Earth Syst. Sci. Data Discuss., 8, 827–857, 2015
www.earth-syst-sci-data-discuss.net/8/827/2015/
doi:10.5194/essdd-8-827-2015

Open Access Earth System Science Data Discussions

Survey of the terrestrial habitats and vegetation of Shetland, 1974 – a framework for long term ecological monitoring

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Received: 12 October 2015 – Accepted: 18 October 2015 – Published: 23 October 2015

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Published by Copernicus Publications.

Abstract

A survey of the natural environment was undertaken in Shetland in 1974, after concern was expressed that large scale development from the new oil industry could threaten the natural features of the islands. A framework was constructed by the Institute of Terrestrial Ecology on which to select samples for the survey. The vegetation and habitat data that were collected, along with the sampling framework, have recently been made public via the following DOIs: doi:10.5285/06fc0b8c-cc4a-4ea8-b4be-f8bd7ee25342 (Terrestrial habitat, vegetation and soil data from Shetland, 1974) and doi:10.5285/f1b3179e-b446-473d-a5fb-4166668da146 (Land Classification of Shetland 1974). In addition to providing valuable information about the state of the natural environment of Shetland, the repeatable and statistically robust methods developed in the survey were used to underpin the Countryside Survey, Great Britain's national long-term integrated environmental monitoring programme. The demonstration of the effectiveness of the methodology indicates that a repeat of the survey would yield statistics about ecological changes in the islands, such as those arising from the impacts of the oil industry. Currently no such figures are available although there is much information on the sociological impacts, as well as changes in agriculture.

1 Introduction

In the 1960s, the discovery of North Sea oil off the coast of Shetland, Scotland, meant that the islands had to face the prospect of large scale development to accommodate the infrastructure surrounding the industry. In the early 1970s, concern was expressed by the County Council that such development would threaten the natural features of Shetland, such as landscape and wildlife. Accordingly, in 1974, a survey was commissioned by the Nature Conservancy Council (now Scottish Natural Heritage in Scotland), and organised by the Institute of Terrestrial Ecology (ITE) (now part of the Centre for Ecology and Hydrology) to assess the natural environment of the islands. Although

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the terrestrial habitats and vegetation survey are the focus of this paper, assessments of freshwater and littoral habitats, sea-bird populations, geology and geomorphology were also undertaken around the same time as part of a larger integrated survey (Milner, 1975).

The specific objectives of the terrestrial component were:

1. to assess the range of variation within the vegetation of Shetland and to provide a user guide to defined types.

2. to provide a structural basis for monitoring future change in the vegetation (Bunce, 1975).

The Shetland Survey was also a stage in the development by ITE of the methodology of strategic ecological survey, as described by Sheail and Bunce (2003).

The vegetation survey was undertaken using standardized methods outlined by Bunce and Shaw, based on a 1 km square sampling unit (Bunce and Shaw, 1973; Bunce, 1974). Sampling locations were randomly selected from an environmental stratification of Shetland, giving a total of 80 1 km^2 sampling units (resulting in 911 vegetation plots for analysis, as some were inaccessible) from a total of 16 environmental strata (5 per stratum). Records of plant species, soils, habitat types and major biota present were collected.

Prior to the survey, a two-day training course was held, to familiarise the surveyors with the detailed field protocols. Additionally, all survey teams were initially accompanied by a supervisor and regular visits into the field were made by the project leader to ensure consistency and quality in data recording according to criteria laid out in the field handbook (Bunce, 1974).

At the time, the statistical sampling methods used were generally not widely used as a method for ecological monitoring and this was one reason why the results were not reported publicly at the time. The other factor was that the senior author also had other commitments. Therefore this is the first time that the data and results have been made widely available. There have been many changes in the islands since the survey, and

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the data provide a unique opportunity to determine the changes that have taken place in the vegetation, should a repeat survey be undertaken.

In addition to the survey yielding an interesting set of data in itself, the methodological framework for the survey eventually developed in to the largest long-term ecological monitoring project in Britain, the Countryside Survey (CS) (Carey et al., 2008). CS started in 1978 and was most recently undertaken in 2007.

2 Shetland

The islands of Shetland cover an area of about 550 square miles and consist of over a hundred islands and islets of which about 15 are inhabited. The southernmost tip of the largest island, lies over a 100 miles north west of John o'Groats. Lying at the northern limit of the Britain, the isles have considerable biogeographic interest.

The islands are geologically diverse, with the main rock types being metamorphic, including Caledonian schists, gneisses and quartzites. There are also areas of Old Red Sandstone.

The inland topography is gentle with wide shallow valleys. Around the coast, there are sheer cliffs, and numerous sheltered inlets or "voes". There are few trees on the islands, and extensive areas are covered in peat, especially on the Mainland and the northern island of Yell. The soils on Shetland are generally poor, with the most fertile land being on the sandstone in the south where the main crofting districts are located.

The climate is mild, moist and windy. There is little variation in temperature through the year, with the average monthly temperature ranging from 3 °C (February) to 12 °C (July) (Met Office, 2015). The exposed situation of the islands means they are subject to high winds with about 40 days of gales per year. The rainfall is not extreme (about 1124 mm per annum) (Met Office, 2015), but is distributed throughout the year, so that damp and drizzly days are common.

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3 The survey in a local context

At the time of the survey, a review of the available ecological knowledge regarding Shetland was made by Goode (1974). Attention was drawn to the major gaps that were present; few of which have since been filled. Insufficient information and detail was available on the islands in McVean and Ratcliffe (1962). Birse (1974) provided a general account of Sullom Voe and Barkham (1971) and Allot (1971) described aspects of Foula. The specialised habitats of the fell fields and the Serpentine are also summarised by Spence (1974). Most of the published work has concentrated on two specialised habitats – the Fell fields of Ronas Hill and the Serpentine habitats of Unst (Spence, 1974). The small areas of relict scrub, mainly on ungrazed islands in the lochs, are also described by the same author.

The only major paper on the overall vegetation is by Roper-Lindsay and Say (1986) who used phytosociological methods to describe 17 associations in relation to British, Continental and Scandinavian communities. They found difficulties in determining discrete associations because of factors such as intensive land use and the maritime influence. Hence, the present study is the first to provide a complete overview of the vegetation of the Islands.

By contrast, the flora of Shetland is relatively well known, for example Scott and Palmer (1987) for vascular plants and Dalby and Dalby (2005) for lichens, and as summarised in the BSBI Atlas of the British and Irish Flora (Preston et al., 2002) which is due to be updated in 2020, and the original bryophyte atlas published in 1991–1994 (Hill et al., 1991), but recently repeated (Blockeel et al., 2014). Also Hill and Paton (1976) have reported on the saxicolous bryophytes. The phyto-geographic relationships of the Shetland flora have been widely discussed as summarised by Goode (1974). Although some species differ in their ecology because of the northern location, the species complement is closely related to that of Northern Scotland. Recent overviews of the ecology of the islands are given by Berry and Johnston (1980) and Johnston (1999).

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Superficially, the vegetation is similar to Northern Scotland except for the extensive maritime influence and the distinctive vegetation on the Serpentine, which is similar to that of comparable outcrops elsewhere, for example on Rhum in Western Scotland. Although at a lower altitude than in Northern Scotland, the sub-arctic vegetation on Ronas Hill is otherwise similar to high altitudes on other Scottish mountains.

Data from the Countryside Survey (Brown et al., 2014) were used to obtain general comparisons with the environment and land cover of Shetland with the rest of Britain. In terms of a general comparison of the environmental characteristics of Shetland with the Outer Hebrides and Orkney using the Environmental Classes of the ITE Land Classification (Bunce et al., 2007), the former is shown to indeed be an outlier and is dominated by the most pronounced overall land class – 32. Class 32 can be summarised as having variable topography, mainly at medium/low altitudes, peaty soils, peatland and moorland vegetation types and a landscape of scattered lochs and eroding peat hags (Benefield and Bunce, 1982). All the other classes in the islands, except one, a marginal upland class, are also upland, showing that Shetland is upland in its affinities even although it has no land at high elevations. The overall land cover, described by the CS survey data, is dominated by bogs and acid grassland habitats and provides an independent comparison with the results from the vegetation survey described below.

4 Survey design: site selection and stratification

The method used to undertake the survey initially requires that an environmental classification of the whole area in question (in this case, Shetland) is constructed using multivariate analysis of environmental characteristics to produce a set of strata. These strata can then be used for selecting sample sites, in order to sample ecological parameters such as vegetation. 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 the end of the 1970s, this idea of stratifying the landscape led to the successful creation of a stratification for the whole of Great Britain, known as the "Institute

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of Terrestrial Ecology (ITE) Land Classification of Great Britain" (Bunce et al., 1990, 1996a, b). Although this has developed over time (Bunce et al., 1998, 2007), the basic stratification still underpins the CS (Carey et al., 2008).

4.1 Land stratification – "ITE Land Classification of Shetland

This "ITE Land Classification of Shetland" (Bunce and Bassett, 2015) separated the 2046 km squares of the grid of the national mapping agency, the Ordnance Survey, into 16 relatively homogeneous units (known as strata, or land classes) with similar environmental characteristics and geographical features, ascertained from a map study. Most of the criteria were derived from 1 inch to a mile (1 : 63 360) Ordnance Survey maps, with the eighteen geological attributes being recorded from the quarter-inch Geological map (British Geological Survey, 1963), which was the only one to give complete cover. It was decided to use the 1 km grid squares as the sampling unit, as these have the advantage of being fixed and readily referable between maps of different scales.

The range of geographical factors on a map can be broadly divided into physical attributes (such as hills, valleys, coastlines) and features of human geography (for example roads and houses) and it was decided from the outset to consider only the physical geography of Shetland, in order to provide a classification which would be readily interpretable in terms of landform.

The geographical features fall into two types.

1. Continuous e.g. altitude and slope, which can be represented as an integer or decimal number.
2. Attribute data, in which the feature is either present or absent e.g. a cliff or hill-top.

The full list of 150 attributes is given in supporting documentation supplied with the dataset (Bunce, 1975).

There are 2046 1 km squares in Shetland containing some land, which were each allocated to one of the 16 strata using Indicator Species Analysis (now TWINSPAN)

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described in Hill (1973) and Hill et al. (1975) as shown in Figs. 1 and 2. The environmental classes were produced using an arbitrary stopping rule. The first division of the environmental classification was on the basis of inland versus coastal features (Fig. 2). The eight coastal types are distinguished by the different proportions of sea and inlets such as voes. The eight inland classes are based on exposure and drainage patterns. Overall, it was found that the square's relationship with the sea dominated the classification. A summary description of the classes is given in Table 1.

4.2 Sampling sites and plots

The sample survey sites were based on 1 km square units randomly selected from across Shetland, as shown in Fig. 1. Five 1 km squares were randomly chosen from each of the 16 strata (or land classes) for survey, giving a total of 80 1 km squares to be surveyed.

Within each selected 1 km^2 survey site, individual plots were chosen for survey. Each square selected was split into 16 sub-squares using an overlay grid, and a 200 m^2 plot was then randomly selected from within each sub-square using a random number table. If the random allocation of a point in a sub-square landed in water, that sub-square was omitted from the survey, therefore between 1 and 16 plots were surveyed for each of the 1 km^2. In total, 927 plots were selected, although only 911 plots were actually surveyed as occasionally it was not possible to record the plot due to inaccessibility of a particular piece of land, for example due to a dangerous cliff or cultivated land. The location of each plot was marked on a 1 inch to a mile (1 : 63 360) map.

Each plot was 14.1 × 14.1 m (200 m^2) (Fig. 3) and constructed as shown in Fig. 4, with one centre post and 4 corner posts, with a set of 4 strings tagged with markers at specified distances. The centre post had a right angled gauge affixed to the top, in order to orientate the plot at random.

In the field, plots were located using the prepared map, and then by pacing from the nearest relocatable feature. It was stressed in the field handbook that there should be no subjective bias in locating the plots on the ground, and the plots in the field should

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be located as accurately as possible from the map. Data were then collected on ground flora, soils and habitat characteristics for the plot. A habitat sheet for the area within 50 m of the plot was also compiled.

5 Data collected

An overview of all the data collected form the survey is given in Table 2. These categories are described in more detail in the following sub sections.

5.1 Site information, plot locations and information, slope and aspect

For each plot surveyed, from both within the 200 m^2 plot, and also from the surrounding area to within 50 m of the edge of the plot, the presence and absence of a series of attributes were recorded. Attributes included physiological factors such as the presence of rock or cliffs, habitat related factors such as the presence of heather, bryophytes and trees, aquatic habitats such as ponds, presence of buildings, quarries or rubbish, presence of animals and birds, also boundary types and nearby land-use. All classes within each of the pre-defined habitat categories which were relevant to the survey area were marked off on the appropriate data sheet. Precise definitions for each habitat category and its classes were provided, and a full list of habitats may be found in the 1974 field handbook (Bunce, 1974) (supplied as supporting documentation with the datasets). The slope of each plot was measured using a clinometer from the highest to lowest point passing through the centre of the plot. The aspect was taken bearing down the slope, measured with a magnetic compass.

5.2 Vegetation data

Within the plot described in Fig. 3, the area within the first nest of the plot (2 × 2 m) was searched for the presence of all vascular plants (monocots, dicots and ferns), bryophytes and macro-lichens, including tree species. This procedure was repeated for

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each nest of the quadrat, increasing the size each time as shown in Fig. 3. In the final nest (the whole 200 m^2 plot), the percentage cover (to the nearest 5 %) of each species was estimated. In addition, the total cover of bryophytes was estimated from the entire plot, as was an overall estimate for litter, wood, rock, bare ground and standing water.

5.3 Soil data

The soil of each plot surveyed was classified by horizon using a set of standard categories. In the centre of each plot a shallow pit was dug to enable examination of the surface layers of soil, and auger samples were taken to classify lower horizons. Precise definitions for each of the descriptive categories used and are detailed in the field handbook. A sample from the top 10 cm was taken away for pH analysis. A single composite soil sample was taken from each plot, at the centre of the vegetation quadrat, using a trowel. Samples (weighing approximately 1 kg) were taken to a depth of 15 cm and placed in a labelled plastic bag. A pH reading was taken on a representative fresh sub-sample from each soil sample, using a field pH meter.

6 Data quality

During the survey, all survey teams were initially accompanied by a supervisor and regular visits into the field were made by the project leader to ensure consistency and quality in data recording according to criteria laid out in the field handbook (Bunce, 1974).

The datasets were transferred from the original field sheets to spreadsheets in the 2000s. They were checked and corrected to produce a final validated copy. Standard validation checks included plot and site counts to ensure no duplicate numbering and hence double counting of plots, also range checks were undertaken where possible for values falling within certain ranges, such as soil pH or slope values.

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In terms of the soil data, the descriptive profile data were collected to the standards set out in the training and field handbook, but were not formally checked for quality aside from checks from supervisors during the survey.

7 Analysis to date

Aside from the initial analyses undertaken in the final report in 1975, little analysis has been undertaken using the data since, largely due to the authors' other commitments and the inaccessibility of the dataset to other workers. The analyses undertaken to date is described in the following sub sections.

7.1 Vegetation survey

The dominant species found in the survey are typical of the northern habitats of Britain. Along with several species of mosses, *Calluna vulgaris* had the highest frequency, and also *Potentilla erecta, Carex panicea*, *Nardus stricta* and *Juncus squarrosus* (Table 3). (Nomenclature follows that of Clapham et al. (1952), as used at the time of the survey).

In the original survey report (Bunce, 1975), Indicator Species Analysis (ISA) (Hill et al., 1975) (now TWINSPAN) (Hill and Šmilauer, 2005) was used to classify the species lists into 32 classes. The first division was on the basis of heathland species such as *Empetrum nigrum* as opposed to grassland species such as *Holcus lanatus*. Subsequent divisions separated classes such as the Serpentine grasslands and different types of blanket bogs.

Species groups were constructed from the vegetation data and were designed to help explain details of the structure of the vegetation in Shetland. The groups differed widely from those in Britain and reflect the unique nature of the vegetation of the islands. Details are given in the full report with a discussion of their characteristics (Bunce, 1975). Detailed descriptions of the vegetation classes are included including the most frequent and dominant species.

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The majority of the vegetation is associated with blanket peat, which also intergrades with acid grassland. Agricultural grasslands and Serpentine grassland diverge as separate groups. Surprisingly, only two groups are directly controlled by management – peat cutting and burning, the reminder are controlled by environmental factors.

In the 1975 report (Bunce, 1975), the principal axes of variation in the vegetation were correlated with those of the environment using orthogonal regression. The primary axes were correlated with an r value of 0.877, showing that the main gradients are highly correlated. The first axis of the environment is from acid blanket bogs to fertile grasslands which compares with a gradient of wet peat soils of low pH as compared with mineral moist soils of relatively high pH. The factors that limit peat formation are the relatively nutrient rich bed rocks, the maritime influence and good drainage. All the fertile soils have been used for agriculture which has increased inputs such as fertiliser and manure adding to the fertility and further divergence from the peatlands. Further detailed discussion is available in the report (Bunce, 1975) but the conclusion is that with such high correlation, there would have to be major changes in nutrient inputs to deflect the status of a given patch of vegetation in the short term. However, if agricultural inputs had declined to a major degree in the 40 years since the survey, it would be expected that there would be a shift towards more acidic soil conditions.

7.2 Resource assessment

As the relationship between the vegetation plots and the environmental land classes is known, the coverage of the plot types throughout the islands may be calculated. The 32 plot types described above were grouped into convenient classes and key species identified as follows, presented with an overall estimate of the percentage of the islands covered:

Calluna/Eriophorum 37.1 %, *Calluna/Nardus* 23.3 %, *Nardus* 12.7 %, *Juncus effusus* 11.2 %, *Calluna/Rhacomitrium* 3.0 %, *Festuca rubra* 4.4 %, *Agrostis/Holcus* 8.3 %.

This analysis was the first of its type where cover was calculated from a statistical sample and shows the dominance of bog and heathland vegetation in the islands. By

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performing analysis in this way, maps may be produced to show the distribution of different vegetation types, an example of which is shown in Fig. 5, showing the estimated distribution of the *Calluna/Eriophorum* group. The basics of this type of analysis later came to form the basis of calculations of the national estimates of Broad Habitats (Jackson, 2000) in Britain, as calculated from Countryside Survey data (Scott, 2008; Barr et al., 2014a, 2014b; Bunce et al., 2012; Brown et al., 2014).

8 Methodology as a framework for long-term monitoring

The survey methods were based on those first successfully developed for surveying woodlands across Great Britain (Wood et al., 2015; Bunce and Shaw, 1973). Whereas that survey had focused on woodland sites, the Shetland survey was the first time that samples were being used to obtain an integrated assessment of the response of vegetation to the environment across a defined population across a whole landscape and range of habitats. It was the first project to complete all the stages of land classification, survey, statistical analysis of vegetation and environment through to the estimation of the extent and distribution of ecological resources. The structure of the project provided the basis for the further development of strategic survey methods. The methods developed throughout the 1970s and continued to be tested on a regional basis, as in the Cumbria Survey (Bunce and Smith, 1978).

Although the Shetland survey took place over 40 years ago, the basic methodology has come to underpin much larger and more significant surveys across the whole of Great Britain. The 1 km square unit sampled at random, with random plots sampled within, became a standard sampling strategy, variations of which are currently used very successfully in several large ecological surveys in Britain, such as the Countryside Survey (Carey et al., 2008), and the Glastir Monitoring and Evaluation Programme (Emmett and GMEP team, 2014). In these surveys, the methods are now implemented very successfully using hand held computers to assist recording the field data and global positioning systems (GPS) to record the location of the vegetation plots. The development

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of Geographical Information Systems (GIS) has greatly facilitated the types of analyses able to be undertaken using this kind of data, and has enhanced the ability to analyse and capture ancillary explanatory datasets, as described in the Integrated Assessment Report for the Countryside Survey (Smart et al., 2010). Outwith the UK, within the European Biodiversity Observation Network (EBONE), methods adapted from the basic principles of the Bunce and Shaw methods have been developed to roll out across the whole of Europe (Bunce et al., 2011, 2008). During the EBONE project, the methods were widely tested across 12 European countries, and also Israel, Australia and South Africa. The methods were proven to be robust, reliable and repeatable at a continental, landscape scale (Roche and Geijzendorffer, 2013).

A key aim of the sampling design was that the methods chosen should be standardized, therefore highly repeatable. The size of the plot was chosen with reference to continental phytosociologists who at the time most widely used plots of between 100 and 200 m^2 (Bunce and Shaw, 1973). After preliminary field tests, it was found that the number of species recorded usually stabilised at this size. The area of 200 m^2 was thus adopted for this survey, with 5 nests within. This design of plot aids a systematic search of the vegetation within; it is also straightforward to layout in the field, and ensures a standard sized plot is laid out every time.

The repeatability of the methods have been proven in large surveys such as the GB Woodlands Survey of 1971, repeated in 2001 (Wood et al., 2015) and the Countryside Survey (CS) of 1978, repeated in 1990, 2000 and 2007 (Carey et al., 2008; Norton, 2012; Sheail and Bunce, 2003). The plots from both of those surveys were sufficiently accurately marked on 1 : 10 000 maps in order to relocate the plot again accurately. Changes in vegetation have been monitored in Britain at about ten year intervals since 1978 via the CS, demonstrating the robustness of the procedure. The major difference between the Shetland Survey and the CS being that 16 (200 m^2) plots were surveyed in each kilometre square on Shetland, whereas only 5 (of that size) were used in the CS, partly because of the experience gained in Shetland, and partly due to the time considerations in surveying the whole country. In the CS, although there are fewer plots

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($5 \times 200\,m^2$ plots), a habitat mapping component has been introduced, whereby areas of Broad and Priority Habitats (Jackson, 2000) are mapped across each 1 km square, giving the ability to estimate the overall stock of these habitats across the country. Additional smaller plots are also recorded (Maskell et al., 2008). In Shetland, as in the individual woodlands of the Great Britain Woodland Survey (Kirby et al., 2005; Wood et al., 2015), the data from the 16 plots are relied upon to describe the overall population.

There are many successful environmental monitoring programmes in Britain (for example the Environmental Change Network (UK Environmental Change Network, 2015), the National Soil Inventory (Cranfield University, 2015), the UK Forest Inventory (Forestry Commission, 2013)), Europe (for example Long Term Ecological Research (LTER) programmes (Parr et al., 2003)) and worldwide (for example Global Earth Observation System of Systems (Lautenbacher, 2006)). All of these have their own merits, however, many programmes have a narrow focus, and most have different measurement protocols and sampling designs (Parr et al., 2002). Issues remain such as the ability to aggregate data across scales, the consistent monitoring of global biodiversity change, and linking in situ and earth observations (Metzger et al., 2013a). The underlying principles of the Shetland/CS methodology provide an ideal framework for the planning of large scale monitoring, not only in Britain, but across Europe and worldwide. Metzger et al. (2013a) describe how the idea of environmental stratification as a basis for environmental survey would be ideal to start addressing some of these issues. Indeed stratifications of Europe and the world have already been produced (Metzger et al., 2005, 2013b).

9 Conclusions

Considering the increased popularity in tourism and the high profile of Shetland in national news since the oil industry arrived, it is surprising that there has been little interest in the overall vegetation for the last 30 years, considering the expansion of ecological research. In addition to being a key milestone in the development of methodology for

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larger scale monitoring programmes such as the British Countryside Survey (Carey et al., 2008) and the Welsh Glastir Monitoring and Evaluation Programme (Emmett and GMEP team, 2014), the 1974 Shetland Survey data provide a unique baseline from which changes in the vegetation could be determined from repeated locations. A repeat survey or monitoring programme based on the framework described in the present paper would not only yield important scientific results but when interpreted using the modern procedures developed in Countryside Survey, these could be converted into policy relevant conclusions and would add considerable value to the existing datasets. The methodology has been shown to be robust and has been used in the CS to follow changes over 30 years. CS has had considerable impact in shaping government policy in biodiversity, particularly in the realm of hedgerow legislation (Barr and Gillespie, 2000; Petit et al., 2003; Anonymous, 1997). None of this would have been achieved had the methodology not been grounded on a sound statistical base.

Within the CS project, changes taking place in the character of the vegetation can be detected, as well as their underlying causal factors. In Shetland, there are a range of factors which could have had an impact on the vegetation in the last 40 years. These include variations in sheep numbers, the state of crofting, sulphur deposition from local shipping and oil deposition, particularly that spilled from the Braer oil tanker which ran aground off Shetland in 1993.

A key benefit of the repeatable methodology described is that it gives an unbiased assessment of change, as shown in the case of the CS and Woodland Survey. A repeat survey of Shetland would provide objective information about the extent of the changes in vegetation since 1974. Results from the repeat surveys and analysis of vegetation changes from the Countryside Survey (Carey et al., 2008) and the British Woodland Survey (Wood et al., 2015; Kirby et al., 2005) have both shown unexpected results that would not have been revealed, had these objective methods not been used.

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Data availability

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

Bunce, R. G. H.,Bassett, P. A., Wood, C. M.: Terrestrial habitat, vegetation and soil data from Shetland, 1974, NERC Environmental Information Data Centre, doi:10.5285/06fc0b8c-cc4a-4ea8-b4be-f8bd7ee25342, 2015.

Bunce, R. G. H., Bassett, P. A.: Land Classification of Shetland 1974, NERC Environmental Information Data Centre, doi:10.5285/f1b3179e-b446-473d-a5fb-4166668da146, 2015.

Both of the datasets are available from the CEH Environmental Information Data Centre Gateway (https://gateway.ceh.ac.uk) and via the following links: https://catalogue.ceh.ac.uk/documents/f1b3179e-b446-473d-a5fb-4166668da146, https://catalogue.ceh.ac.uk/documents/06fc0b8c-cc4a-4ea8-b4be-f8bd7ee25342.

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: Shetland Vegetation Survey Handbook of Field Methods (Bunce, 1974), Report to NCC on some aspects of the ecology of Shetland. Part III: The Terrestrial Survey of Shetland (Bunce, 1975).

Author contributions. C. M. Wood prepared the manuscript with significant contributions from R. G. H. Bunce, and is the current database manager for the Land Use Research Group at CEH Lancaster. R. G. H. Bunce designed the experiment (along with M. W. Shaw) and ran the survey in 1974.

Acknowledgements. We thank the land owners and agents who gave permission to conduct surveys on their land. Without their cooperation this project would not have been possible. We

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also thank the field surveyors: R. G. H. Bunce, P. Bassett, S. K. Morrell, J. Heap, J. B. Hambrey, J. Caird, J. Mackintosh, P. Bibby, M. Ferguson, M. Sturges, D. Thomas, J. Thomas, J. Wilson, P. Swain, M. Horner. Thanks also go to C. Hallam for entering data.

References

Allot, G.: A report on the lowland vegetation of Foula, Brathay Exploration Group Field Studies Report, 11, 48–57, 1971.

Anonymous: The Hedgerows Regulations, The Stationery Office, London, pp. 16, 1997.

Barkham, J. P.: A report on the upland vegetation of Foula, Brathay Exploration Group Field Studies Report, 25–47, 1971.

Barr, C. J. and Gillespie, M. K.: Estimating hedgerow length and pattern characteristics in Great Britain using Countryside Survey data, J. Environ. Manag., 60, 23–32, doi:10.1006/jema.2000.0359, 2000.

Barr, C. J., Bunce, R. G. H., Clarke, R. T., Gillespie, M. K., Hallam, C. J., Howard, D. C., Maskell, L. C., Ness, M. J., Norton, L. R., Scott, R. J., Scott, W. A., Smart, S. M., Stuart, R. C., Wood, C. M., and Wright, S. M.: Countryside Survey 1990 estimates of Broad Habitat areas in Great Britain, NERC Environmental Information Data Centre, doi:10.5285/32dda22c-24cc-4fa8-adcb-5481b1b77ef1, 2014a.

Barr, C. J., Bunce, R. G. H., Clarke, R. T., Gillespie, M. K., Howard, D. C., Maskell, L. C., Norton, L. R., Scott, R. J., Scott, W. A., Smart, S. M., Stuart, R. C., Watkins, J. W., Wood, C. M., and Wright, S. M.: Countryside Survey 1998 estimates of Broad Habitat areas in Great Britain, NERC Environmental Information Data Centre, doi:10.5285/ad7babc3-6b43-4754-8981-edcf03769f11, 2014b.

Benefield, C. B. and Bunce, R. G. H.: A preliminary visual presentation of land classes in Britain, Institute of Terrestrial Ecology, Grange over Sands, 39 p., 1982.

Berry, R. J. and Johnston, J. L.: The natural history of Shetland, Collins, London, 1980.

Birse, E. L.: Bioclimatic characteristics of Shetland., in: The Natural Environment of Shetland, edited by: Goodier, R., NCC, Edinburgh, 24–32, 1974.

Blockeel, T. L., Bosanquet, S. D., Hill, M., and Preston, C. D.: Atlas of British & Irish Bryophytes, Pisces Publications, Newbury, 2014.

British Geological Survey: Quarter-inch geological map of Scotland HMSO, 1963.

ESSDD

8, 827–857, 2015

Survey of the terrestrial habitats and vegetation of Shetland, 1974

C. M. Wood and R. G. H. Bunce

Brown, M. J., Bunce, R. G. H., Carey, P. D., Chandler, K., Crowe, A., Maskell, L. C., Norton, L. R., Scott, R. J., Scott, W. A., Smart, S. M., Stuart, R. C., Wood, C. M., and Wright, S. M.: Countryside Survey 2007 estimates of Broad Habitat areas in Great Britain, NERC Environmental Information Data Centre, doi:10.5285/f03cba75-8bca-4679-ae2a-77a9fcbd4df3, 2014.

Bunce, R. G. H.: Shetland Vegetation Survey Handbook of Field Methods, Institute of Terrestrial Ecology, Grange over Sands, 28 p., 1974.

Bunce, R. G. H.: Report to NCC on some aspects of the ecology of Shetland. Part III: The Terrestrial Survey of Shetland, Institute of Terrestrial Ecology, Grange over Sands, 1975.

Bunce, R. G. H. and Bassett, P. A.: Land Classification of Shetland 1974, NERC Environmental Information Data Centre, doi:10.5285/f1b3179e-b446-473d-a5fb-4166668da146, 2015.

Bunce, R. G. H. and Shaw, M. W.: A standardised method for ecological survey, J. Environ. Manag., 1, 239–258, 1973.

Bunce, R. G. H. and Smith, R. S.: An ecological survey of Cumbria, Structure Plan Working Paper, 4, Cumbria County Council and Lake District Special Planning Board, Kendal, 1978.

Bunce, R. G. H., Barr, C. J., Clarke, R. T., Howard, D. C., and Lane, A. M. J.: ITE land classification of Great Britain 1990, NERC Environmental Information Data Centre, doi:10.5285/ab320e08-faf5-48e1-9ec9-77a213d2907f, 1990.

Bunce, R. G. H., Barr, C. J., Clarke, R. T., Howard, D. C., and Lane, A. M. J.: ITE Merlewood Land Classification of Great Britain, J. Biogeogr., 23, 625–634, 1996a.

Bunce, R. G. H., Barr, C. J., Clarke, R. T., Howard, D. C., and Lane, A. M. J.: Land classification for strategic ecological survey, J. Environ. Manag., 47, 37–60, doi:10.1006/jema.1996.0034, 1996b.

Bunce, R. G. H., Barr, C. J., Clarke, R. T., Howard, D., and Lane, A. M. J.: ITE Land Classification of Great Britain 1998, NERC Environmental Information Data Centre, doi:10.5285/971671a6-98b4-4d80-b165-21dace7373b9, 1998.

Bunce, R. G. H., Barr, C. J., Clarke, R. T., Howard, D., and Scott, A.: ITE Land Classification of Great Britain 2007, NERC Environmental Information Data Centre, doi:10.5285/5f0605e4-aa2a-48ab-b47c-bf5510823e8f, 2007.

Bunce, R. G. H., Metzger, M. J., Jongman, R. H. G., Brandt, J., de Blust, G., Elena-Rossello, R., Groom, G. B., Halada, L., Hofer, G., Howard, D. C., Kovář, P., Mücher, C. A., Padoa-Schioppa, E., Paelinx, D., Palo, A., Perez-Soba, M., Ramos, I. L., Roche, P., Skånes, H., and

ESSDD
8, 827–857, 2015

Survey of the terrestrial habitats and vegetation of Shetland, 1974

C. M. Wood and R. G. H. Bunce

Wrbka, T.: A standardized procedure for surveillance and monitoring European habitats and provision of spatial data, Landsc. Ecol., 23, 11–25, doi:10.1007/s10980-007-9173-8, 2008.

Bunce, R. G. H., Bogers, M., and Roche, P.: Manual for habitat and vegetation surveillance and monitoring: temperate, mediterranean and desert biomes, Alterra, Wageningen, 2011.

Bunce, R. G. H., Wood, C. M., Henrys, P. A., Smart, S. M., Howard, D. C., and Barr, C. J.: Countryside Survey 1978 estimates of Broad Habitat areas in Great Britain, NERC Environmental Information Data Centre, doi:10.5285/c8feabac-7c3f-4c35-91f7-296782b957d1, 2012.

Bunce, R. G. H., Bassett, P. A., and Wood, C. M.: Terrestrial habitat, vegetation and soil data from Shetland, 1974, NERC Environmental Information Data Centre, doi:10.5285/06fc0b8c-cc4a-4ea8-b4be-f8bd7ee25342, 2015.

Carey, P. D., Wallis, S., Chamberlain, P. M., Cooper, A., Emmett, B. A., Maskell, L. C., McCann, T., Murphy, J., Norton, L. R., Reynolds, B., Scott, W. A., Simpson, I. C., Smart, S. M., and Ullyett, J. M.: Countryside Survey: UK Results from 2007, NERC/Centre for Ecology & Hydrology, Lancaster, 2008.

Clapham, A. R., Tutin, T. G., and Warburg, E. F.: Flora of the British Isles, Cambridge University Press, Cambridge, 1952.

Cranfield University: National Soils Inventory, http://www.landis.org.uk/about/index.cfm, last access: 2 September 2015.

Dalby, D. H. and Dalby, C.: Shetland Lichens, Shetland Amenity Trust, Lerwick, 2005.

Emmett, B. E. and GMEP team: Glastir Monitoring & Evaluation Programme, First Year Annual Report to Welsh Government (Contract reference: C147/2010/11), NERC/Centre for Ecology & Hydrology, Bangor, 442, 2014.

Forestry Commission: National Forest Inventory, http://www.forestry.gov.uk/website/forestry.nsf/byunique/infd-89s9ls, last access: 15 January 2013.

Goode, D.: The flora and vegetation of Shetland, in: The Natural Environment of Shetland, edited by: Goodier, R., NCC, Edinburgh, 50–72, 1974.

Hill, M. O.: Reciprocal averaging: an eigenvector method of ordination, J. Ecol., 61, 237–249, doi:10.2307/2258931, 1973.

Hill, M. and Paton, J.: The Bryophytes of Shetland, Nature Conservancy Council/Institute of Terrestrial Ecology, Bangor, 1976.

Hill, M. O. and Šmilauer, P.: TWINSPAN for Windows version 2.3, Centre for Ecology and Hydrology, University of South Bohemia, Wallingford, 2005.

ESSDD

8, 827–857, 2015

Hill, M. O., Bunce, R. G. H., and Shaw, M. W.: Indicator species analysis, a divisive polythetic method of classification, and its application to a survey of native pinewoods in Scotland, J. Ecol., 63, 597–613, doi:10.2307/2258738, 1975.

Hill, M. O., Preston, C. D., and Smith, A. J. E.: Atlas of the bryophytes of Britain and Ireland, Harley books, Colchester, 1991.

International Organization for Standardization: ISO 19115:2003, http://www.iso.org/iso/catalogue_detail.htm?csnumber=26020, last access: 12 October 2015.

Jackson, D.: Guidance on the Interpretation of the Biodiversity Broad Habitat Classification (Terrestrial and Freshwater Types): Definitions and the Relationship with Other Habitat Classifications (JNCC Report, No 307), JNCC, 73 p., 2000.

Johnston, J. L.: A naturalist's Shetland, T. and A. D. Poyser, London, 1999.

Kirby, K. J., Smart, S. M., Black, H. I. J., Bunce, R. G. H., Corney, P. M., and Smithers, R. J.: Long term ecological change in British woodland (1971–2001). A re-survey and analysis of change based on the 103 sites in the Nature Conservancy "Bunce 1971" woodland survey, Final report, Peterborough: English Nature, English Nature Research Reports Number 653, 139 + appendices, 2005.

Lautenbacher, C. C.: The Global Earth Observation System of Systems: Science Serving Society, Space Policy, 22, 8–11, doi:10.1016/j.spacepol.2005.12.004, 2006.

Maskell, L. C., Norton, L. R., Smart, S. M., Scott, R., Carey, P. D., Murphy, J., Chamberlain, P. M., Wood, C. M., Bunce, R. G. H., and Barr, C. J.: Vegetation Plots Handbook CS Technical Report No.2/07, Centre for Ecology and Hydrology, Lancaster, 2008.

McVean, D. N. and Ratcliffe, D. A.: Plant communities of the Scottish Highlands. A study of Scottish mountain, moorland and forest vegetation, Monographs of the Nature Conservancy, HMSO, London, 445 p., 1962.

Met Office: UK climate – Historic station data (Lerwick): http://www.metoffice.gov.uk/pub/data/weather/uk/climate/stationdata/lerwickdata.txt, last access: 1 September 2015.

Metzger, M. J., Bunce, R. G. H., Jongman, R. H. G., Mücher, C. A., and Watkins, J. W.: A climatic stratification of the environment of Europe, Global Ecology and Biogeography, 14, 549–563, doi:10.1111/j.1466-822X.2005.00190.x, 2005.

Metzger, M. J., Brus, D. J., Bunce, R. G. H., Carey, P. D., Gonçalves, J., Honrado, J. P., Jongman, R. H. G., Trabucco, A., and Zomer, R.: Environmental stratifications as the basis for national, European and global ecological monitoring, Ecological Indicators, 33, 26–35, doi:10.1016/j.ecolind.2012.11.009, 2013a.

ESSDD
8, 827–857, 2015

Metzger, M. J., Bunce, R. G. H., Jongman, R. H. G., Sayre, R., Trabucco, A., and Zomer, R.: A high-resolution bioclimate map of the world: a unifying framework for global biodiversity research and monitoring, Global Ecol. Biogeogr., 22, 630–638, doi:10.1111/geb.12022, 2013b.

Milner, C.: Shetland project monitoring report Nature Conservancy Council, Contract Report to the Nature Conservancy Council, 1975.

Norton, L. R., Maskell, L. C., Smart, S. S., Dunbar, M. J., Emmett, B. A., Carey, P. D., Williams, P., Crowe, A., Chandler, K., Scott, W. A., and Wood, C. M.: Measuring stock and change in the GB countryside for policy: key findings and developments from the Countryside Survey 2007 field survey, J. Environ. Manag., 113, 117–127, doi:10.1016/j.jenvman.2012.07.030, 2012.

Parr, T., Ferretti, M., Simpson, I., Forsius, M., and Kovacs-Lang, E.: Towards a long-term integrated monitoring programme in Europe: network design in theory and practice, Environ. Monitor. Assess., 78, 253–290, 2002.

Parr, T. W., Sier, A. R. J., Battarbee, R. W., Mackay, A., and Burgess, J.: Detecting environmental change: science and society – perspectives on long-term research and monitoring in the 21st century, Sci. Tot. Environ., 310, 1–8, doi:10.1016/S0048-9697(03)00257-2, 2003.

Petit, S., Stuart, R., Gillespie, M., and Barr, C.: Field boundaries in Great Britain: stock and change between 1984, 1990 and 1998, J. Environ. Manag., 67, 229–238, doi:10.1016/S0301-4797(02)00176-7, 2003.

Preston, C. D., Pearman, D. A., and Dines, T. D.: New atlas of the British and Irish flora. An atlas of the vascular plants of Britain, Ireland, the Isle of Man and the Channel Islands, Oxford University Press, Oxford, 2002.

Roche, P. and Geijzendorffer, I.: EBONE: integrated figures of habitat and biodiversity indicators: quantifying indicators of an integrated biodiversity observation system, Alterra Wageningen UR, 2013.

Roper-Lindsay, J. and Say, A.: Plant communities of the Shetland Islands, J. Ecol., 74, 1013–1030, doi:10.2307/2260230, 1986.

Scott, W. A.: Countryside Survey. Statistical Report (Countryside Survey Technical Report No. 4/07), NERC Centre for Ecology and Hydrology Lancaster, 2008.

Scott, W. and Palmer, R.: The flowering plants and ferns of the Shetland Islands, Lerwick: Shetland Times Ltd ix, 468 p.-col. illus., maps., ISBN: 900662565, 1987.

ESSDD
8, 827–857, 2015

Sheail, J. and Bunce, R. G. H.: The development and scientific principles of an environmental classification for strategic ecological survey in the United Kingdom, Environ. Conserv., 30, 147–159, doi:10.1017/S0376892903000134, 2003.

Smart, S., Maskell, L., Dunbar, M., Emmett, B., Marks, S., Norton, L., Rose, P., and Simpson, I.: An Integrated Assessment of Countryside Survey data to investigate Ecosystem Services in Great Britain. Countryside Survey Technical Report No. 10/07, NERC Centre for Ecology and Hydrology, Lancaster, 2010.

Spence, D. H. N.: Subarctic debris and scrub vegetation in Shetland, in: The Natural Environment of Shetland, edited by: Goodier, R., NCC, Edinburgh, 50–72, 1974.

UK Environmental Change Network: UK Environmental Change Network, http://www.ecn.ac.uk/, last access: 2 September 2015.

UK GEMINI: UK GEMINI, http://www.agi.org.uk/join-us/agi-groups/standards-committee/uk-gemini, last access: 12 May 2015.

Wood, C. M., Smart, S. M., and Bunce, R. G. H.: Woodland Survey of Great Britain 1971–2001, Earth Syst. Sci. Data, 7, 203–214, doi:10.5194/essd-7-203-2015, 2015

ESSDD

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Table 1. Description of strata.

Group	Strata	Description
1	Strata 1–4	Coastal strata with few rivers running into the sea within the square. There is more than 80 % land area, and terrain is relatively gentle.
2	Strata 5–8	Coastal group with more sea and steeper slopes. It is more likely to contain headlands and sea cliffs. There are also more likely to be more rivers entering the sea.
3	Strata 9–12	High altitude inland group with a 600–900 foot hill within the square or close by. There are few small water bodies and the major rock is likely to be gneiss.
4	Strata 13–16	Lower, more undulating group with much peat and many freshwater lochans. The hills are about 300 feet and the rock is more likely to be Old Red Sandstone.

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Table 2. Summary of data collected.

Data category	Description
Ground flora	Vascular plants, bryophytes and lichens present in the plot % cover/abundance estimates
Plot description and habitats	Tick list of features (broad categories): – Rock habitats – Aquatic habitats – Open habitats – Vegetation structure – Animal signs – Management – Land use
Soil data	Tick list description from small pit and augur boring in the centre of the plot – to determine soil type Composite soil sample from top 10–15 cm taken for pH.
Within 50 m of plot description	Tick list of features (broad categories). As for plot, plus adjacent land use and boundary type Slope, aspect.

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Table 3. List of the 25 most abundant species recorded in the survey.

	Species	Total records
1	*Hypnum cupressiforme*	741
2	*Calluna vulgaris*	740
3	*Potentilla erecta*	699
4	*Dicranum scoparium*	681
5	*Carex panicea*	648
6	*Nardus stricta*	638
7	*Rhytidiadelphus loreus*	608
8	*Cladonia impexa*	607
9	*Juncus squarrosus*	601
10	*Sphagnum rubelllum*	598
11	*Eriophorum angustifolium*	596
12	*Cladonia uncialis*	550
13	*Rhacomitrium lanuginosum*	547
14	*Scapania sp.*	542
15	*Agrostis canina*	536
16	*Luzula multiflora*	535
17	*Trichophorum caespitosum*	525
18	*Empetrum nigrum*	507
19	*Hylocomium splendens*	487
20	*Mnium hornum*	482
21	*Anthoxanthum odoratum*	447
22	*Festuca vivipara*	434
23	*Erica tetralix*	433
24	*Agrostis tenuis*	433
25	*Campylopus flexuosus*	431

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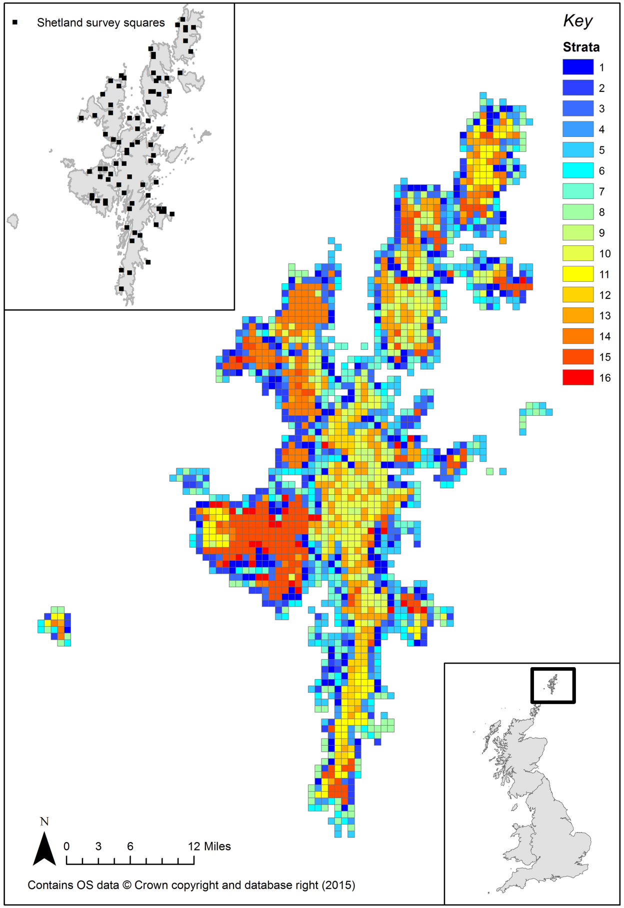

Figure 1. Map of sampling sites and strata.

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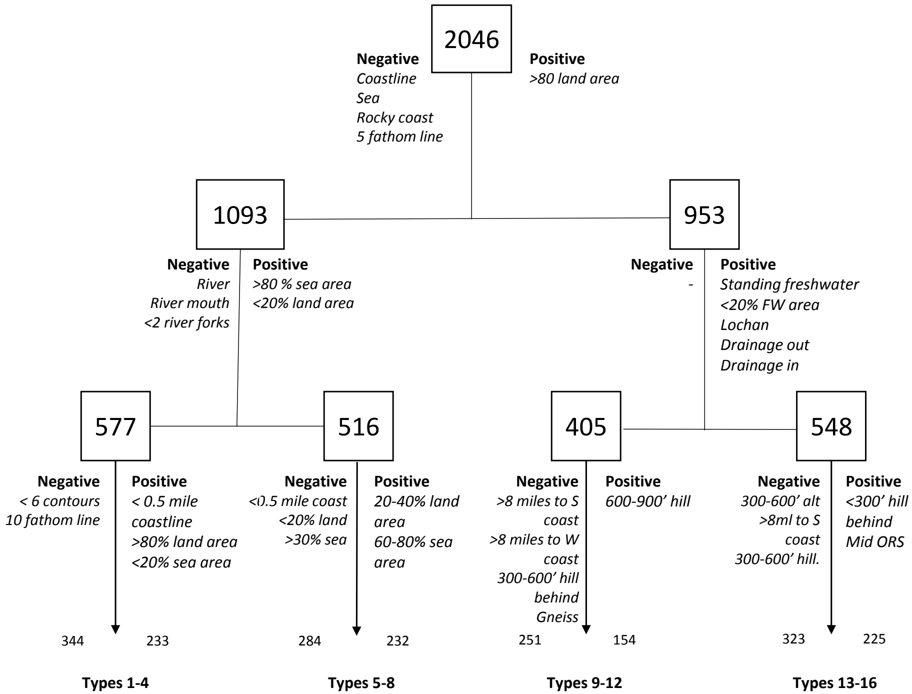

Figure 2. Hierarchy of divisions in the land classification (numbers refer to number of 1 m grid squares).

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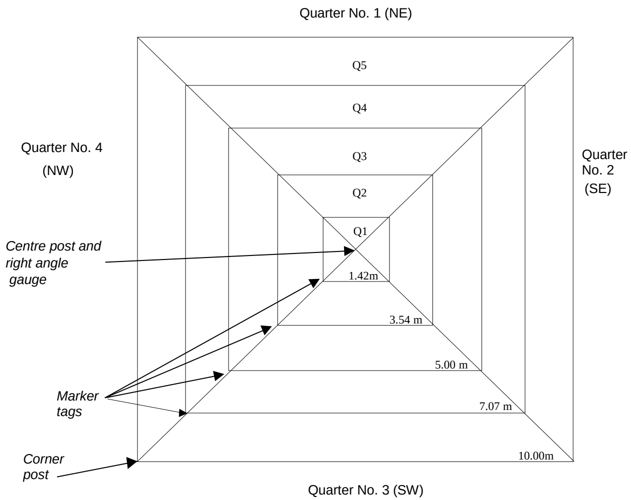

Distance string position from centre - 1/2 diagonal:

Q1 = 4 m^2 quadrat (2 m x 2 m) = 1.42 m diagonal

Q2= 25 m^2 (5.00 x 5.00 m) = 3.54 m

Q3 = 50 m^2 7.07 x 7.07 m) = 5.00 m

Q4 = 100 m^2 (10.00 x 10.00 m) = 7.07 m

Q5 = 200 m^2 (14.14 x 14.14 m) = 10.00 m

Not to scale

Figure 3. Layout of vegetation plot.

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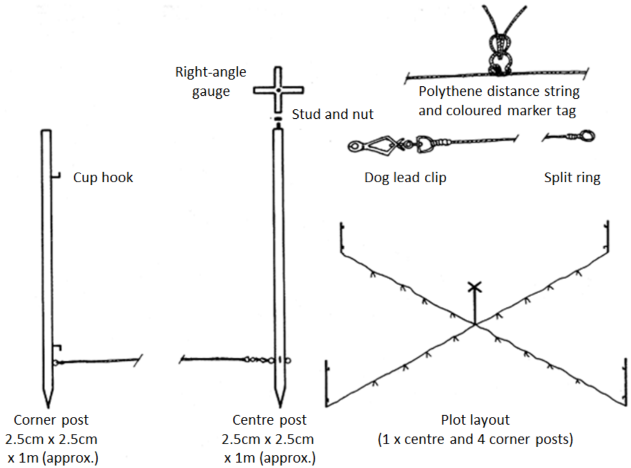

Figure 4. Plot construction.

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Figure 5. Estimated distribution of the *Calluna/Eriophorum* group.

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