998)

Conservation of rare arable flowers

An important aspect of these field-by-field surveys has been the close contact with farmers throughout. From a total of 37 farms visited, 14 were particularly rich in arable flowers. On these farms, the farmers have been invited to consider managing their richest field margins for the conservation of the rare arable flora. Some have entered Countryside Stewardship (CS) Agreements[3] which offer payments to farmers for the conservation of the countryside, and include options which are beneficial for arable flowers. A few others have not entered formal management agreements, but are keen to conserve their rare arable flora and might for instance reduce their herbicide applications on arable flower-rich margins. We are hoping to re-visit these sites to assess whether rare arable plants are benefiting from sympathetic management or whether they continue to decline.

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[3] Arable flower-rich sites are given priority for CS grants in the Oxford Heights

The maps were produced using DMAP software developed by Dr. Alan Morton.

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Appendix

Table 1. Target arable plant species which are thought to be rare or declining within Oxfordshire.

National Status: RDB = listed in Red Data Book, NS = Nationally Scarce, BAP (P) = UK Biodiversity Action Plan (BAP) Priority Species, BAP (C) = UK BAP Species of Conservation Concern, Sch 8 = Schedule 8 species

Survey Area Status = number of documented records for the actual survey area (Fig. 2)

vc 23 = number of tetrads (2 km x 2 km) in Killick *et al.* (1998) (total 21); vc 22 = number 5 km x 5 km squares in Bowen (1968) (total 6); pre 68 = recorded before 1968; H = additional historical records taken from Hunt (1996).

LIST A - Species considered to be of higher conservation priority in Oxfordshire

			Survey Area Status	
Scientific name	**English name**	**National Status**	**vc 23**	**vc 22**
Adonis annua	pheasant's-eye	RDB, BAP (C)	0	H (1)
Agrostemma githago	corncockle	extinct	H (2)	2
Anagallis arvensis ssp. foemina	blue pimpernel	-	1	0
Anisantha diandra	great brome	-	0	0
Anthemis arvensis	corn chamomile	-	0	4
Apera interrupta	dense silky-bent	NS	0	2
Apera spica-venti	loose silky-bent	NS	3	0
Bupleurum rotundifolium	thorow-wax	extinct	0	1
Centaurea cyanus	cornflower	RDB, BAP (P)	3	3
Euphorbia platyphyllos	broad-leaved spurge	NS, BAP (C)	0	0
Filago lutescens	red-tipped cudweed	RDB, Sch 8	0	3
Filago pyramidata	broad-leaved cudweed	RDB, BAP (P), Sch 8	3 (pre 68)	4
Fumaria densiflora	dense-flowered fumitory	NS	0	H (2)
Fumaria muralis	common ramping-fumitory	NS	1 (pre 68)	0
Fumaria parviflora	fine-leaved fumitory	NS	0	0
Fumaria purpurea	purple ramping-fumitory	NS, BAP (P)	0	0
Fumaria vaillantii	few-flowered fumitory	NS	0	0
Galeopsis angustifolia	red hemp-nettle	NS, BAP (P)	1	1

Galium tricornutum	corn cleavers	RDB, BAP (P)	0	1
Iberis amara	wild candytuft	NS	0	0
Lythrum hyssopifolia	grass-poly	RDB, BAP (C)	0	0
Misopates orontium	weasel's-snout	-	0	2
Ranunculus parviflorus	small-flowered buttercup	-	H (1)	H (1)
Ranunculus sardous	hairy buttercup	-	0	0
Scandix pecten-veneris	shepherd's needle	NS, BAP (P)	0	1
Silene gallica	small-flowered catchfly	NS, BAP (P)	H (1)	1
Thlaspi perfoliatum	perfoliate penny-cress	RDB, Sch 8, BAP (P)	2 (pre 68)	1
Torilis arvensis	spreading hedge-parsley	NS, BAP (P)	1	0
Valerianella rimosa	broad-fruited cornsalad	RDB, BAP (P)	0	1
Veronica praecox	Breckland speedwell	-	0	0
Vicia parviflora	slender tare	NS	0	H (1)

LIST B - Species considered to be of lower conservation priority but locally important in Oxfordshire

			Survey Area Status	
Scientific name	**English name**	**National Status**	**vc 23**	**vc 22**
Anchusa arvensis	bugloss	-	6	5
Bromus secalinus	rye brome	-	0	2
Chrysanthemum segetum	corn marigold	-	7	2
Euphorbia exigua	dwarf spurge	-	12	6
Fumaria bastardii	tall ramping-fumitory	-	1 (pre 68)	0
Geranium pusillum	small-flowered crane's-bill	-	9	5
Kickxia elatine	sharp-leaved fluellen	-	5	6
Kickxia spuria	round-leaved fluellen	-	4	6
Legousia hybrida	Venus's-looking-glass	-	4	3
Lithospermum arvense	corn gromwell	BAP (C)	0	1
Myosurus minimus	mousetail	-	1	0
Papaver argemone	prickly poppy	-	3	5
Papaver hybridum	rough poppy	-	1	2
Petroselinum segetum	corn parsley	BAP (C)	0	4
Polygonum rurivagum	cornfield knotgrass	-	0	0
Ranunculus arvensis	corn buttercup	BAP (C)	1	1
Sherardia arvensis	field madder	-	7	5
Silene noctiflora	night-flowering catchfly	-	2	5
Spergula arvensis	corn spurrey	-	6	4
Valerianella dentata	narrow-fruited cornsalad	BAP (C)	1 (pre 68)	3

Table 2: Target arable plant species recorded in the Oxford Heights from 1996 to 1998 and number of fields, farms, 1 km grid squares and crop types in which they occurred.

Abundance: r = rare; o = occasional; lf = locally frequent; f = frequent; c = common

Crop types: wc = winter cereals; wb = winter broad-leaved crops; sc = spring cereals; sb = spring broad-leaved; rt = root crops and maize; sa = set-aside.

Target species (Scientific name)	Target species (English name)	No. of fields	No. of farms	No. of 1 km squares	Abund-ance	Crop type
List A species						
Anisantha diandra	great brome	12	4	5	o	wc, wb, sa
Anthemis arvensis	corn chamomile[1]	1	1	1	r	sa
Apera interrupta	dense silky-bent	14	5	8	f	wc, sc, sa
Centaurea cyanus	cornflower[1]	1	1	1	r	wc
Scandix pecten-veneris	shepherd's needle	6	1	3	lf	wc, sc, sb
List B species						
Anchusa arvensis	bugloss	65	15	28	f	all
Chrysanthemum segetum	corn marigold	17	7	12	lf	all
Euphorbia exigua	dwarf spurge	14	9	13	o	all
Geranium pusillum	small-flowered crane's-bill	98	21	43	f	all
Kickxia elatine	sharp-leaved fluellen	9	6	9	o	wc, sc, sb, sa
Kickxia spuria	round-leaved fluellen	11	5	9	lf	wc, sc, sb
Legousia hybrida	Venus'-looking-glass	11	7	8	o	wc, sb, sa, rt
Lithospermum arvense	corn gromwell	4	3	3	r	wb, sb
Myosurus minimus	mousetail	3	3	3	r	wc
Papaver argemone	prickly poppy	46	18	27	lf	all
Papaver hyridum	rough poppy	1	1	1	r	wc
Petroselinum segetum	corn parsley	10	5	9	lf	wc, wb
Polygonum rurivagum	cornfield knotgrass	2	2	2	r	wc
Ranunculus arvensis	corn buttercup	1	1	1	r	wb
Sherardia arvensis	field madder	10	5	9	lf	wc, wb, sa, sc
Spergula arvensis	corn spurrey	11	7	9	lf	all
Total surveyed		**290**	**37**	**137**		

[1] It is not clear whether corn chamomile and cornflower are of native origin or not. It is possible that both species came in as seed contaminants or garden escapes.