MAKING PLANTS COUNT

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Early-purple Orchids, among other plants, in a woodland habitat. Richard Revels

A new National Plant Monitoring Scheme for the United Kingdom has been launched. Here, the authors explain why it is necessary, and what it can achieve.

Our knowledge of how British wildlife is changing is based, to a very large extent, on a minority of species for which we have good annual monitoring data, including birds, mammals (incorporating bats) and butterflies (Greenwood 2003; Brereton *et al*. 2006; Barlow *et al*. 2015). These sample-based schemes are carried out by volunteers, typically coordinated by staff of non-governmental organisations, and they provide high-quality information from which annual changes in the abundance of species or species groups are produced. Results have allowed relationships with potential drivers (e.g. pollution, land management, weather and climate change, pests and diseases, invasive species) to be investigated or inferred. The results are widely publicised, increasing awareness of and participation in the schemes, as well as providing environmental policy-makers and practitioners with the information which they need to inform decision-making (Dickinson *et al*. 2012). These data have also been used intensively by researchers to explore both fundamental and applied ecological questions (Roy *et al*. 2012, 2014) and underpin several national biodiversity-indicators (Defra 2014).

Here we describe the development of a standardised monitoring scheme for vascular plants that is intended to track changes in the flora of the United Kingdom. This National Plant Monitoring Scheme (NPMS) is being run as a partnership of the Botanical Society of Britain and Ireland (BSBI), the Centre for Ecology and Hydrology (CEH), the Joint Nature Conservation Committee (JNCC) and Plantlife, and was launched in March 2015.

The need

Although vascular plants provide key 'ecosystem services', we have relatively little information on how the majority of species are faring within habitats. Much of our understanding of how plant populations are changing is dependent on our

ability to extract trend information from records collected by volunteers over different scales of time and space and at varying intensities (Preston *et al*. 2002; Telfer *et al*. 2002). The different ways in which naturalists might collect records will inevitably create some 'noise' in the data, and this can potentially mask trends and weaken the detection of signals in which we are interested, although our ability to quantify trends in such data by using statistical techniques is rapidly improving (e.g. Hill 2012; Isaac *et al*. 2014). The Countryside Survey (www.countrysidesurvey.org.uk) offers a more structured, plot-based alternative that focuses on change at the habitat scale, but is largely limited to very common species and habitats, as well as being undertaken only every 8–10 years approximately. Other relevant plant surveys include the BSBI's Monitoring Scheme (Rich & Woodruff 1996; Braithwaite *et al*. 2006) and Plantlife's Wildflowers Count, but these lack suitable design features (sampling scheme, spatial resolution, species selection, frequency of resurvey) required to derive annual trends in abundance for specific habitats equivalent to those that are routinely being produced for birds and butterflies. The need for a standardised approach to plant-monitoring, one that would provide timely and robust estimates of status and trends, was therefore identified as a high priority within the *Terrestrial Biodiversity Surveillance Strategy* published by the JNCC in 2008. A scoping study to investigate how this might be achieved soon followed (Walker *et al*. 2010), and this has provided the foundations for the NPMS which, since 2012, has been developed by the project partnership.

Wood Avens is an example of a plant that occurs in more than one of the NPMS habitat categories. Richard Revels

The method

During the development of the NPMS, the partnership has worked closely with a wide range of volunteers, statisticians, and species- and habitat-monitoring experts, as well as with potential participants and data-users, to develop a robust method that aims to:

- Provide reliable measures of change for individual species and species groups within semi-natural habitats;
- Utilise both positive and negative indicator species for each habitat;
- Be simple, repeatable, and achievable by volunteers.

As for the Breeding Bird Survey (BBS) and Wider Countryside Butterfly Survey (WCBS), sampling is based upon a random sample of 1 × 1km squares (monads) throughout the United Kingdom. The NPMS stratified-random selection is weighted towards monads with a higher cover of semi-natural habitat (based on existing inventories such as the CEH Land Cover Map). This means that volunteers will, on average, survey monads that are generally richer in semi-natural habitats than would be encountered in the countryside as a whole. This will help to achieve sufficient replication at the habitat level, as well as maximising volunteer engagement through providing focused opportunities to visit semi-natural habitats and encounter distinct sets of species. Crucially, this bias towards semi-natural habitats will be taken into account in any analysis of trends, as the weighting is known and can be updated as information on the locations of semi-natural habitats is improved or updated.

Within NPMS 1 × 1km squares, participants will establish small, fixed plots to record. The decision to record in small, fixed plots reflected the need for a repeatable method (in respect of area, habitat, etc.) that was not overly complex or

time-consuming to undertake and was not overly susceptible to recorder bias. For this reason volunteer self-selection of plot locations was rejected, as this would have resulted in a bias towards the richest areas, as recorders would by nature gravitate towards these areas if given the choice. Such a bias would have meant that monitored plots could 'only get worse or remain stable', whereas the aim of the NPMS was to provide a method for estimating and tracking both positive and negative changes in habitat quality. A key element of the survey design is therefore a random location of plots in habitats using a systematic grid within monads, with up to 25 pre-selected locations at intersections on this grid. Volunteers then record plots where these points coincide with semi-natural habitats included in the scheme (Box 1), aiming for a minimum of five plots, including three square and two linear plots, within each square (Box 2, page 249). Ideally, each plot would be in a different habitat from the others, although clearly this will not be possible in areas where squares are dominated by a few habitats (e.g. moorland) or if squares have only a small area of land (e.g. islands, coast). Self-selection is permitted where the minimum number of random square plots cannot be reached, as a result, for example, of land-access constraints. Where this occurs, volunteers locate plots in NPMS habitats elsewhere in the square, using the guidance to position plots in representative areas that will be easy to locate in the future.

The size and shape of the plots was determined by a review of relevant literature and feedback from the field trials. Square 5 × 5m plots will be used for open habitats such as grasslands and heathlands, square 10 × 10m plots for woodlands, and linear 25 × 1m plots for hedgerows and habitats where only a small portion of the habitat is accessible (e.g. edges of arable crops and waterbodies, base of rock outcrops, screes, cliff-tops, etc.).

A vital element for the success of the scheme is to involve as many volunteers as possible, with a range of expertise, and so this is reflected in the species selected for survey. Volunteers are given the choice of recording at one of three levels:

- *Wildflower Level* – 212 easily identifiable species, divided into lists applicable for habitats listed in Box 1;
- *Indicator Level* – an expanded list of 403 species, divided into groups applicable for habitats listed in Box 1, including some species which are more challenging to identify (e.g. more grasses, sedges, ferns);
- *Inventory Level* – designed for volunteers who are capable of recording all vascular plant species which they find in a habitat.

The difficulty of identification increases across the levels, and it is hoped that this will encourage progression of volunteers from the Wildflower Level to the Indicator Level as confidence increases through training provision and participation in the scheme. The positive indicator species included in the Indicator Level, and to a lesser extent the

Box 1 Semi-natural habitats included in the NPMS and the number of species included in the Wildflower and Indicator Levels.

Broad category	Fine-scale habitat(s) included	Wildflower	Indicator
Arable field margins	Arable field margins	15	30
Bog & wet heath	Blanket bog; raised bog; wet heath	31	53
Broadleaved woodland	Dry deciduous woodland; hedgerows of native species; wet woodland	49	75
Coast	Coastal saltmarsh; coastal sand-dunes; coastal vegetated shingle; machair; maritime cliff-tops and slopes	65	110
Freshwater	Nutrient-poor lakes and ponds; nutrient-rich lakes and ponds; rivers and streams	29	56
Heathland	Dry heathland; dry montane heathland	28	48
Lowland grassland	Dry acid grassland; dry calcareous grassland; neutral damp grassland; neutral pastures and meadows	62	98
Marsh & fen	Acid fens, flushes, mires and springs; base-rich fens, flushes, mires and springs	33	51
Upland grassland	Montane acid grassland; montane calcareous grassland	31	53
Native pinewood & juniper scrub	Conifer woods and juniper scrub	21	29
Rock outcrops, cliffs & screes	Inland rocks and scree; montane rocks and scree	34	52

Wildflower Level, were randomly selected from a pool of widespread species that occur in the vegetation types that make up the individual habitats; the selection, however, was weighted towards those species that are more characteristic, and therefore indicative of the habitat in question.

As one of the main aims of the NPMS is to produce annual trends, volunteers will be encouraged to revisit plots twice a year, this repeated every year, although this will clearly be dependent on how accessible the squares are, time constraints, costs and retention of volunteers. Less frequent visits, although less ideal, may have to be made, especially in remoter areas. The frequency of resurvey of plots will be accounted for within the analysis of data from the scheme and will not have a significant impact, provided there is sufficient replication within a habitat each year. This problem is likely to hamper only those species and habitats largely confined to remoter squares more difficult of access, as is the case for other species groups, such as montane butterflies and birds. To counter this problem, partnerships and pilots are being developed with local organisations in some of the remote areas where these difficulties are likely to occur.

The challenge

However well it is designed, the success of any volunteer-based monitoring scheme ultimately depends on the engagement of participants and the quantity and quality of the data which they produce. This means that scheme methods cannot be overly complex, but at the same time they need to be based on a robust scientific design that ensures that the results are reliable and meaningful. For the NPMS, the project partnership has been incredibly fortunate in being able to test the recommendations made by scientists, habitat experts and statisticians in a series of field trials and consultations involving nearly 400 dedicated BSBI and Plantlife volunteers. The information gathered in these exercises has been vital in improving our awareness of the volunteer perspective, especially with regard to three aspects of the field survey methodology.

Field trials were an essential component in determining decisions on plot size, shape and placement. A pool of 40 volunteers tested a range of sizes (5 × 5m, 10 × 10m, 25 × 1m, 100 × 1m) and this led to the decision to use smaller plots for all habitats bar woodlands, as larger plots increased the difficulty in estimating abundance, especially in linear habitats. Reassuringly, these conclusions were supported by a review of the relevant literature.

In 2014, a field test was also vital in revealing that the identification of some of the 'fine-scale' NPMS habitats was quite challenging for some volunteers, and this led to the development of a much broader classification more suited to less experienced surveyors (Box 1). As a result, surveyors can now choose to record at a 'fine scale' if they can confidently classify the habitat they are in, or they can use the broad habitat if they are unsure.

The field trials also influenced the selection of the species to be monitored. These were chosen as indicators of good or poor habitat quality and, to ensure wide participation, they included some species that are easy or relatively easy to identify. Therefore, species that are likely to be confused or misidentified were excluded, or in a few cases aggregated (e.g. *Arctium minus/nemorosum*). At the same time, some species more difficult to identify were retained in order to encourage learning and training opportunities. For example, a few distinctive sedges (e.g. Star Sedge *Carex echinata*, False Fox-sedge *C. otrubae*) have been included, and it is hoped that this will encourage volunteers to take more of an interest in this ecologically important but often overlooked group of plants.

This process of involving a large pool of volunteers in the development of the scheme has had the added benefit of creating an informed and inclusive base of people who are, we hope, more aware of the reasoning behind the design of the scheme and therefore generally more accepting of the key features and modifications that have been implemented along the way.

Training, support, and feeding back results

The NPMS has been designed as an accessible scheme, and the guidance material produced should enable all surveyors, regardless of experience, to participate in it. In addition, training provision and support will be of paramount importance for the scheme's ongoing success. This will ensure that there are regional foci, providing opportunities to meet others taking part in the scheme, and enabling development of surveyors' confidence and ability.

Some species, such as *Arctium minus*, shown here, have been aggregated with others (in this case *A. nemorosum*) in the survey to simplify identification. Marcus Webb/FLPA

During the launch year, training will be focused on the method and on providing opportunities to practise the method in the types of habitats that surveyors are likely to encounter. Locations for training that optimise the number of species encountered have been identified.

There will also be workshops focusing on species that some surveyors will find more challenging to identify (e.g. aquatics, grasses, sedges, rushes, ferns). Special emphasis will be placed on those on the Indicator Level lists, with the aim of providing the additional support which surveyors may need in order to move beyond the Wildflower Level. The scheme strongly encourages surveyors to enter their data online, so that the results can be more efficiently verified, analysed and fed back to volunteers within the calendar year. Each autumn, online-data-entry workshops will be provided, to support surveyors with the process and, again, to provide further opportunity for meeting other surveyors and for sharing experiences.

In the second and third years of the scheme, it is planned to expand the training to include more plant- and habitat-identification workshops, ensuring that surveyors are confident in identifying the NPMS habitats. Through running 'train the trainer' and peer-mentoring schemes, volunteers will have the opportunity to become 'approved' NPMS trainers, increasing local opportunities – and thereby, it is hoped, enabling surveyor progression. Face-to-face training will be supported by quarterly newsletters, and additional web-based support materials, including YouTube videos. Constant review of workshops and materials will allow the NPMS team to be responsive to surveyor needs and to provide further support as identified by surveyors.

Sharing results from the scheme is particularly important, as surveyors are always enthusiastic to know what is revealed by the data collected. The autumn newsletter sent to surveyors will include feedback about the results for that year.

What will the NPMS tell us?

Like equivalent schemes for birds, bats and butterflies (e.g. BBS, the UK Butterfly Monitoring Scheme, the National Bat Monitoring Programme), the NPMS is designed to report national trends derived from the summed data for all the plots

Yellow Loosestrife is among the plants to search for in both freshwater and coastal categories. Richard Revels

recorded in any one year. Given sufficient replication, this could include annual trends for individual species, or groups of species, such as positive and negative indicators for individual habitats. Other potentially meaningful groups to report on include non-native species, climate-sensitive and pollution-sensitive species, species requiring cross-pollination, designated and threatened species, and specialists versus generalists that have been used successfully to show contrasting trends for groups of birds and butterflies (Gregory *et al*. 2005).

Clearly, one of the primary aims for the NPMS is not only to track changes in plant populations but also to understand better the factors causing these changes, and how these affect overall habitat quality. Although the NPMS is not designed primarily to monitor changes at the site level, it will, by pooling samples across the scheme, provide invaluable data on direct impacts from physical events, such as severe weather (e.g. storms, droughts, periods of very cold weather) or the introduction and spread of novel pests and pathogens (e.g. ash dieback *Phytophthora*), to more insidious drivers such as pollution, eutrophication and detrimental impacts of climate change. The NPMS is also likely to highlight the effects of major changes in land management, for example agricultural innovations (e.g. GMOs, set-aside) or the introduction of new agri-environment options (e.g. planting of grass/flower margins, arable reversion, etc.). This would include situations where economic changes have influenced the profitability of land-management practices, leading to over- or under-exploitation of certain habitat types, with concomitant effects on species reliant on less intensive (traditional) management (e.g. intensification, abandonment). Central to the design of the NPMS, however, will be its capacity to track both positive and negative changes in habitat quality, including those from unpredicted drivers that come to light in the future.

The controversy over the use of neonicotinoids has raised the public profile of pollinating insects in terms of both the ecosystem service which they provide and the declines which they have experienced over recent decades, the latter due partly to parallel declines in their nectar plants (Biesmeijer *et al*. 2006). The NPMS will have an important role to play in the debate over pollinator declines, as well as for other groups for which plants provide important resources, such as food or shelter. This raises the possibility of a 'shared network' of squares (and plots) that could be monitored for

a variety of taxon groups by a range of national schemes and organisations. As an example, the BBS successfully incorporates the sampling of mammals and butterflies within the same monads as those sampled for birds. The target NPMS squares have potential to provide a focus for sampling of other species groups given that the scheme's design is weighted towards semi-natural habitats.

Although not a primary aim of the scheme, NPMS plots, if well documented with sketches and photos, may well become the focus for detailed studies of sites. Equally, they could provide conservation-site managers and local groups, such as educational establishments, local communities and others, with opportunities to raise awareness of and participation in environmental activities within their local area. For example, plots may provide opportunities to observe environmental changes, such as the spread of exotic species, and management actions introduced to control them (e.g. 'balsam-bashing'). Preselected squares could also provide a focus for recording activities outside the plots themselves, thereby increasing public participation in recording activities more generally. For at least a subset of squares, these activities could be combined with satellite imagery, habitat-mapping, and soil-diversity sampling to provide a more in-depth understanding of environmental changes that would be of use to environmental practitioners and academics alike, although this approach would clearly need financial support from relevant funding bodies. This focus on the NPMS squares, however, would need to be carefully controlled to ensure that it did not influence the management of plots and thereby make them unrepresentative of the habitat as a whole (a problem avoided in some other surveys by keeping the locations of plots/squares confidential).

How can I get involved?

The NPMS is open to anyone with an interest in wild plants, regardless of level of expertise. If you would like more information, please visit the website www.npms.org.uk, where you can sign up, read about the survey and download all the information you will need in order to take part. Alternatively, you can contact the scheme coordinator at support@npms.org.uk.

Box 2 Steps for volunteers recording a NPMS square. Note that steps 1–4 are completed only in the first (baseline) year.

1. Register at www.npms.org.uk.
2. Square allocated within a preferred region (e.g. near home or holiday residence); map shows 25 preselected points and areas shaded to identify likely areas of NPMS Broad Habitats.
3. Choose whether to record all vascular plant species (Inventory Level) or species on the Wildflower or Indicator Level lists.
4. Reconnaissance of the square in spring, visiting accessible points marked on the map.
5. During late spring/early summer, identify at least three points that coincide with an NPMS habitat, and record 5 × 5m-square plots (10 × 10m in woodlands).
6. During the same visit identify at least two locations where a linear habitat crosses the grid on the map, and record 25 × 1m linear plots (12.5 × 2m plot is used for rock outcrops and screes).
7. If there are fewer than three accessible points with NPMS habitat, the surveyor either (a) selects plots in NPMS habitats closest to these or (b) selects plots in habitats covering very small areas (e.g. flushes, and springs) or (c) records more linear plots.
8. Repeat the survey later in summer.
9. Enter records online at www.npms.org.uk.
10. Resurvey the same plots annually.

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National Plant Monitoring Scheme

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