Botanical Society of the British Isles

Royal Botanic Garden Edinburgh

A great leap forward – Biological recording since the 1962 *Atlas of the British Flora*

20th – 21st September, 2012

Royal Botanic Garden, Edinburgh

Programme and Abstracts

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Welcome!

This is an important and exciting year for BSBI. Publication of the 1962 *Atlas of the British Flora*, and the years of structured recording that preceded it, revolutionised approaches to monitoring our flora and fauna, and greatly influenced similar projects elsewhere in the world. Fifty years on, it is an opportune time to review how this landmark publication came about, and its legacy in terms of providing a 'baseline' for documenting and interpreting changes in the abundance, spatial distribution and co-occurrence of communities and individual taxa.

This two-day conference organised jointly by BSBI and the Royal Botanic Garden Edinburgh is intended as a tribute to those who brought the Atlas to fruition, and a celebration of the ground-breaking research that has ensued following its appearance. Twenty-five presentations will cover the use of data from biological recording schemes to relate trends to changes in climate and land use, lesson learnt in terms of strengthening and standardising recording protocols, and new opportunities made possible through advances in computer technology, theoretical analyses and molecular genetics.

We are grateful to an outstanding line-up of speakers for agreeing so readily to participate and for the time spent preparing their contributions. Equally importantly, we thank all delegates for their support, and hope that the conference proves stimulating and enjoyable, and also generates new ideas for research and productive collaboration.

The Organising Committee

A Great leap forward – Biological Recording since the 1962 *Atlas of the British Flora*

Royal Botanic Garden, Edinburgh, 20-21 September 2012

Co-authors of presentations are omitted from the programme but included on the abstracts.

Thursday 20th September
08.50 Registration and coffee

Session 1: Chair – **David Pearman**
09.30 Welcome to RBGE – **Pete Hollingsworth**
09.35 Introduction and welcome from BSBI – **David Pearman**
09.45 **Peter Marren** (UK) – The 1962 Atlas: history, approach and production.
10.15 **Chris Preston** (Biological Records Centre, CEH Wallingford, UK) – Following the BSBI's lead: the influence of the *Atlas of the British Flora*, 1962-2002.

10.45 **Coffee break**

Session 2: Chair – **Chris Preston**
11.15 **Trevor Dines** (Plantlife, UK) – Biogeographical patterns in the British and Irish flora.
11.45 **Robert Crawford** (University of St Andrews, Scotland, UK) – Distribution of British plants in relation to their ecophysiology.
12.15 **Richard Ennos** (Institute of Evolutionary Biology, University of Edinburgh, UK) – Biogeography of European trees: glacial refugia and postglacial migration routes.
12.45 **Alison Jukes** (University of York, UK) – Predicting the distributions of non-native plant species and variation in recorder effort in Britain.

13.15 **Lunch**

Session 3: Chair – **Ian Denholm**
14.15 **Simon Smart** (CEH Lancaster, UK) – Ten years of vegetation change since the BSBI Future Flora Conference: matching predictions with observations.
14.45 **David Pearman** (BSBI, Truro, UK) – Separating the native and alien flora: progress and problems.
15.15 **Brian Huntley** (University of Durham, UK) – A context for recent changes: Late-quaternary dynamics of species' distribution and abundance patterns.

15.45 **Tea Break**

Session 4: Chair – **Carly Stevens**
16.15 **Mark Hill** (Biological Records Centre, CEH Wallingford, UK) – How much apparent change is real? Recording bias and how to correct for it.
16.45 **Wouter van Landuyt** (Brussels, Belgium) – Regional variation in floristic change: a comparison between plant atlases of Britain and Flanders.
17.15 **Sebastian Sundberg** (Uppsala University, Sweden) – Decrease of boreal plants in Sweden established by repeated surveys during the 20th Century.

18.30 **Reception and poster session**
19.30 **Conference dinner** (optional)

Friday 21st September

Session 5: Chair – **Mark Hill**

09.00 **Michael Braithwaite** (UK) – Changes in the Berwickshire flora since the New Atlas.

09.30 **Helen Roy** (Biological Records Centre, CEH Wallingford, UK) – Responses of phytophagous insects to a changing flora.

10.00 **Antje Ahrends** (Royal Botanic Garden, Edinburgh, UK) – Patterns of isolation in the flora of the British Isles.

10.30 **Coffee Break**

Session 6: Chair – **Helen Roy**

11.00 **Carly Stevens** (Lancaster Environment Centre, University of Lancaster, UK) – Assessing the impact of atmospheric nitrogen deposition on UK habitats: evidence from national surveys.

11.30 **Peter Carey** (Bodsey Ecology Ltd, Huntingdon, UK) – Population studies and national distributions.

12.00 **Chris Thomas** (University of York, UK) – Animal distributions and climate change.

12.30 **Giovanni Rapacciuolo** (Imperial College and CEH Wallingford, UK) – Can species distribution models predict recently-observed changes in the distribution of the British Flora?

13.00 **Lunch**

Session 7 Chair – **Pete Hollingsworth**

14.00 **Rob Marrs** (University of Liverpool, UK) – Over-dominance in British woodland ground flora – a potential cause of reduced species-richness?

14.30 **Natasha de Vere,** (National Botanic Garden of Wales, Carmarthenshire, UK) – Barcode Wales: Creating and using a DNA barcode database for the nation's native flowering plants and conifers.

15.00 **Petr Pysek** (Institute of Botany, Academy of Sciences of the Czech Republic) – Standing on the shoulders of giants: from floristic data to understanding plant invasions.

15.30 **Tea Break**

Session 8: Chair – **Kevin Walker**

16.00 **Keith Porter** (Natural England, UK) – How botanical recording benefits conservation.

16.30 **Pete Hollingsworth** (Royal Botanic Garden, Edinburgh, UK) – Understanding species diversity and species limits in British land plants: insights from genetics.

17.00 **Mick Crawley** (Imperial College, London, UK) – Are we recording the right things?

17.30 Closing remarks

17.35 **Close of conference**

Abstracts of Oral Presentations

The 1962 Atlas: History, Approach and Production

Peter Marren

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The BSBI Maps Scheme was hailed as the largest survey of its kind in the field of British natural history, a claim that, given its technical challenges, may still stand. It was the product of a boom-time in the fortunes of BSBI and field botany generally. The Scheme gave the Society a sense of unified purpose as a major scientific project within the abilities of its membership, and encouraged by the new Flora by Clapham, Tutin & Warburg (1952). By 1953 the Society had agreed to adopt the 10-km grid square as the mapping unit, a decision that has governed species mapping in Britain ever since. With grants from the Nuffield Foundation and the fledgling Nature Conservancy, the project was launched with the Cambridge graduate Franklyn Perring as its full-time administrator and Max Walters of the Cambridge Botany School as part-time director. Over the ensuing five years some 1,500 participants sent in one-and-a-half million records, and all but 7 grid squares in Britain and Ireland were visited. The phrase square-bashing became familiar. Data was collected on field cards, stored on punch cards and printed as dot-maps on a state-of-the-art machine. The resulting Atlas was published to great acclaim in 1962 and the first edition of 3,000 quickly sold out. The Maps scheme was a success because it tapped into the strengths of British field botany: a long tradition of detailed plant recording; a strong desire to record change and establish a quantifiable basis for nature conservation; the intellectual striving to understand why plants grew where they did; and perhaps because of the complexity of the British landscape, as a result of which British plants have *interesting* distributions. Within the half-hour I will sketch the history of the Atlas scheme from its beginnings in 1950 through to publication, and include personal testimony by some of those who took part.

Following the BSBI's lead: the influence of the *Atlas of the British Flora*, 1962-2002

Chris Preston

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The distribution maps published in 1962 in the *Atlas of the British Flora* were the result of a *comprehensive survey* of *10-km squares* and were based mainly on *field records collected by volunteers*. Maps of 786 of the 1706 taxa covered *distinguished recent from older records*. All these features were to have a great influence on the future of natural history in Britain and western Europe in the next forty years.

One of the most unexpected results of the Atlas was to give a great stimulus to the production of county floras. Botanists who had received their initial training in systematic recording during the Atlas recording scaled down the mapping techniques to 2-km squares (tetrads) although the machinery used to produce the maps was not replicated at the local level. These floras were local initiatives: professional botanists rarely played a crucial role and, when they did, their influence sometimes led to approaches which have not stood the test of time.

Ornithologists also adopted 10-km square and tetrad mapping for both national and county atlases, although such mapping became one of several different approaches to recording rather than the primary tool it was to become for botanists. The Biological Records Centre at Monks Wood promoted recording of other groups of plants and animals and many further national atlases resulted, as did some county atlases of other groups.

The 1962 Atlas was undertaken to advance science. However, its scientific impact, though very difficult to assess, appears to have been indirect and perhaps rather slight, as the mass of data collected was not at that time amenable to scientific analysis. However, the visual depiction of rarity, and the (often unexpected) evidence it provided for the regional decline of many widespread species, gave it an importance in plant conservation which no-one seems to have foreseen, despite the fact that both BSBI as a whole and several leading Atlas protagonists as individuals were heavily involved in the nascent plant conservation movement. The resurvey of 1 in 9 Atlas squares in the BSBI Monitoring Scheme (1987-1988) highlighted for the first time the critical need for statistical tools to compare the results of repeat surveys. However, the use of plant traits to examine the drivers of change was not then appreciated.

Grid-square mapping was an idea taken by the BSBI pioneers from The Netherlands. Despite this, the spread of similar mapping projects in western Europe at both national and regional scale was very uneven. However, the Atlas led directly to Atlas Florae Europaeae, although the pragmatic recording which had characterised the BSBI project was gradually changed over the years to a more taxonomically orientated approach.

A comparison of the Atlas project with less successful proposals for enlisting naturalists as "amateur scientists" in the immediate post-war years helps identify the reasons for the success of the BSBI approach.

Biogeographical patterns in the British and Irish flora

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We have recently been experimenting with methods of classifying distribution maps into groups characterised by a common pattern. In this paper we use one of the variants of Spherical k-means clustering (PSKM W0.5) described by Hill *et al.* (submitted) to classify the native records of 1405 taxa mapped in the *New Atlas of the British & Irish Flora* (2002). Twenty such clusters are identified and named after the 'key species' which is most closely aligned to the cluster centre and therefore best represents each distribution pattern. The *Urtica dioica* cluster is the most widespread, and is characterised by species which are found throughout the British Isles; the most geographically restricted, *Romulea columnae*, cluster is concentrated in the Channel Islands and the Lizard peninsula. No group is characterised by species which are predominantly Irish but the *Chaerophyllum temulum* differs from the *Epilobium hirsutum* group largely in the absence or rarity of its species as natives in Ireland. The clusters differ not only in their distribution patterns but also in the life-form and ecological traits of their component species. Some are composed largely of species with similar distributions in the northern hemisphere whereas others have a heterogeneous mix of wider distributions. Particularly high concentrations of species which are threatened in Britain are found in the *Romulea columnae* cluster and in two more geographically restricted clusters of species, in East Anglia (*Medicago sativa*) and the Scottish Highlands (*Carex atrata*), in a cluster characterised by species of the English chalk (*Hippocrepis comosa*) and in a rather more widespread group of species in southern England (*Clematis vitalba*).

Reference: Hill, M.O., Harrower, C.A. & Preston, C.D. (submitted). Spherical k-means clustering is good for interpreting multivariate species occurrence data.

Distribution of British Plants in relation to their ecophysiology

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Maps can provide the best insight into the physiological tolerance of plants not by showing where they grow, but by indicating where they do not grow. However, interpretation of distribution limits merely in terms of geography in an area as small as Britain needs care, especially when it is remembered that over much of the British Isles and Ireland, isotherms that have a latitudinal orientation in summer have a longtitudinal one in winter. An understanding of ecological adaptations needs to be extended therefore beyond the boundaries of the British Isles and include a genetic dimension, given the existence of meta-populations comprising a range of physiological variations. Studies of the Purple Saxifrage (*Saxifraga oppositifolia*) give such an insight for the role of genetic variation and physiology in relation to plant distribution (Crawford, 2008). A number of case histories are discussed where limits and gaps in species distributions can possibly be explained in terms of physiological limitations. The Atlas of the British and Irish Flora provides some curious gaps in distribution which prompt further enquiry, e.g. why does the White Water-lily (*Nymphaea alba*) not grow in Orkney when it flourishes in the Hebrides as well as Shetland? In relation to altitudinal and latitudinal limits to tree survival, many studies have sought a connection with carbon balance. As plants are rarely starved of carbon, such an association has usually proved elusive, unless it is targeted at susceptible organs and tissues. Recent work on bark physiology illustrates a remarkable facility for carbon recycling in the Common Birch (*Betula pubescens*) with indications that it is also operative in Rowan (*Sorbus aucuparia*) and Hazel (*Corylus avellana*) and that this might account for the success of these species in regions with long winters.

Reference

Crawford, R.M.M. (2008) Plants at the Margin - ecological limits and climate change. Cambridge University Press, Cambridge.

Biogeography of European trees: glacial refugia and postglacial migration routes.

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Over the last fifty years a combination of approaches (fossil pollen and macrofossil analysis, climate tolerance reconstruction and phylogeography) has been used to establish the distributions of European tree species at the last glacial maximum (LGM), and the subsequent changes in these distributions during the Holocene. At the LGM boreal taxa such as Pinus, Betula and Populus were widely distributed in sparsely forested lowland areas to the south and east of the Scandinavian ice sheet, extending to surprisingly high latitudes. These taxa also occupied multiple isolated sites with locally favourable microclimates in the Mediterranean area, often at high elevation. Boreal species expanded rapidly from their northern, rather than from their southern, locations during the early Holocene to occupy previously glaciated areas. In contrast nemoral species, components of the temperate deciduous forest, were largely confined to humid mid-elevation sites in mountainous areas in the Alps and the three Mediterranean peninsulas, with small fragmented populations of the more cold-tolerant nemoral species present immediate north of these areas. Range expansion of nemoral species from these refugial populations was highly idiosyncratic in terms of timing (Quercus early, Carpinus late), the number of source populations involved (Fraxinus multiple, Fagus single), and the migration routes followed. The current distribution of forest tree taxa in Europe cannot be understood without an appreciation of both their behaviour during the last glaciation and their subsequent postglacial history.

Predicting the distributions of non-native plant species and variation in recorder effort in Britain

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Climate change and invasive non-native species are significant threats to biodiversity and ecosystem services. Evidence is growing on how climate change is compounding the negative effects of invasive species, increasing the abundance and ranges of non-native taxa. Previous studies have shown that distributions of non-native plants in Britain are influenced by both climate and land use. The main aim of this project is to determine how climate and land use are affecting the distributions of non-native plants with different levels of establishment in Britain. Future distributions of non-native plant species will be predicted using climate projection data. Hectad (10 x 10 km grid square) records of 1667 non-native plant taxa recorded between 1987 and 2009 were used for analyses. Environmental variables included mean temperatures of the warmest and the coldest month, mean summer and winter precipitation, growing degree days over 5°C (GDD5) and ratio of actual to potential evapotranspiration (APET). Proportions of different types of land cover were obtained from the Land Cover Map 2000. An establishment index was calculated for each species using records assigned a status by a recorder, indicating how much each species is reproducing and spreading in the wild. Current distributions were modelled using Generalised Linear Models, constructed using a subsample of well-recorded hectads and then used to predict species richness of different groups for the rest of Britain. Comparing recorded and modelled species richness shows how well the models predict distributions and which areas of Britain are over- or under-recorded for different groups. As suggested by previous studies, distributions of established species are predicted best by climatic variables, while casual and recently introduced species are more strongly associated with land use. Areas of high and low recorder effort appear to be similar for natives, non-natives, and for non-natives introduced at different times, as the same vice-counties appear to be under- or over-recorded. Using projected climate data to indicate possible future distributions of groups of species will help to identify areas where non-native species will potentially have a greater negative impact.

Ten years of vegetation change since the BSBI Future Flora Conference: matching predictions with observations.

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At the BSBI 'Future Flora' conference in 2002 I finished my paper with a roughly delineated forward look at the main kinds of change likely to impact common habitats and common plant species across Britain in the subsequent decade. I listed the following:

1. Increased broadleaved woodland cover in England, but more land-take for transport and urban growth
2. Progress toward conservation of Priority Habitats, especially at the landscape scale, guided by the Biodiversity Action Plans
3. Extensifying impact of cross-compliance as a condition of receiving farming subsidies and resulting from reform of the Common Agricultural Policy
4. Wider uptake of both organic farming and possible cultivation of GM crops.

The first part of my talk will revisit these gazes into the crystal ball, matching predictions with evidence of change over the last ten years. In the talk in 2002 I also illustrated recent patterns and processes of change in common species and vegetation using data from the Countryside Survey. I return to this unique recording programme once more using recent work to illustrate the remarkable rise of the ecosystem services concept in the last ten years culminating in the production of the UK National Ecosystem Assessment. I will focus on the role of plant species in delivering ecosystem services, now and in the future, using the application of recent species niche modelling to explore the impact of climate projections on some exemplar taxa. As a further excuse to show pictures of interesting plants I will also present the results of an analysis that attempts to answer the question "which single plant species delivers the most ecosystem services across Britain?" Does such a worthy species actually exist? If not, which handful of species should you plant in your back garden to ensure a ready supply of ecosystem services into the future?

The last part of my talk focuses on the increasing need to include social science perspectives in our search for ecological solutions to the growing pressure that increasing affluence and population size are placing on our planet. So I shall mention the rise of the 'social-ecological system' as a more constructive unit of organisation than just ecosystem and then discuss interesting aspects of the human behaviours we exhibit when we appreciate landscapes, habitats and species and argue that we are still more a nation of nature lovers than a nation of political activists of any colour. In a final ploy to again justify showing more pictures of interesting plants I shall illustrate our more passionate connection with the herbage of Britain by suggesting that a good indicator is the words (sometimes hearty expletives) of appreciation we can't help utter when we finally discover the particular plant we had been looking for on that day, month, year, lifetime! So a dry and rational start moving toward a quantitative and conceptual middle and ending with a small, slightly eccentric celebration of the things plants make us say.

Separating the native and alien flora – progress and problems

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A brief recapitulation is given of work to date and progress over the last few years in Britain and Europe, with the major change being better understandings of North-western European distribution and alien plant occurrences. Uses of this approach are discussed, reinforcing the continuing fixation in Britain, at least, with the divide between treatment of natives and of aliens, and the steps necessary to accommodate this. Illustrations of this are presented.

A set of petaloid monocotyledons is examined - mostly well-known garden plants, all with not only a late discovery, but also with a subsequent almost immediate clumping of records from a number of counties. This is contrasted with the discovery and traits of almost all the other species of similar broad habitats in those counties.

Finally a summary of tools, changes and perceptions is given. To the tools should be added a significant improvement in the numbers of species covered in popular, keyed, floras, which has led, in turn, to a rapid increase in the number of recorders dealing with them. This has complicated understanding of the perceived threat to the native flora from alien species, and successes to balance this in the wider conservation world are disappointingly low.

How much apparent change is real? Recording bias and how to correct for it

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Individual botanical recorders have biases and blind spots. They may avoid the spring season, never find aquatic macrophytes, or refuse to note garden escapes. They may have a passion for churchyards or be employed to study unimproved grassland or ancient woods. Some may even take their delight in derelict land. We describe a method of characterising recorder bias by mining records to define groups of co-occurring species. We then examine how far it is possible to distinguish between changes in recorder fashion and real changes in species' frequency.

Regional variation in floristic change: a comparison between plant atlases of Britain and Flanders

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Like Britain, Flanders has been covered by two major plant atlases. Both atlases are grid-based, although the recording scale is 4 x 4km in Flanders, rather than 10 x 10 km in Britain. The first Flanders atlas covers the period 1939-1971 (Van Rompaey 1972) and the resurvey the period 1972-2004 (Van Landuyt 2006). The two projects are sufficiently comparable for us to compare floristic change in Flanders with that in six environmentally-defined regions of Britain.

Flanders is one of the most densely populated and intensely urbanised regions in Europe. Its land cover is most comparable with south-eastern England, although urbanisation is considerably higher in Flanders. Flanders is exposed to environmental pressures that are among the highest in Europe: nitrogen deposition , herbicide usage and the degree of habitat fragmentation by transport and urban infrastructure are all extremely high. As a consequence, highly diverse, heterogeneous landscapes were replaced by a more homogenous landscape during the 20th century. Habitat loss and agricultural intensification caused declines and local extinctions of numerous indigenous plant species, while other species have benefited from anthropogenic impacts and expanded in range.

Floristically, Flanders is most similar to eastern England. One of the major driving forces of distribution change in Flanders is eutrophication. Comparable changes took place in the south-eastern and south-western lowland environmental zones in England. However, this relationship was not present in the other regions of Britain. Indeed, the opposite Ellenberg Nitrogen trend was detected in the Scottish Highlands zone and is probably due to abandonment of small scale arable fields in this area. In Flanders, the increase in indicator species of nutrient-rich soils is clearly related to soil type, with the most marked changes on acid sandy soils rather than heavy clays.

A common trend in Britain and Flanders is – not surprisingly – the expansion of neophytes. Although the general expansion of most neophytes is similar in Flanders and Britain, striking differences exist, perhaps due to arrival time of the species, differences in horticultural practices or local adaptation. Two taxonomically close species that apparently share a similar ecological niche can have completely different expansion rates in Britain compared to the continent (e.g. *Senecio squalidus* versus *Senecio inaequidens*).

Investigating variation in floristic change in two areas with different recording histories confirms the similarity of the major drivers of environmental change in the western European lowlands, but reveal striking differences between these and adjacent highland areas.

Decrease of boreal plants in Sweden established by repeated surveys during the 20th century

Sebastian Sundberg

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In this talk, I present the results of an analysis of the changes among 451 vascular plant taxa between two major inventories during the 1900's in the province of Uppland, situated at the northern fringe of the boreo-nemoral zone in east central Sweden. Additionally, I will touch upon changes in two more southerly Swedish provinces. The first inventory was done mainly during the 1910s-1930s, while the modern one was done 1991-2003 – an average time span of 65 yrs. The 451 species include taxa that were considered less common to rare in the early 1900's. The modern inventory was made systematically in a grid of 5 × 5 km squares (and 2.5 × 2.5 km quadrants) covering the province. To enable comparisons, the old survey was digitised from maps and transferred to the modern grid.

Overall, 24 % of the species increased, 31% decreased, and 45% were relatively stable at the square level between the surveys. Two boreal peatland species, *Carex heleonastes* and *Juncus stygius*, went regionally extinct. Up to 33% of the variation in species changes can be explained by tested variables in ANCOVAs and multiple linear regressions. The most important factor was biotope, which explained 20% of the variation. Tall species and immigrants (after 1800) increased, while boreal, small, management-favoured, and annual species decreased. Among Ellenberg's indicator values, nutrients (+), pH (+), light (-), temperature (+) and salt (+) had effects, but their degree of explanation was small. Notably, the effect of nutrients was considerably smaller (5% explanation) than in a comparable study from the province of Scania (Skåne; 18%). Among biotopes, species of nutrient-poor shores, coniferous forests, rich fens, cultivated soil, and semi-natural grasslands declined. Species of ruderal ground, swamp forests, herb-rich forests, nutrient-rich freshwater shores, and seashores increased. Complex changes in land-use (decline of semi-natural grasslands, intensified agriculture and forestry, drainage and exploitation), regulation of natural water level fluctuations, a warmer climate, and eutrophication seem to be the main drivers of the floristic changes in the province of Uppland during the 1900's.

The 50 plants classified as boreal decreased by 33-35%. Of these, 29 declined and five increased significantly. Significant factors that explain the changes among boreal plants are: 1) plant height (positive relationship; 16-17% explanation), 2) favoured by management (negative; 11-13%), and 3) pH (positive; 8%). Five of a total of 20 species that went regionally extinct are boreal peatland plants (see above, and e.g. *Saxifraga hirculus*).

Floristic changes among boreal plants in the provinces of Skåne (1938-1996, average 41 yrs) in the south and Bohuslän (Bohus county; 1920-2009, c 69 yrs) in the southwest show similar patterns, but the declines were more pronounced in Skåne (-68%) but perhaps milder in Bohuslän (*c* -26%). However, five boreal species disappeared from Bohuslän. The species changes in Uppland and Bohuslän are correlated. Thus, small boreal plants generally appear more sensitive than tall ones to global change in Sweden.

Changes in the Berwickshire Flora since the New Atlas

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A project to repeat-record the vice-county of Berwickshire hectad by hectad was two-thirds complete by the end of 2011 enabling provisional results to be analysed. The provisional result of an earlier paper on *Berwickshire's disappearing plants*, 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% 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.

Responses of phytophagous insects to a changing flora

Helen E. Roy[1], Tristan Bantock[2], Marc Botham[1], Chris D. Preston[1], David B. Roy[1] & Alan Stewart[3]

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Changes in the distribution of the British flora have been well documented (Preston et al., 2002; Braithwaite et al., 2006). One might expect phytophagous insects, particularly host plant specialists, to respond to such changes, as they are dependent on plants for their food supply. However, large-scale assessments of the changes in distribution of insect taxa are rare, even though insects represent a major component of terrestrial biodiversity and there has been a long tradition of biological recording. In particular, the absence for most insect groups of repeat national surveys has limited the extent to which we can compare surveys at different time-periods. However, changes in the ranges of many species over time can be identified from the available sequence of records, and current research is providing more rigorous techniques to extract trend information from continuous records (Hill, 2011). Furthermore, phytophagous insects may respond to changes in the availability of food plants growing as agricultural crops, in parks and gardens and in the wild, whereas botanical studies usually provide information solely on wild populations. Assessment of insect population trends in relation to plant distributions are also complicated by the fact that other aspects of the environment have been changing simultaneously. We will review emerging evidence from analyses of insect distribution datasets in relation to changes in the distribution of plants alongside the effects of climate change, the arrival of non-native species and habitat modification.

Lepidoptera are the most extensively studied group of insects in the UK and as such provide a wealth of evidence highlighting changes in the geographical range, abundance, phenology and biotic interactions of species. Some species of Lepidoptera have switched hosts in recent years. The Brown Argus butterfly, *Aricia agestis*, has expanded its distribution northwards in the UK, spreading away from calcareous grassland habitats (where its main host plant is *Helianthemum nummularium*) into other types of grassland, where its larvae feed on Geraniaceae species (mainly *Geranium molle* and *Erodium cicutarium*). This change in host plant association has been facilitated by warming climate rather than changes to the distribution of plants. The arrival and spread of non-native plants has been one of the most noticeable changes to the UK landscape. There are many documented examples of the arrival and establishment of non-native phytophagous insects which are dependent on these non-native plants. The planthopper, *Prokelisia marginata*, on cordgrass, *Spartina anglica*, provides one such example. There are a number of conifer-specialists that have recently arrived in Britain and are feeding on conifers within parks and gardens. The western conifer seed bug *Leptoglossus occidentalis*, native to North America, arrived in Britain in 2008. Some native insects are also benefiting from the proliferation of conifers in gardens. *Eremocoris fenestratus* was historically associated with junipers in the Chilterns and had not been recorded since the 1960s until 2010 when specimens of this bug were found on garden cypresses in London.

Here we provide examples of changes in the distribution patterns of phytophagous insects in response to changing flora and interactions with environmental change. We conclude that change in the distribution of host plants is simply one of several simultaneous environmental changes to which phytophagous insects are responding.

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Patterns of isolation in the flora of the British Isles

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Loss of connectivity between species habitats (fragmentation) is thought to constitute a critical threat to biodiversity. Many natural habitats in the UK have undergone considerable fragmentation through historical and present-day human activities. This is of particular concern in the face of climate change as, due to loss and fragmentation of habitat, species may not be able to respond with range shifts and/or access adaptive genetic variation from nearby conspecific populations. The degree of fragmentation is thus a critical component to consider in species risk assessments. A great variety of different methods to assess fragmentation have been developed and these have been applied to individual taxa and habitats. However, to our knowledge, distributional patterns and fragmentation therein have never been systematically assessed at the scale of an entire flora.

With over 9 million records, the Atlas of the British and Irish Flora represents one of the most complete distributional assessments of a flora worldwide. Based on this resource, we characterised spatial patterns for the *c*. 1500 native vascular plants of the British Isles with a view to establishing which species have many isolated records. For example, we assessed how many species have no or few neighbours in immediate distance, measured as the mean number of edges around occupied cells. We also assessed the isolation of individual patches by quantifying distances to the nearest neighbouring patch, and the minimum total distance needed to connect all patches. Aggregating the individual species maps, we identified hotspots of isolation, In order to move from a static distributional assessment to a more functional view, we are complementing these analyses with information on species traits. The atlas scale (10 km) is obviously too coarse to capture the appropriate scale of isolation for many species. However, this first pass analysis of large scale spatial patterns of the entire flora identifies species that have a large proportion of their occurrences isolated and as such helps to prioritise future risk assessments.

Assessing the impact of atmospheric nitrogen deposition on UK habitats: evidence from national surveys

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Atmospheric nitrogen (N) deposition poses a serious threat to sensitive semi-natural plant communities in the UK. Critical loads represent the level of pollutant below which significant harmful effects cannot be detected but, in the UK, critical loads are exceeded in large areas of the country. With only small declines in levels of N deposition predicted for the next decade, this threat will persist. Vegetation surveys targeted at individual plant communities show a very clear picture of reduced species richness at high levels of atmospheric N deposition. Evidence from surveys of acidic grasslands across Europe shows declines in species richness and changes in species composition with increasing levels of N deposition. These trends can be seen in both spatial and temporal analyses. Similar relationships have also been observed in other habitats including heathlands and calcareous grasslands.

Despite clear evidence of community change and reductions in diversity, there was little evidence for how individual species are responding to N deposition. To address this, we used national vegetation surveillance datasets including the BSBI Local Change Survey and Vascular Plant Database, British Lichen Society database and British Bryological Society database. Data were analysed to identify the relationship between the presence and absence of species and N deposition whilst accounting for habitat, location, land use intensity, sulphur deposition and climate. Analysis focused on species typical of acid grasslands, calcareous grasslands, heathlands and bogs. Generalised additive models were used to analyse the data. Species showed a range of responses to N deposition, with many species showing no relationship with N deposition. However, a number of species did show statistically significant relationships with N deposition; calcareous grassland was the habitat where the most species showed a negative response. Relationships could be classed as positive, negative, hump-shaped or U-shaped relationships. Few of the vascular plant species analysed showed statistically significant positive relationships whilst no terricolous lichen species showed positive relationships. A number of terricolous lichen species showed negative relationships, suggesting that they are particularly sensitive to N deposition. There were also a number of vascular plants showing negative relationships; many of these were of small stature or poor competitive ability.

Modelling and long-term recording of populations shed light on the changes in distribution of orchid species

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In 1992, the first climate envelope models were published for the predicted distribution of *Himantoglossum hircinum* under climate change scenarios. The first date that the models used for predictions, 2010, has passed and it would be interesting to see what has happened. Since those first models, created using primitive datasets, several things have happened. It soon became obvious that, to answer the question of what determines the distribution and abundance of the species, far more was required than climate envelope models, which rightly have their critics. Population data has been gathered from several populations from 1987 to the present day to try and understand the population dynamics of *H.hircinum* and dispersal models were developed in the mid 1990s, and again by recent authors in 2011, using ever better climate datasets.

The number of populations of *H. hircinum* and the size of those populations has been increasing and the actual data are compared to the predictions of the models from the 1990s. Populations on the eastern range boundary in Germany have also been increasing. The comparison suggests that climate envelope modelling was surprisingly accurate.
Lessons learnt from *H. hircinum* are used to interpret the increase of *Ophrys apifera* and *Anacamptis pyramidalis* in recent years, both of which have been increasing in abundance and range in the UK.

Can species distribution models predict recently-observed changes in the distribution of the British Flora?

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Conservation planners often wish to predict how species distributions will change in response to environmental changes. Species distribution models (SDMs) are the primary tool for making such predictions. Many methods are widely used; however, they all make simplifying assumptions, and predictions can therefore be subject to high uncertainty. With global change well underway, field records of observed range shifts are increasingly being used for testing SDM transferability. We used distribution records for native British vascular plants from two time periods, corresponding to the periods of intensive recording effort leading to the publication of the national distribution atlases, to test whether correlative SDMs based on climate change can provide useful approximations of potential distribution shifts. We modelled species' past distributions from climate using nine single techniques and a consensus approach, and project the geographical extent of these models to a more recent time period based on climate change; we then compared model predictions with recent observed distributions in order to estimate the temporal transferability and prediction accuracy of our models. We also evaluated the relative effect of methodological and taxonomic variation on the performance of SDMs. Models showed good transferability in time when assessed using widespread metrics of accuracy. However, models had low accuracy to predict where occupancy status changed between time periods, especially for declining species. Model performance varied most among species, but there was also considerable variation among modelling frameworks. Past climatic associations of British vascular plants retain a high explanatory power when transferred to recent time – due to their accuracy to predict large areas retained by species – but fail to capture relevant predictors of change. We strongly emphasize the need for caution when using SDMs to predict shifts in species distributions: high explanatory power on temporally-independent records – as assessed using widespread metrics – need not indicate a model's ability to predict the future.

Over-dominance in British woodland ground flora – a potential cause of reduced species-richness?

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The invasion of native habitats by alien species has received considerable attention. However, in Britain 'over-dominance' by a small number of aggressive native plant species (sometimes termed 'Thugs') may have an equal, or greater, impact on the richness of native woodlands. Here, we examine this hypothesis using data from a national structured survey. We have modelled the realised niche of potential over-dominant species along the principal coenocline of British woodlands, and examined niche overlaps with 77 woodland specialist species and two alien species. Four native species (*Hedera helix*, *Mercurialis perennis, Pteridium aquilinum*, *Rubus fruticosus*) had a much greater cover than all other field-layer species, and between them they entirely covered the response range of all other field-layer species, replacing one another along the coenocline. These findings, combined with autecological information suggest that these species, could be described as 'over-dominant' or 'Thugs'. Two alien species (*Acer pseudoplatanus, Rhododendron ponticum*) did not fit between the realized niches of the native ones. Our results also identify which field-layer woodland-specialist species are likely to be impacted by a change in dominance of each 'Thug' species, and provides a novel quantitative method of risk assessment to aid conservation policy. Understanding how woodland communities remain diverse, even in the presence of aggressive native species, may provide insights into how the impact of invasive species can be managed.

Barcode Wales: Creating and using a DNA barcode database for the nation's native flowering plants and conifers.

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DNA barcoding uses standard regions of DNA to act as a tool for identifying species. Once reference databases are created, samples can be identified from small fragments of leaf, seed, and root or from pollen grains. Next generation DNA sequencing approaches allow the analysis of samples containing mixtures of different species. Here we present the creation of a DNA barcode database for all of the native flowering plants and conifers of Wales, using the plant DNA barcode markers, *rbcL* and *matK*. For the 1143 species of Wales (455 genera, 95 families and 34 orders) we have 3304 *rbcL* and 2419 *matk* DNA sequences, covering 98% and 90% of the Welsh native flora. The majority (85%) of our samples come from herbarium material using especially optimised protocols.

Using our DNA barcodes we can identify 77% of unknown samples to species and 100% to genus. Species discrimination can be further improved using spatially explicit sampling. Mean species discrimination is 82% within 10 x 10 km squares and 93% for 2 x 2 km squares. Our database of DNA barcodes for Welsh native flowering plants and conifers represents the most complete coverage of any national flora to date. We are developing applications that make full use of this resource including: analysis of root and pollen samples; characterising pollinator ecosystem services; phylogenetic community ecology; and drug discovery using DNA barcoded honey.

Standing on the shoulders of giants: from floristic data to understanding plant invasions

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Invasion ecology, as a field studying historical processes, largely depends on regional botanical tradition and floristic data accumulated over centuries of botanical research. This is because much of the current knowledge base is inferred from reconstructions of past invasions and analyses of their modern dynamics. The talk will explore how primary botanical data can be used to infer about macroecological patterns and processes of plant invasions at various scales, hence contributing to our understanding of habitat invasibility, species invasiveness and spread, as well as factors determining these phenomena. Experiences with building a national database of alien species in the Czech Republic, its recent update and with building the pan-European DAISIE database by using botanical literature and regional checklists, will be also discussed.

How botanical recording benefits conservation

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Species information is the basic currency of nature conservation and underpins targets, decisions and measures of change. Vascular plant data are particularly important, both because of the way in which habitats (and sites) are described in terms of their vegetation communities – which are themselves defined largely by the vascular plants they contain – and because of the priority given to the conservation of individual taxa. The statutory agencies with responsibility for nature conservation in the UK rely heavily upon species data collected through the activities of volunteer recording. The BSBI, as a national society, plays a pivotal role in these recording activities and is a key partner of the conservation agencies. Species records underpin Natural England's plant conservation work in various ways: they help us to identify and prioritise sites and taxa needing special protection, and to better understand the distribution, ecology and habitat management requirements of such species. They also contribute to an on-going 'stock take' of how our nationally rare, scarce, Red-listed and UKBAP species are faring at local, regional and national scales, thereby allowing us to assess the success or otherwise of the actions we take to secure their conservation. Our need for species data is met by a mixture of records made by our own staff and those gathered by the volunteer recording community. The balance between these two sources has shifted in the last decade with more reliance now being placed upon data provided by the 'voluntary sector'; a trend that is likely to continue given the growing pressure on staff resources within Natural England. The demand for up-to-date data increases year by year, in tandem with a growing expectation that conservation priorities, decisions and actions will always be based on the best available information. As numbers of records increase, and our ability to handle them improves, so our definition of what constitutes a 'good evidence base' has become ever more exacting. Informed opinion alone is no longer good enough, and we are now expected to provide far more evidence – of which species records are a crucial part – when defending sites or species, or when providing advice to others. Increasingly, species data are being used alongside other data types to demonstrate cause-and-effect associations and to predict the impacts of environmental change on plant-community composition and species distributions and abundance. The analysis of cause and effect often requires large quantities of high quality data at fine spatial resolution. Natural England is currently providing funds to the BSBI through a Memorandum of Agreement to encourage the systematic recording of rare, scarce and threatened species, to make it easier (and quicker) for recorders and others to get their records into the 'system', and to facilitate the development of the BSBI's Distribution Database and the accessibility of the BSBI's records on the NBN Gateway. The aim of our partnership with the BSBI is to help to ensure that the recording community is well supported and continues to thrive, but also that the records being made by that community contribute directly and speedily to the 'evidence base' upon which the conservation of our wild plants depends.

Understanding species diversity and species limits in British land plants: insights from genetics

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Species level mapping data is based on an understanding of species limits and an ability to effectively identify species when they are encountered. The typical approach to species delimitation and identification is use of morphological characters. This approach is extremely powerful. However, there are some circumstances where molecular data provide additional insights. In this talk I will review the impact of genetic data in understanding species level taxonomy in the British flora, focusing on two main areas:

- Insights into the biology of taxonomically complex groups
- The strengths and limitations of DNA barcoding for high-throughput species identification and species delimitation

During the talk, I will emphasise how species history, and traits such as breeding system and dispersability, influence the relationship between genetic marker variation and species limits inferred from morphology. I will also provide a brief summary of emerging opportunities for enhancing our understanding of plant biodiversity based on recent developments in molecular genetics.

Are we recording the right things?

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The preceding talks are testimony to the outstanding achievements of BSBI's recording protocols over the last 50 years. The question I address here is whether we can do better in future.

The questions we are likely to be asked will have to do with quantification and prediction. What is the impact of *Impatiens glandulifera*? How far is *Conyza floribunda* likely to spread? The issues centre on what we record and how we record.

The Society is acutely conscious of the fact that BSBI members do recording for fun; make the procedure look too much like hard work and we shall lose some or all of that precious commitment.

In an ideal world, sampling would be fully randomised, constant effort, and we would have a network of permanent quadrats in which the abundance of all species was measured at regular intervals (say 5 or 10 years). But that is not what BSBI members do. We are biased (we typically go to nicer-than-average places to botanise) and there is no attempt to control for sampling effort (some members report a single interesting plant, while others record everything they see).

I propose two changes: 1) that we record by habitat rather than by squares; 2) that we pay more attention to the status of the plants we record. I give a range of examples from Berkshire, East Sutherland and London to illustrate the advantages of these changes.

Poster summaries

Evaluating change in species frequency

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Global warming and various environmental factors such as changes in air quality can result in quite rapid changes in plant distribution. If recording occupies an extended period, as is usual in the case of county Floras, this can result in a significantly distorted distribution (dot map). Temporal changes are sometimes obvious but need not be, and in any event it is desirable to have an objective means of assessing them. This can be achieved by simple plots of tetrad counts against time, as we demonstrate with the help of records of bryophyte species over a 10 year period in VC59 (South Lancs), during which certain epiphytic species were rapidly increasing their range.

Thirty years of botanical recording on Ben Lawers NNR

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Ben Lawers is one the most botanically diverse sites in Britain with multiple designations for the rare mountain species and habitats that occur there. It is owned and managed by the National Trust for Scotland with support from Scottish National Heritage.
Long-standing management objectives relate to maintaining the populations of rare species, area of important plant communities and diversity of both. In 1981, an extensive survey provided data on the distribution and abundance of Red Data species of vascular plants, as a baseline against which these objectives could be measured. Since then a rolling programme of monitoring has been on-going, aimed at detecting changes in their populations. The accumulated data have been recognised as outstanding. Measuring the extent and condition of *Natura* communities was introduced following the Habitats Directive.
Much has been learned about the difficulty of recording accurate data to support management decisions. There are indications that several rare species, e.g. *Minuartia rubella, Erigeron borealis* and *Woodsia alpina* have maintained their populations over the 30-year period. Others, e.g. *Salix lanata, Saxifraga rivularis* and *Sagina nivalis* have been at the verge of extinction or giving concern of a probable decline. Two of these have been the subject of recovery projects.

Hay Time: A landscape-scale approach to upland hay meadow restoration using green hay – preliminary results

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Upland hay meadows are one of the rarest grassland types in the UK. Restoration of a typical sward following agricultural improvement requires the deliberate reintroduction of plants as seed. The North Pennines AONB Partnership's "Hay Time" project began in 2006 to coordinate and monitor the reintroduction of seeds to multiple meadows across the North Pennines. In the first phase, seed was added to 94 ha of meadows. Interim analysis of monitoring data found an increase in species richness in 63% of sites, an increase in positive indicator species scores in 80% of sites and an increase in negative indicator species scores in 53% of sites. Seventeen species showed a statistically significant increase in frequency. The results demonstrate the start of a shift in sward composition towards that typical of MG3 upland hay meadow. It is anticipated that future monitoring will demonstrate further positive changes in the long process of meadow restoration.

The Flora of North Lancashire

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The first definitive account of the past and present occurrence of flowering plants and ferns of North Lancashire together with an analysis of change and a characterisation of the flora.

Native Woodland Survey of Scotland

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The aim of the Native Woodland Survey of Scotland is to identify the type, extent, composition and condition of all native, nearly native and plantation on ancient woodland sites (PAWS) woodlands of at least 0.5ha in order to create a woodland map linked to a spatial dataset.