Changes in the Berwickshire Flora since the New Atlas

Michael E Braithwaite[1]

A project to repeat-record the vice-county of Berwickshire hectad[2] by hectad was two-thirds complete by the end of 2011 enabling provisional results to be analysed. The preliminary result of an earlier paper on *Berwickshire's disappearing plants* (Braithwaite, 2010b) that populations of species that are rare or scarce are being lost at a rate of 16% a decade is confirmed and is amplified by single-species studies, while evidence and comment is presented of some species that are spreading and of the limitations of the repeat survey in monitoring the decline of more widespread species. The overall number of taxa recorded per hectad has increased by a remarkable 21% over 16 years and the reasons for this are analysed to determine whether or not naturalised neophytes are having an increased impact on the native flora. The increased impact proves to be modest.

Keywords: change over time, colonisation, extinctions, naturalised neophytes, rare species

Introduction

The flora of Berwickshire v.c. 81 was recorded systematically hectad by hectad on a sample basis at monad[3] scale between 1987 and 1999, noting 6-figure GRs[4] for most populations of the scarcer species, whether native or alien. In 2007 a new cycle of recording was commenced following approximately the same hectad by hectad sequence as the 1987-99 survey. One module of the recording plan is to refind as many as many as possible of the populations of species that are rare or scarce (Braithwaite, 2004) and to search for others, recording fine-scale detail of their populations. This work has led to the publication of a *Berwickshire BSBI Botanical Site Register* (Braithwaite, 2011). Another module is to record as many taxa as possible in each hectad or part hectad.

The Study Area

V.c. 81 Berwickshire lies near the centre of Britain, taken north to south. Its lowlands are agricultural and its uplands grassland, moorland and forestry. It has a fine coast, though much of it is cliff, a varied river system and diverse wetlands. It thus has elements representative of many of the habitats found in Britain, though there are no truly montane areas, while ancient woodland, still open water and urban habitats are under-represented. Indeed the largest town, Eyemouth, has a population of only 3,400. Berwickshire has an area close to that of twelve hectads. The sixteen whole and part hectads re-surveyed to date have a total area of 811 monads, or 67% of the v.c., and all major habitats are sampled.

The countryside of Berwickshire was transformed during the agricultural revolution c. 1780-1820 with large farms being created out of smallholdings and common land. The accompanying drainage and ploughing destroyed or severely modified many of the botanically interesting sites. The remaining habitat is highly fragmented, except along the coastal strip and in the grouse moors of the Lammermuir hills. Two centuries later, the long-

[1]Clarilaw Farmhouse, Hawick, Roxburghshire, TD9 8PT
Email: mebraithwaite@btinternet.com

[2] 10x10km grid square
[3] 1x1km grid square
[4] 100x100m grid references

term effects of this fragmentation remain a powerful driver of change in plant species distributions.

Methods

The methods used in the repeat survey are summarised in the introduction above and those relating to rare or scarce species have been detailed in Braithwaite (2010b). Monads for resurvey have been selected primarily as those thought to be the most species-rich, whether for native or alien species. Accordingly towns and villages have been extensively sampled, as well as natural habitats. The repeat survey has been rather more intensive than the first survey. For this reason and the lack of a stratified sample, there is little opportunity for statistical analysis of the trends in species distributions.

Resurvey of rare or scarce species

The approach to species that are rare or scarce has been to focus on species that are 'site-faithful', at least in the fragmented habitats of Berwickshire over a 20 year period, so that colonisation can ignored as immaterial (this 'site-faithful' concept would not work at finer scales, such as 100m or 10m, as many populations do fluctuate at fine scales). Sites are defined as far as possible by coherent management units. Most are considerably smaller than 1km^2. Larger sites are subdivided into units no larger than 1km^2. Sites have been searched at an appropriate season, using 100m scale historical records as a guide, scoring each population as present 1 or absent 0 or possibly overlooked ¼, ½ or ¾. 437 populations of rare or scarce plants selected from those listed in the *Berwickshire Vice-county Rare Plant Register* (Braithwaite, 2004) as meeting the 'site-faithful' criterion have now been reassessed in this way. This allows the statistics presented in Braithwaite (2010b) to be updated in table 1.

Table 1: Losses of populations of rare or scarce species

Status	**Sample**	**Losses**	***%Loss/ decade***	***95% confidence***	**Half-life Years**
SSSIs	118	14.75	***8***	± ***5***	**83**
Other	319	89.75	***19***	± ***4***	**34**
All	**437**	**104.5**	***16***	± ***3***	**41**

The practice of surveying populations for presence/absence only, rather than for percentage decline, leads to a requirement for large sample sizes to obtain results of statistical significance. Indeed one reason why the re-survey of all but the largest populations has been at 10m scale is so that future repeats will have a more detailed database to work from. The results, table 1, confirm the previously reported average loss of populations of rare or scarce species at a disastrous 16% per decade which is equivalent to half the populations being lost in 41 years. This result is now statistically robust. Losses in SSSIs are compared with those in the wider countryside. While losses of populations in SSSIs have been very substantial they are only about half as severe as the rest.

Unfortunately the statistics of losses for individual Broad Habitats have wide confidence limits and are not presented here. What can be said is that there is much evidence of a strong random element in the losses leading to similar results for many of the Broad Habitats. Populations on cliffs (the 'Rock' Broad Habitat) are unsurprisingly the most resilient while there is a suggestion that losses in the relatively continuous coastal strip are rather lower than the average for the fragmented inland sites. In contrast the large expanse of moorland has suffered its full share of losses.

In considering the high rate of losses it is instructive to consider the size of the individual populations. 39% are no larger than a single 10x10m cell and these are being lost at the rate of 32% per decade. A further 22% occupy just two such cells and are being lost at 10% per decade.

To compare this 'site-faithful' approach with one where all records are considered, the analysis has been repeated at hectad scale. At that scale 'site-faithful' rare or scarce species are declining at 14% per decade. If new discoveries of these same species are included there is an apparent net gain of 6% a decade, so the losses are wholly concealed by more intensive survey. If all rare or scarce species are included the net gain is 20% a decade: an extreme result that relates in part to striking real gains in such groups as arable weeds and clubmosses and in part to a better understanding of some of the more critical species.

An advantage of working with discrete populations is that the causes of losses can often be deduced with reasonable confidence, table 2. Excluding the losses for which the causes are unknown, about one-third have been due to physical disturbance, one-third to eutrophication, one-fifth to under-grazing, 7% to natural causes such as vegetation succession and just 3% to competition by invasive species, both native and alien.

Table 2: Causes of losses of populations of rare or scarce species

Cause group	Cause of loss	Losses	Subtotal	%
Disturbance	Agricultural/forestry operations	8.5		
Disturbance	Development (housing/caravans)	4		
Disturbance	Habitat fragmentation/drainage	10		
Disturbance	Muirburn	2		
Disturbance	New pond (wetland converted)	2.5		
Disturbance	Quarried	3.5	30.5	***36***
Eutrophication	Eutrophication	18.5		
Eutrophication	Flush degraded	10.25	28.75	***34***
Grazing regime	Grazing, too little	16.25	16.25	***20***
Invasive species	Alien invasion (*Centranthus*)	1.5		
Invasive species	Bramble invasion (*Rubus*)	1	2.5	***3***
Natural forces	Coastal storms	3		
Natural forces	Vegetation succession	3	6	***7***
Unknown	Unknown	20.5	20.5	***Excl.***
All	**Total**	**104.5**	**104.5**	

Historical single species studies

To examine these trends in more detail data is presented from three single-species studies chosen from those few scarce species for which there are sufficient records to analyse.

Following a full resurvey of *Sedum villosum* in Berwickshire, the rate of decline between various dateclasses has been calculated (Braithwaite, 2010c). It has then been a simple mathematical exercise to extrapolate backwards in time to calculate the number of monads in which the species is likely to have been present at various dates in the past. Taking these estimates together with historical localities and a detailed knowledge of the v.c. and its history of botanical recording, informed guesses have been made of the individual monads in which there may have been former populations of *Sedum villosum* which were never discovered, table 3.

Table 3: Losses of populations of *Sedum villosum*

Dateclass	1831-1899	1900-1978	1979-1999	2000-2011	Ever
Sample	11	10	12	10.5	33
Survival	1	3.75	7	10.5	
Losses	10	6.25	5	0	
% Loss/decade	***14***	***17***	***31***		
Extrapolated monads (* more realistic figure)	(*75) 114	27	22	11	
Date extrapolation	1849	1959	1989	2009	

The table may be understood by working through the oldest dateclass 1831-99 as an example. The average date of the 11 monad records held is 1849, resurvey in 2009 refound *Sedum villosum* in just one of these 11 monads (and in no monad was the species thought to have been possibly overlooked and thus meriting a fractional score). This is equivalent to a loss of 14% in each decade between 1849 and 2009.

It soon became apparent that the estimate of 114 monads for 1849 could not be allocated realistically on the ground so it was modified to 75 monads, about two-thirds of the estimate. Two factors are thought to come into play. First the estimate of 114 monads is very imprecise. Secondly there is reason to expect a lower rate of loss in the core area of the distribution in the heart of the Lammermuirs where the historical coverage was poor. As long as there is a core area where a species is frequent, losses at monad scale will be mainly at the fringes. That is to say, losses thought to have been suffered when a proportion of the flushes with populations of *Sedum villosum* were cut-over only affected the monad distribution in areas where the species had only one or two populations at monad scale.

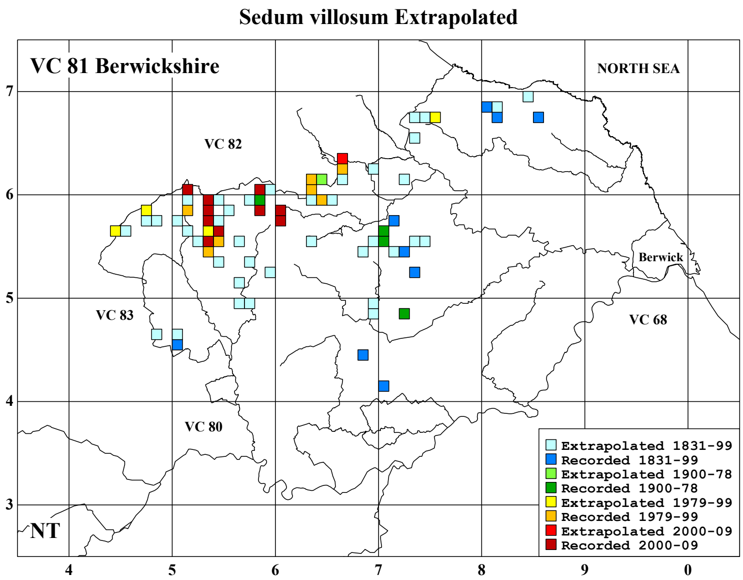

Figure 1: Extrapolated 1km distribution map of *Sedum villosum*

The distribution map, figure 1, shows *Sedum villosum* retreating into the Lammermuirs as the lowland habitats were physically destroyed and suggests that there were also losses from an early date in the hills from where there are few localised historical records. The overall extent of the severe losses is all too apparent. While many of the early losses are thought to have been due to flushes being cut-over, the causes of the dramatic recent losses are uncertain.

Eutrophication and climate change are the prime suspects. It is suggested that these factors act to dramatically accelerate a natural process of vegetation succession.

Viola lutea, like *Sedum villosum*, has suffered severe historical losses in the east of the v.c. but has proved more resilient in the west where there are still substantial areas of relatively unimproved hill grassland. The calculated losses per decade are: 1855-2007, 13%; 1945-2007, 8% and 1986-2007, 7%. *Viola lutea* is thus currently declining at about half the average rate of 16% for rare or scarce species.

When the records for *Neottia ovata* were examined it became clear that the species is not strictly 'site-faithful' in Berwickshire. There are a few current localities in altered habitat such as that created where a sand and gravel quarry had been worked out. As an experiment an allowance for natural turnover has been built into the calculations, table 4. After this crude adjustment it appears that *Neottia ovata* is currently declining at about the average rate of 16% for rare or scarce species.

Table 4: Losses of populations of *Neottia ovata*

Dateclass	**1829-1899**	**1900-1978**	**1979-1999**	**2000-2011**	**Ever**
Sample	26	11	16	18	49
Natural turnover to 2007 (losses replaced)	13	2	1	0	
Survival	3.5	3	9	18	
Losses (not replaced)	9.5	6	6	0	
% Loss/decade	***8***	***16***	***22***		
Extrapolated monads	84	67	38	23	
Date extrapolation	1855	1945	1986	2007	

Limitations with 1km samples

The distribution map for *Campanula rotundifolia*, figure 2, exemplifies the limitations of the survey methodology for species that are not rare or scarce. This species favours nutrient-poor grassland and is widespread in the uplands but has become scarce and is thought to be declining in the Merse, the agricultural heartland of the v.c. The repeat survey has located rather more populations in the Merse than the first survey so there is no evidence of decline in the map itself. The only way to study change would be to look at the underlying records for the first survey on sites which were revisited in the repeat survey and seek to judge whether the populations have survived, being the methodology used for species that are rare or scarce. This is not possible as the populations were not specifically searched for during the repeat visits.

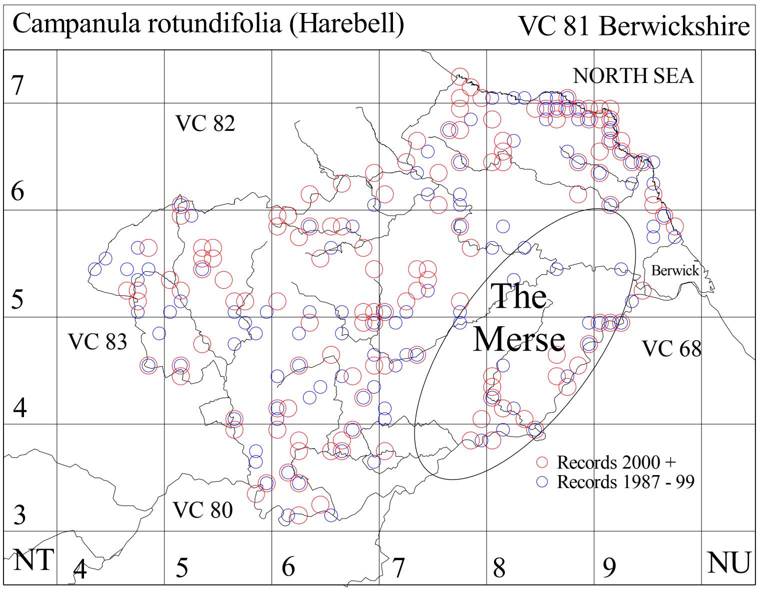

Figure 2: 1km distribution map of *Campanula rotundifolia*

It is instructive to examine the sensitivity that might have been expected had *Campanula rotundifolia* been subject to full monad or tetrad[5] surveys, table 5.

Table 5: The distribution of *Campanula rotundifolia* at different spatial scales

Spatial scale	**Units at risk (estimate)**	**Units not at risk (estimate)**	***% Loss/ decade units at risk***	***% Loss/ decade all units***
Monad	40	400	*16*	*1.5*
Tetrad	20	180	*5*	*0.5*
Hectad	0	23	*0*	*0*

Even if the underlying losses at population scale are the same for *Campanula rotundifolia* as for rare or scarce species, losses at coarser spatial scales will be much lower as there will usually be several or many populations per unit. *Campanula rotundifolia* is only at risk of losses at monad scale in the arable heartland of the Merse, where the species is so scarce that there are but one or two populations per monad. Full monad surveys of the v.c. might have been expected to show a loss of about ten monads between surveys 16 years apart, almost all in the Merse. Full tetrad surveys might have shown a loss of only one or two tetrads, which would have been likely to have been obscured by recording biases between the two surveys.

Fundamental asymmetry between spread and decline

One of the clearest messages that can be drawn from these studies of the Berwickshire flora is the fundamental asymmetry between spread and decline in response to environmental changes (Braithwaite, 2010b). Spread can be rapid: 1.4km/year is about the norm for rapidly spreading species (Braithwaite, 2010a). Decline can be very gradual indeed, with a whittling away round the edges of a distribution leaving isolated populations in the most resilient habitat. It is thus seems totally normal for an ecosystem to have many more declining species than spreading ones at any one time.

[5] 2x2km grid square

Evidence of spread

The survey methodology is effective at picking up evidence of species that are spreading strongly, but not of slow spread as any change is masked by the uneven sampling. Only a few species have been spreading strongly. These include the roadside halophytes such as *Puccinellia distans* and *Spergularia marina* which spread south to north. This dramatic event has been widely reported on across Britain. Less well chronicled is the almost simultaneous spread of *Rumex longifolius* from north to south. Although the colonisation in Berwickshire has been along the main roads, figure 3, the habitat colonised is back from the carriageway and only modestly affected by salt. The A1 near the coast was colonised from 1994 while the A68 towards the west of the v.c. was colonised from 2001. In one part of the v.c. only has this species colonised away from the roadsides. This is in the Gordon area NT64 where it has colonised disturbed ground on peaty soils at the margins of formerly extensive wetlands. An extensive survey to record this species along the Berwickshire roads was made in 2007. In 2007 *Rumex longifolius* was frequent along the A1 in hectad NT86. When this hectad was resurveyed in 2011 only three plants could be found, suggesting a dramatic decline. This abrupt reverse appears to have been mirrored throughout the Scottish Borders. The forces driving the spread and decline are a mystery. Hybridisation with *R. obtusifolius* could be a factor, but is probably a minor one. *Rumex longifolius* has made more modest incursions before, notably in the 1970's (pers. comm. G. A. Swan).

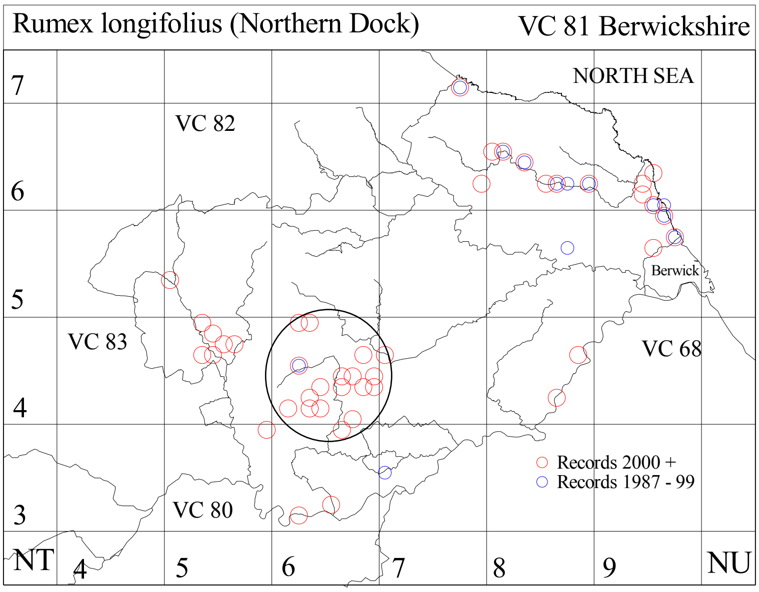

Figure 3: 1km distribution map of *Rumex longifolius*

Change in the British Flora 1986-2004 (Braithwaite et al., 2006) reported an increase in *Phyllitis scolopendrium* in Britain, possibly driven by climate change. This trend is fully supported by the Berwickshire resurvey, figure 4. The change is best demonstrated by a map of the habitats, figure 4(b). The fern has colonised outwards from wet cliffs in deans to open woodland banks, where all the records are recent ones. It may well have become more frequent on walls and in the deans themselves, but quantitative data is not available.

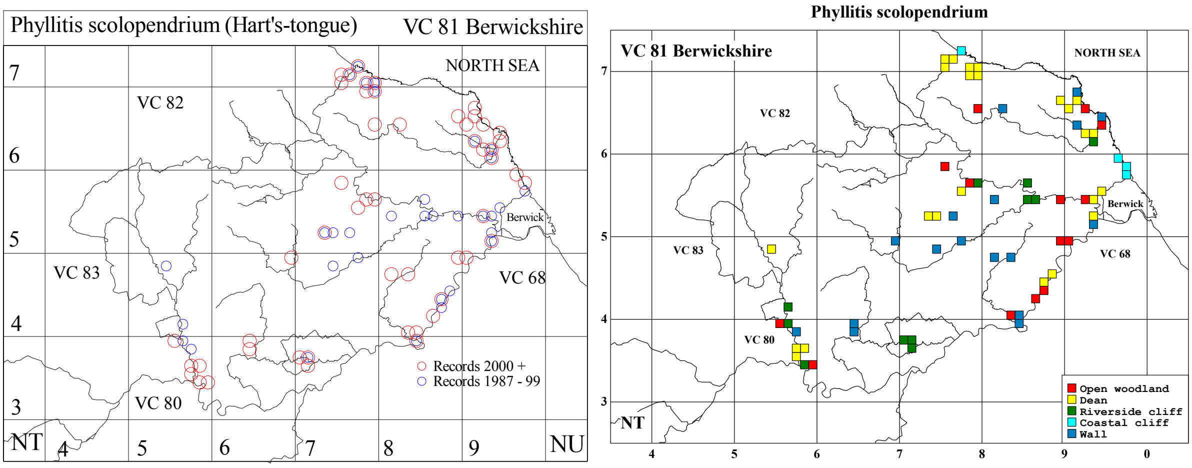

Figure 4: 1km distribution maps of *Phyllitis scolopendrium*, (a) dateclasses, (b) habitats

All the clubmosses had become scarce in Berwickshire by 1990 with *Lycopodium clavatum* reduced to very occasional non-fertile plants in open moorland which were probably short-lived. Muirburn and deposition of atmospheric nitrogen compounds were thought to be causing the decline. *Lycopodium clavatum* was then discovered in abundance on forestry tracks in 2007. A complete survey of stony forestry tracks and moorland access roads has now been made at 100m scale, mostly by 2009, figure 5. The colonisation has been remarkable and is ongoing. No doubt the species had been overlooked for a while, but the age of the forestry and of the moorland access tracks suggests that all colonisation has been since 1990 and that much of it is more recent. Heavy spore-rain from the forestry colonies is thought to be driving a modest revival of the species on open moorland.

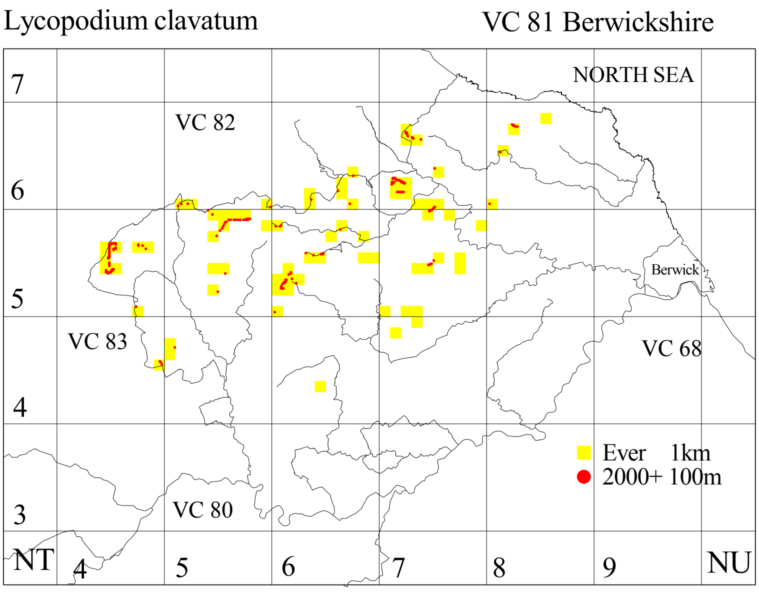

Figure 5: 100m distribution map of *Lycopodium clavatum*

Of the neophytes that are represented as threats to the native flora, *Fallopia japonica* has had its full share of publicity. As far as Berwickshire is concerned this species is spreading very slowly at monad scale, figure 6. Just how limited the numbers of riverside colonies are would only be apparent at finer scales. The species has not multiplied by vegetative dispersal to the extent that was feared and the few ruderal colonies are not very intrusive. Control measures have reduced the vigour of some colonies but have seldom eliminated them. Indeed

Symphoricarpos albus, which forms similar dense patches, could be argued to be more of a threat, particularly to the woodland flora. It is still favoured by game interests as pheasant cover.

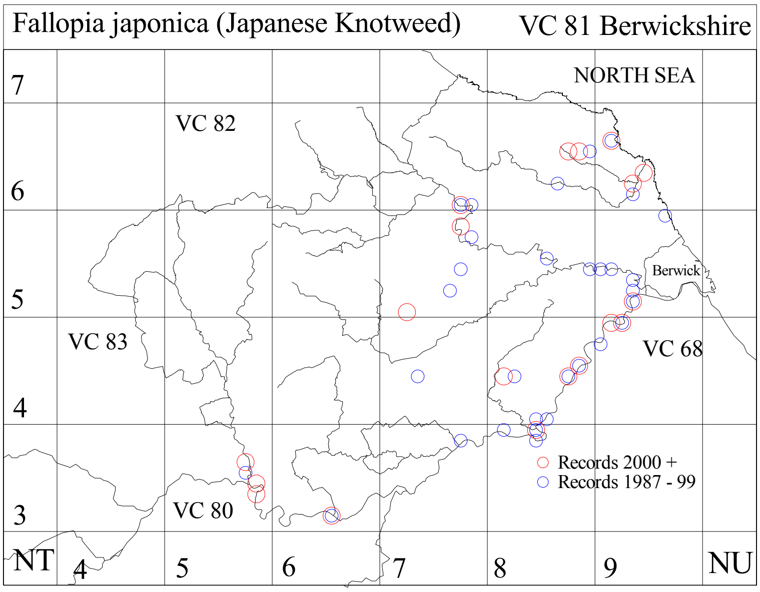

Figure 6: 1km distribution map of *Fallopia japonica*

A much more invasive species that has had little national attention until recently is *Allium paradoxum*. This species spreads rapidly along watercourses and along roadsides and thence to many of the native woodland fragments where it dominates, out-competing such vernal species as *Adoxa moschatellina*, *Chrysosplenium alternifolium* and *Primula vulgaris.* In the last decade it has colonised the Eye Water NT86, NT96 and has become much more frequent around the county town of Duns NT75 and along the Leader Water NT53, NT54, figure 7.

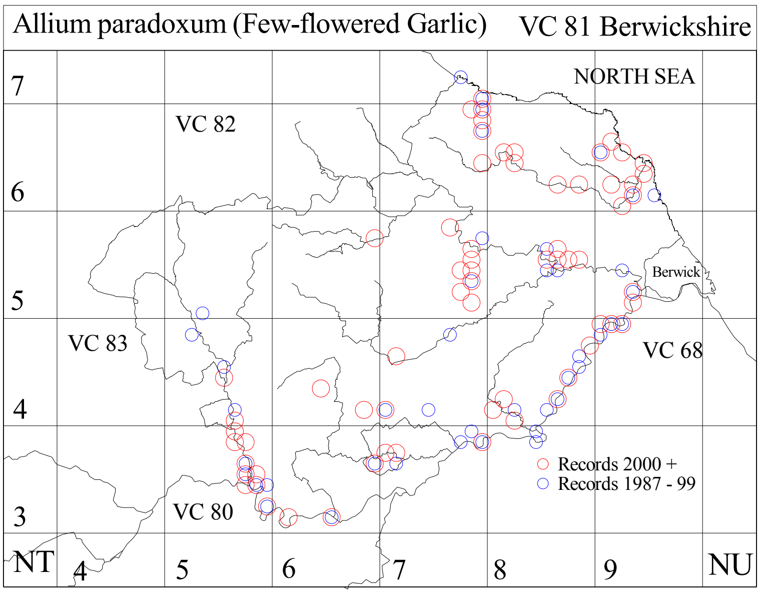

Figure 7: 1km distribution map of *Allium paradoxum*

Taxa per hectad

One of the objectives of the Berwickshire resurvey is to find as many taxa as possible in each hectad (the critical groups *Hieracium*, *Rubus* and *Taraxacum* are ignored). The outcome has been surprising. Taking a sample of four complete hectads first surveyed between 1987 and 1993, an average of 100 extra taxa (21%) have been found in each hectad, table 6. This figure is net of losses.

Table 6: Status of taxa per hectad (averaged)

Status	Av Taxa/ Hectad 1987-99	%	Av Taxa/ Hectad 2000-11	%	Increase taxa	*Increase %*
Native	353	*75.4*	374	*65.9*	21	*6*
Archaophyte	47	*10.0*	58	*10.1*	11	*23*
Native+Arc	**400**	***85.4***	**432**	***76.0***	**32**	***8***
Neophyte	59	*12.7*	98	*17.3*	39	*65*
Casual	8	*1.8*	37	6.7	29	*344*
Neo+Cas	**67**	***14.5***	**135**	***24.0***	**68**	***100***
All	**467**	***100.0***	**567**	***100.0***	**100**	***21***
All Sp/Ssp	452	*96.7*	539	*95.1*	87	*19*
All Hybrids	15	*3.3*	28	*4.9*	13	*82*

The increase of 100 taxa (net of losses) is made up as: native hybrids 8 (awareness); planted native trees and shrubs 7; other natives 6 (sample increase); archaeophytes 11 (set-aside, game crops); naturalised neophyte trees and shrubs 12; other naturalised neophytes 27; planted alien trees, shrubs and crops 29.

The increase in hybrids reflects much greater awareness following the BSBI Hybrids Project. The increase in true natives has been minimal, with gains from the increased sampling nearly balancing the all-too-real losses. The increase in archaeophytes is more surprising, but the part that relates to arable weeds can be traced to the recent fashions for set-aside and game/wild-bird crops which favour arable weeds. Not all archaeophytes are arable weeds but the others are a miscellany of special cases, such as that of *Sedum album* which has become invasive in some rocky grassland.

The increase in naturalised neophytes becomes understandable when analysed by the Broad Habitat most favoured by each, table 7. For naturalised neophytes, unlike planted neophytes, there has been very little change in recording practice between the two surveys

Table 7: The Broad Habitats of additional naturalised neophytes

Habitat	Increase	Comment
Aquatic	1	e.g. *Lemna minuta, Elodea nuttallii*
Arable	2	e.g. *Anisantha diandra*, *Amsinkia micrantha*
Coast	1	e.g. *Rosa rugosa*
Grassland	6	Dumped garden plants narrowly naturalised
Moorland	0	
Riverside	2	Oddities, e.g. *Cochlearia megalosperma*
Rock	2	Walls ex garden, e.g. *Campanula poscharskyana*
Ruderal	13	Roadside halophytes and dumped ex garden
Wetland	0	
Subtotal	**27**	**Excluding trees and shrubs**
Woodland	12	Trees and shrubs narrowly naturalised
All	**39**	

In contrast, the increase in the average number of casuals from 8 to 37 is mainly due to a change in recording practice. Planted field crops have been recorded for the first time and very much more attention has been paid to trees and shrubs planted in small numbers that have yet to naturalise. It is sad that this change in recording practice has obscured the very real increases. These reflect the variety of exotic taxa now included in game/wild-bird crops such as *Persicaria pensylvanica*, $^{\times}$*Triticosecale rimpaui* and *Zea mays*. A similar burgeoning of variety has occurred in planted trees and shrubs with such species as *Abies nordmanniana*, *Acer campestre* and *Rosa rugosa* becoming commonplace. The number of true casuals is small.

Summary of results

- A repeat survey in Berwickshire has demonstrated a 16% decline per decade at population scale for species that are rare or scarce, equivalent to losing half the populations in 41 years.
- Much smaller declines can be inferred for more widespread species at monad scale or coarser (these have not been measured for Berwickshire).
- The evidence of spread is dramatic in a few species. While the trends were already apparent from incomplete national surveys at hectad scale, even monad scale survey can only begin to indicate whether the impact on the environment is significant.
- An average of 95 extra taxa per hectad (20%) were recorded after 16 years due to the increased planting of alien trees, shrubs and crops (though part of the increase relates to recording bias), to garden species dumped and narrowly naturalised (part recording bias), to set-aside and game crops for arable weeds, to roadside halophytes, to an increased awareness of hybrids and to a larger sample being recorded.
- An average of only 5 extra taxa per hectad (1%) was recorded for fully naturalised neophytes. The dramatic increase in human intervention by planting and dumping has thus not been matched by many additional neophytes invading natural habitats.

Concluding observations on methods used

- Survey at site (population) scale for 'site-faithful' species has worked well for monitoring decline (this is similar to monad scale as there will usually be only one or two populations per monad). It is very difficult to allow for colonisation in species that are not 'site-faithful'. Working at finer scales (100m or 10m) would introduce many more variables.
- Surveys at monad and tetrad scales are superb for the production of distribution maps but, even if all units are visited, do not allow the spread or decline of widespread species to be measured readily, as it is very difficult to adjust for the unavoidable differences between successive surveys. The sample monad survey in Berwickshire was structured to obtain the best possible coverage of species-rich botanical sites rather than as a stratified sample to allow spread or decline to be assessed and its usefulness in this respect is limited.
- While national surveys at hectad scale, even with incomplete coverage, can give early intimation of the spread of neophytes, only finer scale survey can indicate whether the impact on the environment is significant.

Acknowledgements and nomenclature

The author's insights into the Berwickshire flora have benefited immeasurably from expertise shared by his colleagues in the BSBI Local Change project, particularly Bob Ellis and Chris Preston.

Plant nomenclature follows Stace (2010)

References

Braithwaite, M. E. 2004. *Berwickshire Rare Plant Register*, privately published.
Braithwaite, M. E., Ellis, R. W. & Preston, C. D. 2006. *Change in the British Flora 1987 - 2004*, Botanical Society of the British Isles, London.
Braithwaite, M. E. 2010a. How well has BSBI chronicled the spread of neophytes? *Watsonia* 28: 21-31.
Braithwaite, M. E. 2010b. Berwickshire's disappearing scarce plants. *Watsonia* 28: 129-140.
Braithwaite, M. E. 2010c. A wake-up call for the future of Britain's montane flora? *Sedum villosum* in decline in Berwickshire v.c. 81. *BSBI News* 115: 15-17.
Braithwaite, M. E. 2011. *Berwickshire BSBI Botanical Site Register*, privately published (available in summary form as PDF for free download from www.bsbi.org.uk as *A botanical tour of Berwickshire*).
Stace, C. A. 2010. New Flora of the British Isles. 3rd ed. Cambridge: Cambridge University Press.

26 October 2012