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Long-term vegetation monitoring in Great Britain - the Countryside Survey 1978-2007 and beyond

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Abstract

The Countryside Survey (CS) of Great Britain provides a unique series of datasets, consisting of an extensive set of repeated ecological measurements at a national scale, covering a time span of 29 years. CS was first undertaken in 1978 to monitor ecological and land use change in Britain using standardised procedures for recording ecological data from representative 1 km squares throughout the country. The same sites, with some additional squares, were used for subsequent surveys of vegetation undertaken in 1990, 1998 and 2007, with the intention of future surveys. Other data, for example regarding soils, freshwater and habitat diversity and extents, have also been sampled in the same locations on analogous dates. However, the present paper describes only the vegetation surveys.

The survey design is based on a series of gridded, stratified, randomly selected 1 km squares derived from a statistical environmental classification of Britain. 256 1 km sample squares were included in the 1978 survey, 506 in 1990, 569 in 1998 and 591 in 2007. Initially each square contained up to 11 dispersed vegetation plots but additional plots were later placed in different features so that eventually up to 36 additional sampling plots were recorded, all of which can be relocated where practically possible, providing a total of 16,992 plots by 2007. This database of vegetation plots is a unique national resource providing the only comprehensive quantitative ecological coverage of Britain, with a time-series of vegetation samples dating back to 1978. Plots in different habitats, land cover types and landscape features are included.

Although a range of analyses have already been carried out, with changes in the vegetation being related to a range of drivers at local and national scales, there is a major potential for further analyses, for example in relation to climate change.

Data from each of the survey years (1978, 1990, 1998, 2007) are available via the following DOIs: *Countryside Survey 1978 vegetation plot data* (https://doi.org/10.5285/67bbfabb-d981-4ced-b7e7-225205de9c96), *Countryside Survey 1990 vegetation plot data* (https://doi.org/10.5285/26e79792-5ffc-4116-9ac7-72193dd7f191), *Countryside Survey 1998 vegetation plot data.* (https://doi.org/10.5285/07896bb2-7078-468c-b56d-fb8b41d47065), *Countryside Survey 2007 vegetation plot data* (https://doi.org/10.5285/57f97915-8ff1-473b-8c77-2564cbd747bc).

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1 Introduction

The Countryside Survey (CS) of Great Britain was initiated in the late 1970s to monitor ecological and land cover change using quantitative and repeatable methods. The history of the development of the methodology is given by Sheail and Bunce (2003). The survey is based on 1 km squares as a convenient sized unit, which had previously been tested in Cumbria (Bunce and Smith, 1978) and Shetland (Wood and Bunce, 2016) in the years preceding the first survey in 1978. The survey design is based on a series of stratified, randomly selected 1 km squares from across Britain, which numbered 256 in 1978, 506 in 1990, 569 in 1998 and 591 in 2007. The stratification used was the statistical land classification of 1 km squares in GB as described in Bunce et al. (1996a), Bunce et al. (1996c) and summarized in Section 2.

In the first survey, data were recorded from up to 11 vegetation plots of four different types, distributed through each of the squares (which form the main subject of the present paper), along with soil samples and land cover maps using standard classes which were later converted into standard habitat categories (Wood et al., 2012). Subsequent surveys including the vegetation component were undertaken in 1990, 1998 and most recently, 2007 (with an additional habitat survey in 1984). During this period, additional vegetation plots have been placed in different habitats and landscape features for policy objectives, eventually giving up to 36 more plots per square. Varying numbers of each vegetation plot type were initially placed in locations across each survey square according to rules outlined in Section 3. In subsequent surveys, these plots are repeated in these same fixed positions, except those such as on field margins, which are based on rules applied in the field. Details of the types of plot employed are described below, with an average of 29 plots being completed in each sample square.

The survey as a whole provides a wealth of unique ecological data, consisting of an extensive range of measurements at a national scale, covering a time span of 29 years. In addition to the vegetation plots described here, data are also recorded from linear features such as hedgerows, landscape elements such as veteran trees, areal habitats, soils and aquatic invertebrates (see (Carey et al., 2008).

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2 Survey design: site selection and stratification

As a result of the earlier work carried out in the 1970s on a regional scale (Wood and Bunce, 2016;Bunce and Smith, 1978), a sample unit of 1km square was found to be an appropriate size for CS. 1km square is small enough to survey in a reasonable period of time (1 week or less) and yet large enough to contain sufficient environmental features to allow differentiation between squares. 1 km square is also widely used in other European projects (for example in Spain (Ortega et al., 2013)), although in countries with small scale landscapes, for example Northern Ireland, 0.25 km square has been adopted (Cooper et al., 2009).

With over 240,000 1km squares in Great Britain, a sampling approach was essential and a statistical environmental classification was constructed, from which the stratified, random samples of 1km squares were taken. Due to the limitations of computing power and lack of readily available data at the time, the classification initially only covered a subset of 1212 1km squares, rather than the whole of Britain, based on a 15x15 km grid drawn from the National Grid defined by Britain's national mapping agency, the Ordnance Survey.

Altitude, climate, geology, human geography and location variables from each 1 km square were analysed using Indicator Species Analysis (ISA, now TWINSPAN (Hill and Šmilauer, 2005) and stopped at 32 classes. These strata were then described based on the average values of the environmental characteristics of the initial database, for example, altitude and rainfall (Bunce et al., 1996b;Bunce et al., 1996c).

Having constructed this initial stratification, the number of samples to be surveyed in the first (1978) survey was considered. Ideally, this number would depend on the size of the stratum (i.e. how many 1 km squares of the class occurred in GB) and on the ecological variability within the stratum. Preliminary work had suggested that for ecological surveys of this type, at least eight samples per stratum were necessary. Eight 1 km squares were therefore selected at random from each of the classes from the grid of classified squares. Thus the final sample for the first GB survey was a gridded, stratified, random sample of 256 x 1 km squares. Surveying commenced in 1977, although the majority of squares were surveyed in 1978. Note that the location of the 1 km sample squares is not disclosed by agreement with land-owners. This policy ensures that the squares do not attract additional research or land management activity that could potentially undermine their status as an unbiased,

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representative sample of the British countryside. The majority of the land in the sample squares is in private ownership.

A primary objective of the methodology is to reduce variation, as the classification divides the population into discrete strata which are then used to derive samples from which ecological parameters such as vegetation can be recorded. By using this statistically robust method, it is then possible to scale up the results from the sample sites to describe the entire population.

By 1990, all 1 km squares in GB were classified into the same set of strata, which was not considered possible at the start of the 1970s. Known as the 'Institute of Terrestrial Ecology (ITE) Land Classification of Great Britain' (Bunce et al., 1990, 1996b, a), it has developed over the 30 year period (Sheail and Bunce, 2003). The most recent modifications largely concern the incorporation of the requirement for country level reporting, separating Scotland (in 1998) and Wales (in 2007). The basic stratification still underpins the CS and the latest development of the original Land Classification (Bunce et al., 2007) consists of 45 classes (or strata), and is illustrated in Figure 1, along with the sampling framework (Figure 2).

Figure 1. ITE Land Classification, 2007

Figure 2. Map of Countryside Survey sampling locations across Britain

3 Sampling sites and plots

Initially, vegetation and soil data were recorded from five dispersed random ('X') plots in each 1 km square, which were located using a restricted randomization procedure designed to reduce auto-correlation. Vegetation was sampled from a further six plots placed along linear features (two Hedgerow ('H') plots, two Streamside ('S') plots, two Roadside ('R') plots). Plots have never been placed in built-up areas or below the Mean High Water mark, and are only sited where the landowner has given permission. The types and total numbers of plots have increased over time from 1978 to 2007 along with the total number of CS 1 km squares surveyed. The total number of plots within squares varies depending on the landscape type and range of landscape features. Plots differ in size depending upon their type (Table 1). By 2007, the mean number of plots per square was 29 (min. 2, max. 47). The locations of all plots were mapped, together with measurements to local features thus allowing them to be

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found again and re-recorded in the same place. Additional information ensuring the highest degree of accuracy when re-finding plots began to be recorded in the 1990 survey, as described in Section 4.2. The same plot locations have been repeated in all subsequent surveys (where appropriate), with additions.

Table 1. Summary of vegetation plot types, sizes and numbers.

Code	Name	Other names	Where	Size	No. per square
Areal plots					
X[1]	Large	'Wally plot' Main	Random points in open polygons	200 m^2	5
Y[2+4]	Small	Targeted Habitat	Uncommon vegetation types and in 2007, Priority Habitats	4 m^2	Up to 5
U[3]	Unenclosed		Unenclosed Broad Habitats	4 m^2	Up to 10
Linear plots					
B[2]	Boundary		Adjacent to field boundaries and paired with X plots	10 x 1 m	5
A[3]	Arable		Arable field edges centred on each B plot	100 x 1 m	Up to 5
M[4+5]	Margin		Field margins	2 x 2 m	Up to 15
H[1]	Hedgerow		Alongside hedgerows	10 x 1 m	2
D[3]	Hedgerow diversity		Hedgerows/Woody Linear Features	30 x 1 m	Up to 10
S[1]/W[2]	Streamside		Alongside water courses	10 x 1 m	5
R[1]/V[2]	Roadside		Alongside roads and tracks	10 x 1 m	5

[1] first recorded in 1978, [2] first recorded in 1990, [3] first recorded in 1998, [4] first recorded in 2007, [5] if there are 5 A plots in a square and wide margins

4 Data collected

The vegetation survey involves recording plant species presence and abundance in different sizes and types of vegetation plot. In each vegetation plot, a complete list of all vascular plants and a selected range of the more easily identifiable bryophytes and macro-lichens is

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made (with the exception of D plots, which record woody species only). Predetermined combinations of species are recorded as aggregates reflecting known difficulties in their separation in the field (refer to (Maskell et al., 2008). Cover estimates are made to the nearest 5% for all species reaching at least an estimated 5% cover. Presence is recorded if cover is less than 5%. Canopy cover of overhanging trees and shrubs is also recorded even if individuals were not rooted within the plot. Additionally, general information about the plot is recorded to provide a unique reference for analytical purposes as well as habitat characteristics.

4.1 Plot Types

- ***X Plots - Large or Main Plots***

The X plots are large nested plots designed to provide a random sample in proportion to the extent of the different vegetation types in each square and therefore in the wider countryside. X plots were pre-located before going into the field, with one plot being randomly placed into one of 5 equal sectors dividing the 1km survey square. X plots typically sample the most common vegetation types. The X plot is 200m^2 (14.14 x 14.14m); the large size was adopted to obtain the maximum number of species within the study area and is not therefore intended to fit into phytosociological criteria of homogeneity. The methodology was originally produced for woodlands as described by Bunce and Shaw (1973) and was also used and found appropriate for strategic ecological survey, as described by Bunce and Smith (1978). The design of plot not only aids a systematic search of the vegetation present but is straightforward to set out in the field, and ensures a standard area of the plot is covered on every occasion. The plot is set up by using a centre post and four corner posts, with a set of four strings tagged with markers at specified distances. The tagged strings form the diagonals of the square (as shown in Figure 3). The diagonals should be orientated carefully at right angles and the plot should be orientated with the strings on the north/south, east/west axes. The different nested plots shown in Figure 4 are marked by different coloured strings on the appropriate position of the diagonal. The design is to ensure that the whole plot is covered, as tests had shown that a major difference between observers was their search routine.

Within the plot shown in Figure 4, the first nest of the plot (2x2m) is searched first. This procedure is then repeated for each nest of the quadrat, increasing the size each time and only recording additional species discovered in each larger nest (Figure 4). In the final nest (the whole 200m^2 plot), the percentage cover (to the nearest 5%) of each species is also estimated. Estimates of cover for litter, wood, rock and bare ground are also included where present. In 2007, an additional 1m^2 nest (not shown in Figure 4) was introduced, in order allow joint analysis of 1m^2 plots being recorded in parallel as part of agri-environment scheme monitoring programs. This nest is located in the northernmost corner of the inner 4 m^2 nest (named nest '0'). Vegetation height, aspect and slope are also recorded. Soil samples are also taken at the same time, at the site of these plots; the procedure used for recording soil samples is given by Emmett et al. (2008) and is outwith the remit of the present paper.

In arable fields where full access is not possible, species records are made from plots taken from an estimated 14m square, starting three metres into the crop in order to avoid any edge effect. Access is made using drill lines where possible in order to causing minimum disturbance to the crop. Overall cover is also estimated as in other habitat types. The relative uniformity of species within crops led to the adoption of this approach and the subsequent changes observed in species numbers in arable fields justified its use.

Figure 3. X plot construction

Figure 4. Layout of vegetation X plot.

- ***Y Plots - Small, Targeted or Habitat Plots***

These are small (2 x 2m) plots located in less common habitat types, usually of conservation interest, often occurring in small patches not sampled by other plot types. In 2007, additional Y plots also were placed in Priority Habitat (Maddock, 2008) patches that had also not been sampled by any other plot in the square. The Y plots are therefore important in sampling fragments of semi-natural habitat particularly in lowland landscapes where patches may be small and embedded in a matrix of intensive farmland. These plots are placed randomly by surveyors in suitable patches of habitat (based on rules described in Maskell et al. (2008)). Of all the plots recorded, they are most similar to the approach taken when positioning quadrats during National Vegetation Classification (NVC) (Rodwell, 2006) survey where the location of the plot is designed to represent a vegetation unit perceived to be floristically distinct and homogenous. However, protocols for locating Y plots from 1998 onwards stipulated random location from within a larger extent of habitat in the 1 km square or from a number of patches representing the mapped habitat type. The validity of statistically analysing plots located with a degree of subjectivity is an ongoing matter of debate (see for example Lájer (2007);Palmer (1993) for an illustration of analytical problems but also Ross et al. (2010) for counter-argument and examples of analysing temporal change in subjectively located samples).

- ***U Plots - Unenclosed Plots***

These plots were introduced into the CS methodology for the first time in the 1998 survey to characterise the unenclosed Broad Habitats (Jackson, 2000) - these being Calcareous and Acid grasslands; Bracken; Dwarf shrub heath; Fen, marsh and swamp; Bog; Montane; Supra littoral rock and sediment; and Inland rock. Up to ten plots were established in any unenclosed habitat types that occurred within the square (proportional to area), again placed randomly by surveyors. The plots are 2x2 m in all instances, regardless of the habitat in which they are located.

- ***B Plots - Boundary Plots***

Boundary linear plots are recorded at a position on the boundary closest to each X plot and on a cardinal axis from it (i.e. north, south, east or west). A boundary is taken to be any linear physical feature that has a length greater than 20m and which is an interface between the land cover of the 200m^2 X plot and any other land cover type. This might include a hedge, wall, fence, ditch or embankment. These are linear 10 x 1m plots.

- ***A Plots - Arable Field Margin Plots***

Arable field margin plots were recorded for the first time in the 1998 survey. The purpose of establishing the plots was to record the arable weed population at the edge of cultivated fields and any subsequent changes. It is established that non-crop plant diversity increases towards the edge of a field. Field edges therefore contribute an important source of biodiversity not present in the arable X plots, which cover the overall composition of arable crops because as described above, the margin is specifically excluded. The uptake of 'conservation headland' options for arable field management under agri-environment schemes may further enhance species diversity in A plots. The plots are 100m long by 1m wide and located adjacent to B

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plots which border arable fields, up to a maximum of five per square. They always sample the first 1m of cultivated land moving away from the perennial dominated margin.

- ***M Plots - Margin Plots***

M plots are small (2 x 2m) square plots and were new in the 2007 survey. They are associated with B plots where an A plot is present, and the number depends on the widths of the margins present, with up to three per field. They are designed to record the quality of new arable field margins that form part of the agri-environment agreements on farms and other margins put in without agri-environment support. These margins are additional to the cross compliance margin (not relevant in Wales) which is a 2m margin measured from the centre of the hedge. The most common types of margin likely to be encountered are perennial grass margins, with or without supplementary wildflowers. Other rarer types include, uncropped strips, usually cultivated each year (regenerating from the seedbank); wild bird seed cover e.g. kale, quinoa; pollen and nectar mixes, usually with a high proportion of legumes.

- ***H Plots - Hedgerow Plots***

H plots are linear 10 x 1m plots running alongside managed woody linear features ('WLF's, hedgerows). Within H plots, species associated with the managed woody linear features are recorded. When first recorded in 1978, the plot positions were located as close as possible to the two X plots in each square which were furthest apart.

- ***D Plots - Hedgerow Diversity Plots***

Hedgerow diversity plots were recorded for the first time in 1998. The overall purpose was to set up a baseline of plots to monitor woody species diversity in woody linear features. One D plot is placed on each woody linear feature in the square, up to a maximum of ten plots. As well as providing information on woody species diversity, the data collected in D plots also helps to provide an assessment of the condition of hedgerows and other woody linear features by providing vital information about the size of the woody linear features, gappiness, levels of disturbance and species composition. Each plot is 30 m long and includes the full width of the WLF.

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- ***S/W Plots - Streamside Plots***

The term "Streamside plot" denotes linear plots which lie alongside running water features (mainly rivers and streams, but also canals and ditches). The S and W prefixes refer to the different origins of the plots: two Streamside (S) plots were established in the 256 1 km squares in 1978, located as close as possible to the two X plots in each square which were furthest apart. W plots were up to three additional Waterside plots, placed in all squares in 1990 to increase representation of other waterside types. These are linear 10 x 1m plots.

- ***R/V Plots - Roadside and Verge Plots***

The term "Roadside plot" denotes those linear plots which lie alongside transport routes (mainly roads and tracks). The R and V prefixes refer to the different origins of the plots: two Roadside (R) plots were established in the 256 1 km squares in 1978, located as close as possible to the two X plots in each square which were furthest apart. V plots are up to three additional Verge plots first placed in 1 km squares in 1990 to increase representation of other transport types. These are linear 10 x 1m plots.

4.2 Plot Relocation

To analyse change, it is important to relocate the exact same sampling plot locations in successive surveys. The data from the repeated vegetation plots provide a globally unique dataset allowing large-scale yet fine-grained change in overall vegetation and the state or condition of the Broad and Priority Habitats over time to be documented at four points over the last 29 years. There are no other national data sets that cover entire landscapes, including constituent habitats over such a long period of time. In practice, there are actually very few long term studies of vegetation change. Those existing are usually either opportunistic, because some local recording has given a precise location, for example Dunnett et al. (1998) on a roadside verge in Bibury in Gloucestershire; or pertain to specific habitats, such as the Park Grass Experiment at Rothamsted (Silvertown et al., 2006).
During the surveys, plot locations have been recorded on paper using a sketch map with measurements from distinguishing landscape features (Figure 5), and by taking at least two photographs (see Figure 6 for an example), preferably also including key landscape features

in proximity to the plot. In addition to these, permanent metal plates or wooden stakes were introduced in the 1990 survey. In 1998, a GPS position was recorded in some remote squares, which assisted locating plots again in 2007. In 2007, the plot locations were recorded via the ruggedized field computers using the in-built GPS (where a GPS signal was available). Surveyors are also able to record whether the plots have been re-found adequately or otherwise. Circumstances where a plot may not be repeated might include an area becoming built-up, or a feature having been removed.

Figure 5. Example of a plot sketch map

Figure 6. Example of a plot photograph

5 Data quality

Each field survey was carried out by teams of experienced botanical surveyors, and was preceded by an intensive training course, ensuring high standards and consistency of methodology, identification and recording across CS according to criteria laid out in the field handbooks (Maskell et al., 2008;Barr, 1998;Barr, 1990;Bunce, 1978). During the surveys, survey teams were initially supervised and later monitored by experienced project staff in order to control data quality.

Data were recorded on waterproof paper sheets in 1978, 1990 and 1998 and were consequently transferred from the original field sheets to spreadsheets, using a ‘double-punch’ method to minimise errors in data entry. They were checked using range and format checks, and corrected to produce a final validated copy. In 2007, a new electronic data capture method was developed by the Centre for Ecology & Hydrology and used in CS for the first time. The move to electronic methods created greater efficiency in terms of data entry and also eliminated a potentially significant source of error. Improvements to data quality also resulted from the inclusion of mandatory data entry fields for each plot.

In terms of assessing the actual level of botanical expertise in the field surveys, Quality Assurance (QA) reports were completed by independent botanists for the surveys in 1990, 1998 and 2007 (Prosser and Wallace, 2008, 1999, 1992). These reports have been a vital tool in assessing and validating the quality of the botanical record in each CS. Paired species records from a subset of plots (the QA plots) have been analysed in a number of ways to measure the consistency of recording effort within each survey. In all three surveys the QA assessors found more species than the CS field teams, yet in both the 1990 and 1998 assessments, the results showed that there was no bias in the species composition of the vegetation recorded, as described by DCA analysis, despite differences in species richness. In 2007, the QA analysis appeared to show a decline in the quality of botanical recording. However this was possibly due to the much less comprehensive recording of common bryophytes than in previous surveys, and subsequent analyses determined the bias was not significant (Scott et al., 2008). Errors attributable to use of the electronic data capture software were minor and not significant (Prosser and Wallace, 2008).

6 Methodological Development

The now established method of CS, using a stratified random series of samples, was developed over two decades by what was then the Institute of Terrestrial Ecology as described by Sheail & Bunce (2003). The first national series of stratified random samples was the 1971 Woodland Survey (Wood et al., 2015) and strategic sampling at the landscape level was then tested successfully in regional surveys in Cumbria and Shetland (Bunce and Smith, 1978;Wood and Bunce, 2016). These methods have now been proven as a successful national vegetation monitoring strategy incorporating four surveys across nearly 30 years. Minor modifications to the methods have more recently been used for a comprehensive ecological survey of Wales (2013-), the Glastir Monitoring and Evaluation Programme (GMEP) (Emmett and GMEP team, 2014).

Since the first survey in 1978, the methods have gradually developed to incorporate contemporary technologies, for example, the introduction of GPS in 1998, and the use of ruggedised field computers with internal GPS to record the location and species composition of the vegetation plots in 2007. Over time, the development of Geographical Information Systems (GIS) has greatly facilitated both the efficiency of storage of ecological spatial data, and also the types of analyses that can be undertaken. It is now possible to perform much wider analyses than previously, using a range of ancillary explanatory datasets, as described in the Integrated Assessment Report for the Countryside Survey (Smart et al., 2010a). The underlying principles of the Countryside Survey methodology provide an ideal framework for the planning of large scale monitoring, not only in Britain, but across Europe and worldwide, as discussed in Wood and Bunce (2016).

It has now been a decade since the last survey, and current funding constraints mean that the traditional cycle of large one-off national surveys taking place roughly one year in every decade is likely to need revising. Various options are available for repeating all or parts of the survey. A rolling program over several years is attractive because it spreads the financial load. It also allows inter-annual effects of differences in the weather and variation in recorder effort to be more robustly estimated and separated from long-term trends. A Markov chain approach could be used to examine possible outcomes from the time series of plots (for example, Balzter (2000)). Between 2013 and 2016, CS methods have already been applied in an annual rolling program to monitor the effects of the Glastir agri-environment scheme across Wales (https://gmep.wales/).

Plot numbers could be rationalised according to the desired results. Using previous data, it is possible to identify the optimal numbers of plots required by plot type, habitat type and region in order to provide data on specific criteria, for example, species richness change at GB level by plot type. Less costly options for maximising the use of the existing surveys in future surveillance have been suggested as part of the Future Options review for national monitoring in Wales (Emmett et al., 2016a). However, the feasibility of these options has yet to be determined.

7 Use of the data

The Countryside Survey provides a unique and well utilised resource, offering potential for a wide range of analyses at different temporal and spatial scales. A major benefit of the programme is the co-registration of a wide range of recorded ecological variables (i.e. soil, vegetation, habitats, freshwater). In parallel to its direct policy application, a vibrant and productive research agenda has used CS vegetation data often in combination with other datasets to produce improved understanding about the significance and causes of large-scale but finely resolved ecological change in Britain. Questions can be broadly categorised as: ‘What has changed and where?’, ‘What are the drivers of change?’, ‘Is the change important?’ and ‘Can we use forecast future change?’.

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7.1 Key findings

Key findings and fundamental questions about the extent and condition of terrestrial habitats are addressed in the reporting round to policy makers that has followed each survey (e.g. (Haines-Young et al., 2000;Carey et al., 2008;Smart et al., 2009 ;Norton et al., 2009;Emmett et al., 2010;Bunce, 1979;Barr et al., 1993) and elsewhere (Smart et al., 2003;Norton, 2012). Overall changes in plant species richness formed part of a trend in species loss (8%) across Great Britain between 1978 and 2007. Woody species increased in vegetation associated with landscape boundaries by 14% between 1998 and 2007 and by nearly 80% in Great Britain between 1978 and 2007.

The most commonly recorded species in CS, ryegrass (*Lolium perenne*), was the same in 2007 as in both 1998 and 1990. The top ten most commonly recorded species in 2007 also included stinging nettle (*Urtica dioica*), hawthorn (*Crataegeous monogyna*), and bramble (*Rubus fruticosus*) all of which increased between 1998 and 2007.

Long-term change in vegetation from 1978 to 2007 has also been assessed using a range of condition measures (Table 2). In open countryside in Great Britain, between 1998 and 2007 plant species that prefer wetter conditions increased while those preferring fertile soils and high pH decreased. In the period 1978 to 2007, an increase in species preferring wetter conditions was the most consistent signal in plots sampling different parts of the landscape across all countries.

Table 2. Change in the characteristics of all types of vegetation in 200m² Main Plots in Great Britain between 1978 and 2007. Arrows denote significant change ($p<0.05$) in the direction shown.

	Mean Values				***Direction of significant changes 1978 - 2007***
Vegetation Condition Measures	*1978*	*1990*	*1998*	*2007*	*GB*
Species Richness (No. of Species)	17.1	16.5	16.2	15.7	↓
Light Score	6.98	6.95	6.95	6.95	
Fertility Score	4.53	4.64	4.61	4.55	
Ellenberg pH Score*	5.07	5.17	5.14	5.09	

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Moisture Score	5.75	5.71	5.77	5.82	↑

*Ellenberg (1988)

7.2 Wider uses of data to date

After CS in 2007, the data continued to have a substantial impact, contributing to many areas of the UK National Ecosystem Assessment (NEA) (Watson et al., 2011), which articulated ecological status and change in terms of ecosystem services (ES). This was the first analysis of the UK's natural environment in terms of the benefits it provides to society and continuing economic prosperity. Soils, vegetation, headwater stream and land-cover data from Countryside Survey were also jointly analysed with a range of explanatory variable datasets to produce new indicators and analysis of potential ecosystem service delivery in the Integrated Assessment project that marked the final phase of reporting after the 2007 survey (Smart et al., 2010a;Norton et al., 2012).

Subsequently, CS plot data has been used in conjunction with Land Cover Map data (Morton et al., 2011) and wider environmental datasets as part of a natural capital mapping tool which has been used, alongside other modelling techniques, to produce maps of natural capital for policy makers (https://eip.ceh.ac.uk/naturalengland-ncmaps) and to help in understanding the factors influencing spatial differences in ES delivery (Henrys et al., 2015a;Norton et al., 2016). Analysis demonstrated fundamental trade-offs between ecosystem productivity and soil carbon concentration while a range of biodiversity indicators appeared to peak at intermediate levels of productivity (Maskell et al., 2013). The novel inclusion of dynamic ecosystem model estimates of productivity provided both the foundation and research direction for ongoing work that has sought to develop dynamic models of natural capital and ecosystem service delivery (Emmett et al., 2016b;Smart et al., 2017;Rowe et al., 2016).

CS datasets have also made a unique contribution to the development of plant species niche models for ecosystem dominants and many rare species in Britain (Hill et al., 2017;Henrys et al., 2015b;Smart et al., 2010c;Smart et al., 2010b). The policy motivation for this originally was detection and modelling of the effects of atmospheric pollutant deposition (De Vries et al., 2010;Stevens et al., 2016).

The statistically robust, national scale of the CS vegetation data makes it ideally placed to detect realistically scaled relationships between global change drivers, such as pollutant deposition (for example van den Berg et al. (2016);Maskell et al. (2010);Smart et al. (2005a);Stevens et al. (2009)) as well as other drivers of eutrophication and land management change (Smart et al., 2012;Smart et al., 2002;Smart et al., 2003;Smart et al., 2005b;Smart et al., 2006a;Smart et al., 2006b). While research into the causes and consequences of eutrophication was a response to clear policy interest, analysis of CS vegetation data has also contributed evidence in response to concerns over the causes and consequences of loss of pollinators in North West Europe and Britain (Smart et al., 2000;Carvell et al., 2006;Baude et al., 2016).

Habitat specific studies, such as those relating to woodlands (for example (Petit et al., 2004;Kimberley et al., 2013;Kimberley et al., 2016) and hedgerows (McCollin et al., 2000;Garbutt and Sparks, 2002;Critchley et al., 2013)) have been facilitated through the use of CS data. Interesting conclusions have been made through use of the data with regard to increasing numbers of non-native invasive species (Chytrý et al., 2008;Maskell et al., 2006).

The results and information derived from CS can often be set into wider contexts, for example, European (Chytrý et al., 2008;Metzger et al., 2013), or in relation to other monitored datasets (Rose et al., 2016;Scott et al., 2010;Carey et al., 2002;Rhodes et al., 2015).

Data from the 1990 survey were used in the development of a statistically based British vegetation classification, termed the Countryside Vegetation Classification (CVS) as described in Bunce et al. (1999). This led to the development of a computer system termed MAVIS (Modular Analysis of Vegetation Information System), enabling classification of any lists of species from plots into the CVS but also into the phytosociological classes of the National Vegetation Classification Rodwell (Rodwell, 2006). The software is publicly available (Smart and DART Computing, 2017).

8 Data availability

The datasets have been assigned Digital Object Identifiers and users of the data must reference the data as follows:

Earth Syst. Sci. Data Discuss., doi:10.5194/essd-2017-17, 2017
Manuscript under review for journal Earth Syst. Sci. Data
Discussion started: 6 March 2017

- Barr, C.J.; Bunce, R.G.H.; Smart, S.M.; Whittaker, H.A. (2014). Countryside Survey 1978 vegetation plot data. NERC Environmental Information Data Centre. https://doi.org/10.5285/67bbfabb-d981-4ced-b7e7-225205de9c96

- Barr, C.J.; Bunce, R.G.H.; Gillespie, M.K.; Hallam, C.J.; Howard, D.C.; Maskell, L.C.; Ness, M.J.; Norton, L.R.; Scott, R.J.; Smart, S.M.; Stuart, R.C.; Wood, C.M. (2014). Countryside Survey 1990 vegetation plot data. NERC Environmental Information Data Centre. https://doi.org/10.5285/26e79792-5ffc-4116-9ac7-72193dd7f191

- Barr, C.J.; Bunce, R.G.H.; Gillespie, M.K.; Howard, D.C.; Maskell, L.C.; Norton, L.R.; Scott, R.J.; Shield, E.R.; Smart, S.M.; Stuart, R.C.; Watkins, J.W. ; Wood, C.M. (2014). Countryside Survey 1998 vegetation plot data. NERC Environmental Information Data Centre. https://doi.org/10.5285/07896bb2-7078-468c-b56d-fb8b41d47065

- Bunce, R.G.H.; Carey, P.D.; Maskell, L.C.; Norton, L.R.; Scott, R.J.; Smart, S.M.; Wood, C.M. (2014). Countryside Survey 2007 vegetation plot data. NERC Environmental Information Data Centre. https://doi.org/10.5285/57f97915-8ff1-473b-8c77-2564cbd747bc

The datasets are available from the CEH Environmental Information Data Centre Catalogue (https://catalogue.ceh.ac.uk). Datasets are provided under the terms of the Open Government Licence (http://eidchub.ceh.ac.uk/administration-folder/tools/ceh-standard-licence-texts/ceh-open-government-licence/plain , http://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/). The metadata is stored in the ISO 19115 (2003) schema (International Organization for Standardization, 2015) in the UK Gemini 2.1 profile (UK GEMINI, 2015). Users of the datasets will find the following documents useful (supplied as supporting documentation with the datasets): The Sampling Strategy for Countryside Survey (Barr and Wood, 2011) and the Field Survey Handbooks (Barr, 1990;Barr, 1998;Bunce, 1978;Maskell et al., 2008).

9 Conclusions

The vegetation data recorded during the Countryside Survey of Great Britain are an invaluable national resource, which, over the years, has been exploited in a large number of ways. The data are collected in a statistically robust and quality controlled manner, follow standard, repeatable methods and cover wide temporal and spatial scales. The intention is that a repeat survey will be undertaken in the near future (indeed a sub-sample of plots (the majority being located in Wales), have already been surveyed in the summer of 2016, largely as part of the Glastir Monitoring and Evaluation Programme (Emmett and GMEP team, 2014)). As a decade has now passed since the most recent full survey, an addition to this long-term national resource is becoming increasingly timely, particularly in these current times of political, socio-economic and climatic change.

Author Contributions. C. M. Wood prepared the manuscript with significant contributions from all co-authors, and is the current database manager for the Land Use Research Group at CEH Lancaster. R. G. H. Bunce designed the sampling framework and survey strategy in 1978. R.G.H. Bunce, S. M. Smart, L. C. Maskell, L. R. Norton and D. C. Howard have all been part of the Countryside Survey co-ordination team for at least one survey, with W. A. Scott and P.A. Henrys contributing statistical support.

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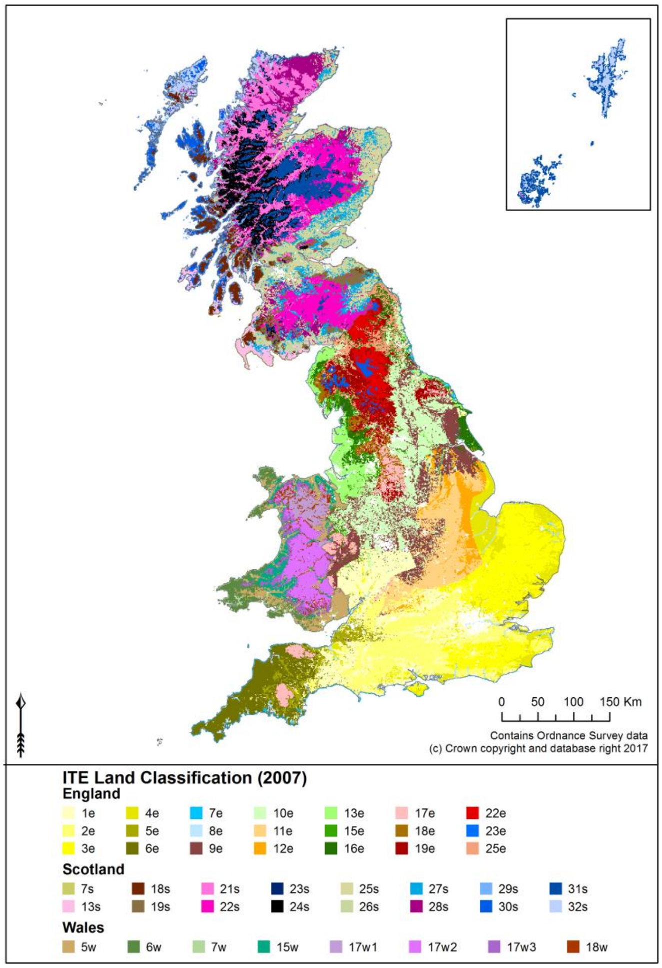
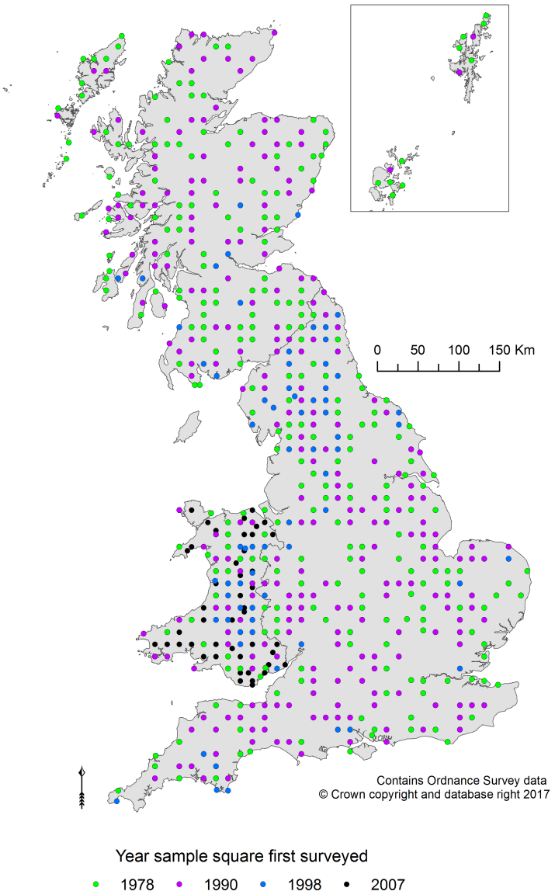
Manuscript under review for journal Earth Syst. Sci. Data
Discussion started: 6 March 2017

Figure 1. ITE Land Classification, 2007



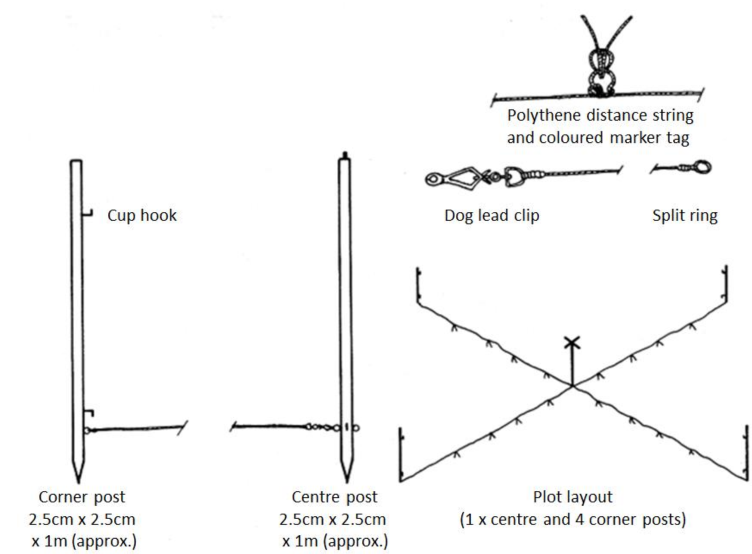
Earth Syst. Sci. Data Discuss., doi:10.5194/essd-2017-17, 2017
Manuscript under review for journal Earth Syst. Sci. Data
Discussion started: 6 March 2017

Figure 2. Map of Countryside Survey sampling locations across Britain



Earth Syst. Sci. Data Discuss., doi:10.5194/essd-2017-17, 2017
Manuscript under review for journal Earth Syst. Sci. Data
Discussion started: 6 March 2017

Figure 3. X plot construction



Earth Syst. Sci. Data Discuss., doi:10.5194/essd-2017-17, 2017
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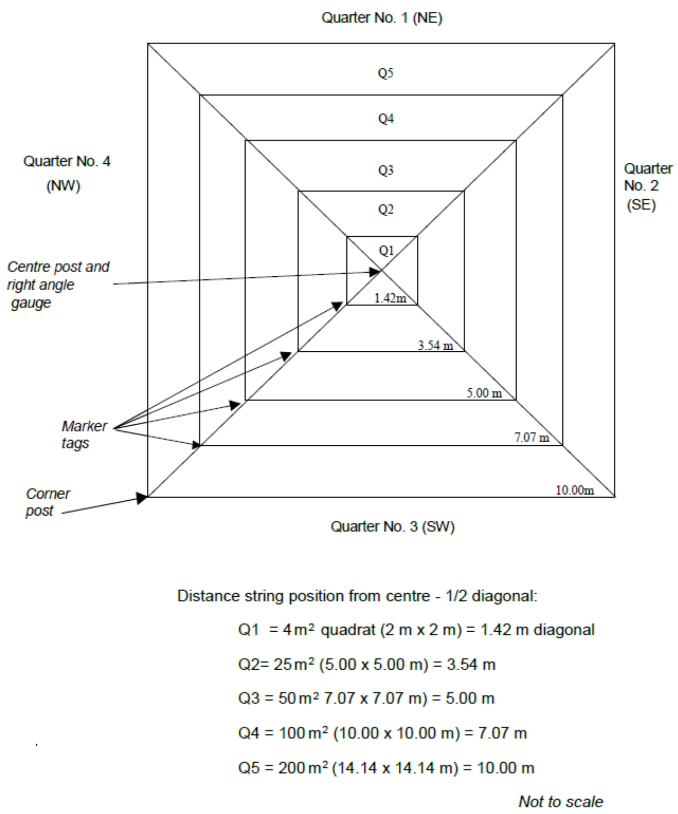
Discussion started: 6 March 2017

Figure 4. Layout of vegetation X plot.



Earth Syst. Sci. Data Discuss., doi:10.5194/essd-2017-17, 2017
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Figure 5. Example of a plot sketch map

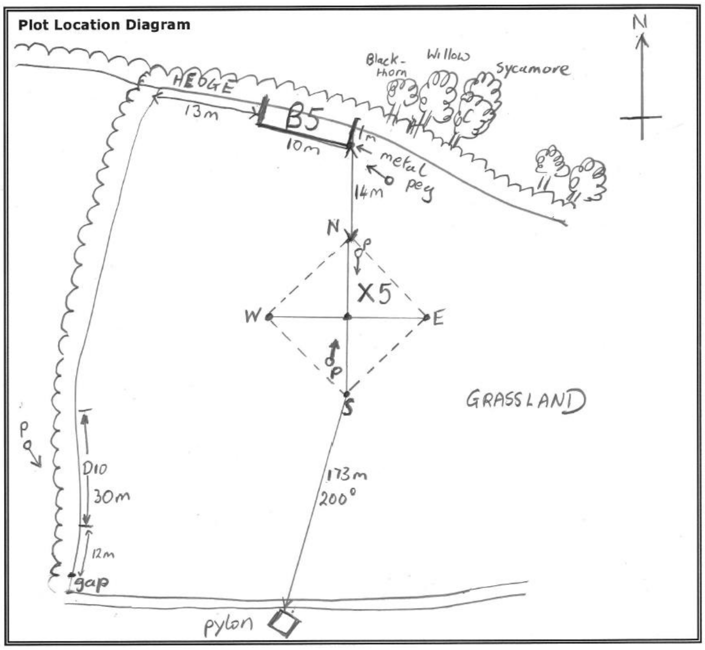

Figure 6. Example of a plot photograph