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Review and Recommendations of Methodologies to be used for Botanical Monitoring of Agri-Environment Schemes in England.

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Summary

Since the introduction of the first Agri-environment (AE) schemes in England in 1987, DEFRA (formerly MAFF) has been committed to monitoring their performance in relation to the scheme objectives. Environmental monitoring programmes, most of which include a major botanical element, have been established in all English AE schemes. However, since 1987, UK policies for biodiversity and rural development have evolved, and there is now a requirement for DEFRA to report on the performance of AE schemes within a wider policy context.

The aim of this project is to make recommendations for the future botanical monitoring programme of AE schemes, scheduled to run from 2003 onwards. The project aims specifically to optimise the use of existing botanical samples and time series data, whilst also taking account of recent developments in botanical monitoring methods. This includes the emergence of Rapid Condition Assessment (RCA) as a means of allocating individual sites or features to a predetermined set of condition categories, using standardised procedures.

At the time of writing, the future strategy for AE schemes in England is under review and the exact structure of the forthcoming schemes is uncertain. Because of this, the assumption has been made here that the maintenance and enhancement of habitats that are of biodiversity value will continue to be one of the main aims of the schemes. In addition, it is assumed that management agreements similar to those currently administered under the CSS and ESAs will continue. Although the recommendations have been formulated within that scenario, the principles should still be applicable even if AE schemes are substantially modified in the future.

The project was carried out in two stages. In the first stage, a review was carried out of botanical monitoring methods in England and the other UK countries. This review covered methods currently in use in AE schemes, ways of analysing and interpreting change in the context of policy objectives, and recent developments in approaches to botanical monitoring. Also in the first stage, botanical data from the previous AE monitoring programmes were classified according to their species composition and geographical location, to assess their continued usefulness in the future programme. Statistical power analysis was then used to estimate the sample sizes required to detect specified magnitudes of change. In the second stage, recommendations for the future botanical monitoring programme were formulated.

Review of Current Methods

In England, grassland botanical monitoring programmes have been established in most Environmentally Sensitive Areas (ESAs), the Countryside Stewardship Scheme (CSS) and the Habitat Scheme (HS). Field methods used for grasslands were mostly based on fixed quadrats or plots. Heathland monitoring in ESAs and the Moorland Scheme (MS) has focussed on grazing of heather, heather abundance and burning practices, and change in species composition. Arable habitats, including field margins, have been monitored in some schemes including the Arable Stewardship Pilot Scheme (ASPS). Other more limited studies have also been done for ditches, banksides, saltmarsh and woodland.

Comparison of monitoring methods between the four UK countries showed that strategies for site selection varied widely, being dictated by the specific objectives of each monitoring programme. There was some consistency between countries in the field methods used for grasslands. On heather moorland, a range of methods has been used to measure grazing intensity, species composition and vegetation structure. Field methods used for other habitats varied according to the monitoring objectives.

Literature searches revealed relatively few examples of research specifically directed at botanical monitoring methods. However, there are clear advantages of using nested systems compared to cover or frequency estimation at single scales. Currently, there does not appear to be a single ideal method for direct measurement of grazing intensity on plants such as heather. Different methods for measuring sward height and structure will be appropriate depending on the objectives of the monitoring. A small number of novel techniques were identified in the review, some of which show promise, although further development is needed.

In England, a range of indicators and methods was used to detect and interpret change, depending on objectives of the monitoring programmes. Quantitative floristic data were reduced to community variables that indicate different attributes (e.g. suited species scores, Ellenberg values, diversity indices, functional groups), and individual species and measures of vegetation structure were used as indicators. Indices of grazing and biomass utilisation were also applied to heather moorland. Plant communities in most samples were classified by National Vegetation Classification (NVC) or the Countryside Vegetation System (CVS). In other UK countries, similar interpretation methods to these were often used.

Suited species scores and Ellenberg values can be related to scheme objectives and management, and indicate the prevailing environmental conditions. The Functional Interpretation of Botanical Surveys (FIBS) approach is potentially powerful but requires expert interpretation and data are lacking for some species. Species richness is widely used but requires careful interpretation. Community variables can potentially be compared with control data, and calibrated with the condition categories developed by the Joint Nature Conservation Committee (JNCC). Current methods for measuring heather condition require further research.

‘Control’ datasets can be used to compare vegetation condition and trends in AE schemes with those in the wider countryside. Sources of control data that have been used for comparisons with AE scheme botanical data include Countryside Survey (CS), survey datasets from English Nature (EN), the Countryside Council for Wales (CCW) and Scottish Natural Heritage (SNH), non-agreement land within ESAs, and results from other independent research.

Environmental data have been collected to assist in interpreting the results of vegetation monitoring. These include data on soil properties, management, climate and topography. Quantitative analyses were not always possible and these environmental data were often used as background information. Climate change and atmospheric deposition of pollutants are also potentially important drivers of vegetation change that are outwith the influence of AE schemes.

Rapid methods of condition assessment are currently being developed, mainly by the statutory conservation agencies. These are working towards common standards of assessment, within the existing JNCC framework. Several studies in various stages of development were identified in this review, covering a wide range of habitats. A common model has been adopted, using both generic attributes and site-specific targets. In this review these methods have been evaluated and their applicability to AE schemes has been explored.

Data Classification and Power Analysis

Plot data from CSS had been classified according to the NVC and CVS using standard software, as part of the monitoring programme. The main grassland and upland datasets from ESAs were re-classified using the same method to ensure standardisation across schemes. Samples from CSS and ESAs were then allocated as far as possible to BAP Broad Habitats and Priority Habitats by cross-referencing to NVC communities.

The AE data were classified into 93 NVC communities, of which 76% were mesotrophic grasslands. Of the mesotrophic grasslands, 42% were agriculturally improved or semi-improved communities. Similarly, 86% of the whole sample was classified as Fertile Grassland or Infertile Grassland in the CVS. In the CSS dataset 66% of the plots were classified into fourteen BAP Broad Habitats, with 34% unclassifiable. ESA quadrats and plots classified into six and nine Broad Habitats respectively, with 18% and 30% respectively being unclassified. In total, seven Priority Habitats were identified within the samples, being 22%, 15% and 30% of the CSS, ESA quadrat and ESA plot samples respectively. BAP classifications of CSS plots did not match well with habitat classifications done in the field as part of the monitoring programme, due to variations in scale.

The location of samples in relation to Government Office Regions and sites with statutory nature conservation designations was also ascertained. The South West had the greatest concentration of botanical monitoring sites (27%) and East Midlands the least (3%). In total, 36% of plots and quadrats for which grid references were available coincided with designated sites.

Power analysis was carried out on CSS, ESA quadrat and ESA plot samples. A range of variables was tested, including species richness, Ellenberg values and suited species scores. Analyses were done on subsets of the data representing the various classifications from NVC, CVS, Broad Habitats and Priority Habitats. A power of 85% was used, i.e. when true differences occur between samples, there is an 85% probability of detecting them. Calculations were done using the variation within a single year’s worth of data, and the variation of differences from repeated surveys.

Power analysis results were used to calculate the sample sizes recommended for the future monitoring programme. For some habitats, data were available that represented sites in favourable condition, and these were used as provisional targets for restoration of Priority Habitats. Power analysis output tables are provided to enable detectable change for given sample sizes to be declared in the future monitoring programme.

Recommendations for Future Monitoring

The main policy driver for biodiversity is currently the UK Biodiversity Action Plan (BAP). AE schemes, which now reside under the England Rural Development Plan (ERDP), are the main vehicles by which BAP national objectives and targets are expected to be met and delivered. Although DEFRA is currently conducting a review of AE schemes, the UK BAP will continue to be the driving force for habitat conservation for some time to come. Therefore, the recommendations for future botanical monitoring are structured around BAP objectives for Priority Habitats.

The overall aim of the botanical monitoring programme will be to assess the contribution of AE schemes in meeting objectives and delivering targets for Priority Habitats. This will be aimed primarily across schemes at the country (England) level, with consideration also given to monitoring within regions, individual schemes and individual sites.

Recommendations are based on the results of the first stage of the project. A workshop was also held to draw on the experience from a range of organisations. A core monitoring programme for grassland and upland Priority Habitats, and for vegetation with potential to re-establish as Priority Habitat, is recommended. A list of habitats in which targeted studies are more suitable is also given.

The general approach will require data from other completed or current projects on the *stock* (inventory) of the target habitats under AE agreement. The *condition* of habitats will be measured using RCA on a sample of AE agreement sites. Vegetation *change* will be measured against targets of condition using quantitative species composition data collected from fixed plots or quadrats. Trends in AE schemes will be compared with those in the *wider countryside* by reference to CS and other programmes. Probable *drivers* of change will be determined by analysing appropriate indicator variables and environmental data.

A variety of methods have been developed by the UK agencies for RCA of designated sites (SSSIs) and AE schemes (e.g. Tir Gofal). The Common Standards Monitoring (CSM) approach of JNCC defines favourable condition of designated site features in terms of features, conservation objectives, attributes and targets. RCA is a general approach for assessing habitat condition against predetermined targets and so clear site objectives are a critical prerequisite. Nationally agreed methods of RCA for lowland habitats should be published by JNCC in 2002. The adoption of these agreed methods for agri-environment scheme monitoring is recommended in this report although some further work is identified that is needed to validate the methods and the targets. There is no currently agreed method of RCA for upland habitats and further work is needed to define sampling methods, attributes and targets for monitoring the condition of upland habitats in agri-environment schemes. For re-establishment sites RCA methods are not well developed and further work is recommended to define additional condition categories together with appropriate attributes and associated targets. It is suggested that RCA be carried out alongside quadrat or plot monitoring of AE scheme sites to provide a database for the validation and future refinement of the RCA methodologies.

Specific recommendations are made for grassland and upland Priority Habitats. A detailed monitoring schedule for each habitat has been drawn up, with the rationale explained in sets of accompanying notes. Scheme objectives and performance indicators have been suggested for each habitat, which are linked to BAP objectives and targets. Some further development work is still required before RCA can be used in AE schemes; this is specified and could be carried out in 2003 in advance of the new monitoring programme. For each habitat, a stratified random sample of sites according to the stock of that habitat in each scheme is recommended. This will include, as far as possible, sites in the current monitoring sample. Vegetation change can be analysed by floristics (species composition) and community variables; a set of the latter is recommended for each habitat. The use of CVS classes for comparing CS data is also recommended.

Schedules have been produced that detail recommended procedures for future monitoring for seven grassland habitats. These are Coastal and Floodplain Grazing Marsh (CFGM), Lowland Calcareous Grassland (LCG), Lowland Dry Acid Grassland (LDAG), Lowland Meadows (LM), Purple Moor-grass and Rush Pastures (PMRP), Upland Hay Meadows (UHM) and semi-improved grassland that has re-establishment potential. Sample sizes required to detect specified magnitudes of change in fixed plots or quadrats are given. Required sample sizes range from 50-200 for different habitats. For habitats with available data, provisional targets are specified, which are represented by sites known to be in favourable condition. Semi-improved grassland is used to represent a potential endpoint of deterioration of Priority Habitats. RCA should be carried out on a large sample of sites, which will include those in the quantitative sample. In each scheme, the field method in current use will be continued to ensure linkage with previous surveys, but minor adaptations are recommended that will enable analyses to be done across all schemes. Quantitative data from plots or quadrats should be calibrated as far as possible against attributes or condition categories from the RCA.

A single schedule has been produced for upland habitats, which are Upland Heathland (UH), Blanket Bog (BB) and potential upland heathland (i.e. degraded upland heathland with potential for restoration). Final recommendations on the application of RCA cannot be made until current development work by the statutory conservation agencies and DEFRA is completed. A sample of 100 management units (MUs) (areas of upland managed as autonomous units) is recommended. UH, BB and potential upland heathland will be monitored in each MU if available. RCA and heather performance will be measured in each habitat, and a single fixed plot established in UH and potential upland heathland. Relationships between RCA, heather performance and botanical data will need to be established to enable progression against targets to be measured.

Recommended sample sizes for quantitative monitoring are as follows:

	Priority Habitat	**No. of sites**
Grassland	CFGM	200
	LCG (existing)	50
	LCG (potential)	150
	LDAG	50
	LM	200
	PMRP	50
	UHM (potential)	100
	UHM (degraded)	100
	Semi-improved	100
Upland	UH, BB & potential UH	100
	Total	1100

A monitoring timetable is provided that indicates which habitats could be surveyed each year over a three year period. Some recommendations are also made regarding plot or quadrat relocation.

RCA could also be used by Project Officers to make judgements about individual sites. However, this would need to be done independently of the monitoring programme to avoid biasing the monitoring sample. AE botanical monitoring could be linked to other monitoring programmes including CS and EN's programme of BAP grassland monitoring.

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CHAPTER 1

INTRODUCTION

1 INTRODUCTION

Agri-environment (AE) schemes in England have been run by DEFRA (previously MAFF) since 1987, when the first Environmentally Sensitive Areas (ESAs) were introduced under the 1986 Agriculture Act. Since then, further ESAs have been introduced along with other schemes such as the Habitat Scheme and Moorland Scheme. Agri-environment schemes now come under the England Rural Development Programme (ERDP), along with the Countryside Stewardship Scheme (CSS), the Arable Stewardship Pilot Scheme (ASPS), the Organic Farming Scheme, the Farm Woodland Premium Scheme and the Hill Farming Allowance Scheme.

Since their first introduction, DEFRA has been committed to monitoring the performance of agri-environment schemes in relation to their stated objectives. As part of this monitoring programme, botanical data have been collected from most schemes. The methods for sampling, field data collection and data interpretation have varied. However, in addition to reporting of scheme performance *per se*, there is now a requirement for DEFRA to report within a wider policy context including, for example, the UK Biodiversity Action Plan (BAP). This will require reporting at national or regional levels, so it will be necessary to use monitoring methods that are compatible between schemes.

The aim of this project is to make recommendations for the future botanical monitoring programme of AE schemes, scheduled to run from 2003 onwards. However, at the time of writing, the future strategy for AE schemes in England is under review and the exact structure of the forthcoming schemes is uncertain. Because of this, the assumption has been made here that the maintenance and enhancement of habitats that are of biodiversity value will continue to be one of the main aims of the schemes. In addition, it is assumed that management agreements similar to those currently administered under the CSS and ESAs will continue. The recommendations for future monitoring have been made within that scenario, but any major change in the objectives or format of AE schemes might necessitate some modification to the monitoring programme. However, the principles should still be applicable even if AE schemes are substantially modified in the future.

Future monitoring will need to be scientifically valid, but also economical. There is a requirement to optimise the use of existing botanical samples and time series data, whilst also taking account of recent developments in botanical monitoring methods. This includes the emergence of Rapid Condition Assessment (RCA) as a means of allocating individual sites or interest features to a predetermined set of condition categories, using standardised procedures.

To date, there has been no comprehensive review that has attempted to compare different methods in terms of their effectiveness, and to link their methodologies to the targets towards which AE schemes now must work. More limited reviews of monitoring methods were carried out previously by Land Use Consultants (1996) for the National Audit Office review of ESAs, and more recently by Ecoscope (2002) in a review of the results of AE scheme monitoring for DEFRA. However, neither of these draft reports was available for consideration in this project. In addition, Glaves (1999) carried out a provisional review of botanical monitoring.

This report is the result of a two-stage process. The first stage involved the review and evaluation of existing methods of botanical monitoring in AE schemes. This covered current AE botanical monitoring methods, methods for analysing and interpreting change in the context of policy objectives, and recent developments in approaches to botanical monitoring. Results of the review are in Chapter 2. Botanical data from the previous AE monitoring programmes were classified according to their species composition and geographical location, to assess their continued usefulness in the future programme. Statistical power analysis was also used to estimate the sample sizes required to detect specified magnitudes of change. The classification and power analyses are described in Chapter 3.

In the second stage of the project, the recommendations for the future botanical monitoring programme have been formulated. This takes into account the policy background and the results of the review and data analyses carried out in the first stage. A workshop was also held to seek views from a wide range of experts. The final recommendations include detailed proposals for a core monitoring programme, along with a suggested list of separate targeted studies. The recommendations include a detailed consideration of the application of RCA. Development work that will be required before the monitoring programme can be implemented, particularly in relation to RCA, is also highlighted. The future recommendations are in Chapter 4.

CHAPTER 2

REVIEW AND EVALUATION OF CURRENT MONITORING METHODOLOGIES AND SCHEMES

1 INTRODUCTION

In this chapter, the different botanical monitoring methods that have been applied in England and the rest of the UK are reviewed, along with related research on botanical monitoring methods. The results they produce are assessed in terms of their relevance to individual site, individual scheme and national policy objectives at the time of their application. Each method is assessed in terms of its relevance to the objectives of individual sites, individual schemes or existing national policy for AE schemes at the time of their application. Each method is also assessed as far as possible in terms of its scientific rigour.

A range of topics has been addressed in this review. Firstly, the current sampling and field methods used to date in English AE botanical monitoring programmes are reviewed. Methods used in the other UK countries are also examined and comparisons made with those in the English programmes. A review of the scientific literature relating to recent research on monitoring methods is carried out, and the relevance to AE schemes is considered. Methods used for detection and interpretation of change in AE schemes are also assessed, along with recent research on this. Datasets that might be used as potential ‘controls’ for the monitoring programmes are evaluated, and the use of environmental data for assessing drivers of vegetation change is assessed. The recent development of Rapid Condition Assessment (RCA) methods in the UK is also documented.

Each section is based around a table that summarises the information gathered from a variety of reports of monitoring agri-environment schemes. The contents of each table and the column headings are explained in each section and there is a brief summary of the findings. Tables are provided separately in electronic format.

2 MONITORING METHODS USED IN ENGLISH AGRI-ENVIRONMENT SCHEMES

2.1 AIM AND SCOPE

The aim of this review and evaluation is to bring together information on the methods used for the past and present monitoring of the English agri-environment schemes. The overall strategy is summarised in ADAS (1995), but information has been collated from individual monitoring reports to ensure that up to date details for each scheme are documented.

2.2 REVIEW TABLE

This review is presented as Table 2.1. The table is divided into the following columns:

A Endnote reference number

This gives the number in the Endnote database from which the information in the row has been collated.

B Scheme

This column gives the scheme for which the report was written and in which the survey was carried out.

C Monitoring Organisation

This column gives the organisation(s) that carried out the project from which the information was gathered.

D Habitat

This column lists the habitats that were surveyed.

E-F Sampling Strategy

This column describes the sampling strategy and is split into two separate fields. The first field describes the sample size and distribution and the second field describes the sampling strategy at each site visited.

G Population of which sample is representative

This column indicates the population i.e. scheme or part of scheme that the sample represents. Parentheses indicate that the sample was believed to be representative by the authors, but was in fact subjectively chosen.

H Field Method

This column describes the method used in the survey. Some methods were generic in their application, having been used in several schemes or several habitats. They have been published and are included in the Endnote database that accompanies this report. The generic methods were:

ADAS plot method for grassland (Critchley & Poulton 1998)
Countryside Survey method (Bunce & Shaw 1973)
Transect line (Smith *et al.* 1985)
GI/BU method for heather grazing assessments (Poulton 1991)
Ditch survey in 20m strips (Alcock & Palmer 1985; Morris *et al.* 1993)

I Quadrat/plot size

J Years sampled

This refers to when sampling took place.

K Duration (years)

This refers to the length of time for which the scheme was monitored. In some cases only part of the sample was resurveyed. A zero in this column denotes a single survey rather than monitoring over a period of time.

L Fixed Unit

A fixed unit is the lowest level in the hierarchy of fixed locations within which repeated measures are made (e.g. a fixed quadrat).

M Environmental data

This column gives the additional environmental and management variables that were measured or assessed for each quadrat/plot.

N-O QA on data collection/ QA on data entry

These columns give the quality assurance (QA) protocols applied to the survey and its data. This column is only filled in if QA was mentioned in a report. An omission therefore reflects either an omission in a report or a lack of QA.

P Ease of relocation of sampling point

An indication of whether the quadrats can be relocated is given in this column. A "?" in the table denotes that there is no mention whether fixed plots were marked permanently. The use of the word "possible" in the table means that relocation of plots can be achieved.

Q Format of current data archive

This column lists the software or hardcopy status of the archive for the data.

R Classification System

This column lists the classification system(s) on which the data archive is based.

2.3 OVERVIEW OF TABLE CONTENTS

2.3.1 Grassland

Grassland habitats have been monitored in land within Environmentally Sensitive Areas (ESAs), the Habitat Scheme and the Countryside Stewardship Scheme (CSS), and have been monitored in terms of plant species composition and the characterisation of plant communities.

ESAs were the first of these schemes, introduced in 1987, with following rounds in 1988, 1993 and 1994. Botanical surveys began in 1987, with the first rounds of ESAs resurveyed after a maximum of eight years, using sampling strategies driven by local objectives, and often requiring subjective selection of fields. The vegetation plots also varied in size though tended to be the same for all ESAs introduced at a given date (see also reviews by Critchley (1997), and, for lowland grasslands, Burke & Critchley (2001)). The original method involved using five 2m x 2m quadrats along a transect (following Smith, *et al.* 1985), to be replaced by the 'ADAS plot' method for those

ESAs introduced in 1993 and 1994. This involved using plots of 8m x 4m consisting of 32 cells and 10 nests within each cell (Critchley & Poulton 1998).

Surveys of former set-aside land and water fringe areas of the Habitat Scheme used small quadrats of 1m x 1m and 0.5m x 0.5m respectively (ADAS 1998i; McLaren 1998). By contrast, the survey of CSS agreements was designed to be comparable with Countryside Survey (CS), requiring the mapping of habitats using the then-new system of Broad Habitats, and using a $200m^2$ nested quadrat per agreement, with additional quadrats within parcels of Priority Habitats (Carey *et al.* 2001a). Data were classified in terms of the Countryside Vegetation System (Bunce 1999), in addition to the National Vegetation Classification (Rodwell 1991 *et seq.*) used for other surveys.

2.3.2 Heathland

Heathland habitats pose particular problems for monitoring, partly because of the complex, patchy nature of the vegetation, and partly because assessing grazing and heather burning is important to understand likely trends in vegetation, especially the changing balance between dwarf shrubs and grasses (Gardner *et al.* 1998). Therefore, surveys for the Moorland Scheme and ESAs have involved several approaches in addition to conventional quadrats. They included aerial photographs to assess heather cover and heather burns (ADAS 1997b; ADAS 1997c; ADAS 1997i; ADAS 1997l); vegetation plots within fenced and unfenced areas to assess effects of grazing and progress of restoration (ADAS 1996g; ADAS 1997b; ADAS 1997c); and other measures of heath condition, including distance to palatable grasses and heather height, cover and age (ADAS 1997c; ADAS 1997h; ADAS 1997i; ADAS 1997l; ADAS 1998f; ADAS 1998j). Grazing has also been monitored using analysis of heather shoots; the percentage of shoots grazed on sample stems was used to generate a Grazing Index (GI), that was converted to a Biomass Utilisation (BU) estimate that could be compared against known grazing thresholds for different heather growth stages and types (Poulton 1991).

2.3.3 Arable

The monitoring of arable habitats within the Habitat Scheme (Water Fringe Areas), Breckland ESA and the Arable Stewardship pilot scheme has concentrated very much on the use of quadrats within particular features managed for wildlife within and around the arable fields. These include uncropped wildlife strips (ADAS 1997a), conservation headlands (ADAS 1997a), and the range of sub-options within the pilot Arable Stewardship scheme, including overwinter stubble, spring fallow, undersown cereals, grass leys, conservation headlands, no-fertiliser conservation headlands, sown and naturally regenerated grass margins, uncropped wildlife strips and wildlife seed mixtures (Critchley *et al.* 2001). The size and shape of the quadrats is strongly influence by the dimensions of the features being studied.

2.3.4 Ditches (dykes/rhynes) and banksides

Monitoring of ditches and banksides has involved assessing plant species occurrence and cover along lengths of the water courses using methods based on Alcock & Palmer (1985) (McLaren 1998; ADAS 1991a; ADAS 1991c; ADAS 1991d; ADAS 1996b; ADAS 1997j). In the Broads ESA, vegetation was characterised within four zones (submerged, floating, emergent and bank). Selection of the sample locations has involved both random and subjective methods.

2.3.5 Saltmarsh

Saltmarsh vegetation consists of complex and dynamic mosaics. Monitoring programmes have tried to encompass this large scale complexity by mapping sites according to the NVC as well as using quadrats (ADAS 1998b; McLaren 2001a; McLaren 2001b; Sherwood, 2001; McLaren 2002).

2.4 EVALUATION

2.4.1 Sampling

In most cases the aim was to take random stratified samples of sites in the scheme, with the stratification being based on factors such as entry into scheme tier, geographical location, soil type and level of agricultural improvement. However, this was sometimes thwarted by practical difficulties caused by insufficient numbers of sites, or sites changing tier or entering or leaving the scheme. In the earlier schemes (Stages 1 and 2 ESAs), sites often had to be selected subjectively. In these cases, sites were treated as case studies. Therefore, the extent to which samples are truly representative of the target vegetation type varies between schemes and between monitoring programmes. In general, random or stratified random sampling in the later schemes ensured that sampling was statistically valid, and where sample sizes were adequate the samples are representative of the target vegetation types. In the majority of cases, initial sampling was done in the first year of operation of the schemes. Samples of agreement land might therefore be biased if agreements signed in the first year differ from those entering subsequently, although the magnitude and nature of any bias is not known. An appraisal of the representativeness of each sample is provided in the table. The implications of this for future monitoring will be dependent on new monitoring objectives, and will be addressed later.

2.4.2 Quality assurance

The main contractors that have carried out botanical monitoring to date are ADAS and CEH. ADAS operates an internal Quality Assurance (QA) scheme that was introduced in 1997, which ensures that data are checked in the field and at data entry. In addition, all data collected for AE scheme monitoring have been checked in this way from the outset. QA carried out on Stage 1 and Stage 2 ESAs is well documented in the monitoring reports (see table). Although less detail is provided in other reports, the same procedures are believed to have been followed. Appropriate automatic data validation facilities have been used on electronic databases. The QA, therefore, is considered to be adequate.

Of the work carried out by CEH, CSS data were double punched (i.e. entered twice to trap errors of mis-typing). Anomalies between the GIS created by MAFF and the GIS created by CEH were checked by surveyors.

QA measures by other contractors have not generally been documented in the monitoring reports (see table).

2.4.3 Duration

Rate of vegetation change depends on many factors, including management, so it is difficult to predict the necessary duration of a monitoring programme and the optimum frequency of survey. Rehabilitation can be slow whilst degradation can happen rapidly. In lowland grasslands in ESAs, few beneficial changes were detected in monitoring programmes of up to 8 years' duration (Burke & Critchley 2001). On heathland in Northumberland under ESA prescription, changes at a community and species scale were detected after 6 years (Adamson *et al.* 2001). On moorland in Dartmoor ESA significant changes in heather frequency, grazing suited-species score and vegetation height were detected after 3 years (ADAS 1998j). Generally, the longer a monitoring programme has been running, the more valuable is the dataset for future monitoring of a given vegetation type, especially if several surveys have been carried out. The longest time intervals between first and most recent surveys to date are 8 years for some grassland monitoring programmes in the early ESAs. However, it is now possible to detect change over even longer timescales by relocating quadrats originally surveyed in the early rounds of ESA monitoring.

2.4.4 Ease of relocation

Most of the survey sites can be relocated, and it should also be possible to relocate fixed quadrats that have been marked with buried metal pipes or plates and have had maps drawn to assist relocation. In many schemes, fixed units have been already been relocated for repeat surveys. Success of relocation has depended on the quality of the individual maps and on the substrate (pipes in peaty soils are less stable than those in mineral soils). In general, the longer the time since the last survey, the more likely there are to be difficulties in relocation. The use of GPS systems in the future should make relocation of plots faster and more accurate.

2.4.5 Data

Data held on the AEMA database are readily accessible. All other data are accessible in electronic form, with the exception of the large dataset from the Lake District ESA rough grazing. Database maintenance and management are required to maintain accessibility, which is more at risk with software systems that tend to change data formats frequently.

3 MONITORING METHODS USED IN AGRI-ENVIRONMENT SCHEMES IN OTHER UK COUNTRIES.

3.1 AIM AND SCOPE

The aim of this section is to review methods used for collecting botanical monitoring data in AE schemes in the UK countries other than England. Methods are compared with those used in English AE schemes and their compatibility with existing methods is assessed.

3.2 REVIEW TABLE

The columns in Table 3.1 are essentially as described in Section 2.2, except that Country is recorded, and information on data quality and sample relocation is not considered relevant.

3.3 OVERVIEW OF TABLE

3.3.1 Scotland

Scottish ESAs were monitored in two phases. The first phase was carried out during 1989 – 1993, across a very wide range of habitats including woodlands, moorland, grasslands, wetlands, arable and machair. In general sites were selected using stratified random techniques, and vegetation was recorded using permanent quadrats (1m x 1m or 2m x 2m depending on habitat) located along transects (Henderson *et al.* 1994a; Henderson *et al.* 1994b; Nolan *et al.* 1994). In 1994 this was replaced by a new monitoring programme designed to assess changes in extent as well as composition of vegetation communities (Cummins *et al.*. 1997; Gauld *et al.* 1997; Cummins *et al.* 2000). Background monitoring was used to measure vegetation change in the ESAs, irrespective of agreement status. This involved selecting 1km squares within each ESA, which were mapped, and fixed quadrats established according to (slightly modified) CS protocols. Prescription monitoring was used to measure vegetation change on land under Tier 2 agreements. For each Key Vegetation Type, up to 30 plot locations were selected from all the possible Tier 2 areas, and vegetation recorded as for background monitoring.

3.3.2 Wales

Monitoring for the Welsh ESAs followed much the same pattern as for those in England. From 1987-1993, the quadrat method was used in the first Welsh ESAs. In 1994 the monitoring was reviewed and restarted (ADAS 1997m; ADAS 1998a; ADAS 1999a; ADAS 1999b; ADAS 1999c; ADAS 2000a; ADAS 2001a) using the ‘ADAS Plot’ methodology (Critchley & Poulton 1998). Again, as in England, heather grazing was assessed using the ADAS grazing index and biomass utilisation (GI/BU) method (Gardner *et al.* 1998). In woodlands in the Cambrian Mountains ESA, saplings and seedlings were identified in permanent quadrats located along transects.

The monitoring of the Tir Cymen scheme was superficially more similar to CS because of the range of plot types. Species data were collected from species plots (either 2m x 2m in areas of homogeneous vegetation structure or $200m^2$ in more complex stands), boundary plots were used for measures such as height and dominant tree and shrub species, and cover plots were used to record vegetation height, cover and dominant species (Entec 1997; Entec 1998). Non-agreement farms were included in the survey. The monitoring for the new Tir Gofal scheme has not been finalised (ADAS 2001b), but the proposal is that it will run from 2001-2013, including 5 years of baseline surveys followed by repeat surveys at the 4 and 9 year point. The field survey methods will include a modified Condition Assessment (see Section 9 for more details) including the use of quadrats of variable size (K. Austin *in litt*. to RDS).

3.3.3 Northern Ireland

Monitoring in Northern Ireland ESAs includes heather moorland, woodland, grassland, hay meadows, hedges and ditches. Monitoring began in 1993, using methods similar to those used in the Stages 1 & 2 English ESAs (Smith *et al.* 1985). Similar methods are likely to be used for the Countryside Management Scheme (Johnstone 2001).

3.4 EVALUATION

In order to address the specific objectives of each monitoring programme, sampling strategies have varied widely both between countries and across different schemes within each country. Comparisons with English schemes have therefore been focussed on field recording methods.

3.4.1.1 Grassland and related vegetation types

Overall, there is some consistency in the grassland field methods that have been applied in the different UK countries. The quadrat method used in the earlier English ESA monitoring programmes was also used in the discontinued monitoring programmes in both Scotland and Wales. It is also being used in Northern Irish ESAs and will be applied in CMS. A slightly modified version is also used in grassland and wetland in the current programme for Scottish ESAs. This method has the strengths that it can detect change through time and is widely applicable across different habitats. Its main weakness is that extrapolation to whole ESAs was not always possible. The more recently developed ‘ADAS plot’ method has also been used in all Welsh ESAs since 1994. The main strengths of this method are that it was better at detecting change than other quadrat or plot methods. Its main weakness was the length of time required to carry out individual quadrat assessments.

Grassland assessments in CSS and Scottish ESAs were done using Countryside Survey methods, so that comparisons could readily be made with the wider countryside. The other main strength of this method was the speed of doing the nested quadrats. The weakness of the method was that only one quadrat per habitat was carried out.

Different approaches have been taken in Tir Cymen and Tir Gofal. The weaknesses in all of the methods were created because of financial constraints on those carrying out the surveys.

3.4.1.2 Heather Moorland

The GI/BU method applied in English ESAs was also used in the Cambrian Mountains and Preseli ESAs in Wales. Various methods have been used in other schemes to measure grazing intensity, species composition and vegetation structure. No method has yet been devised to assess moorland quality adequately. Moreover, detecting vegetation change has proved difficult, because of the twin requirements to monitor quite large patches of vegetation and defining them well enough to be able to record change. Experience from CS suggests that mapping vegetation patches in unenclosed land is prone to errors of an equivalent scale to the likely changes between surveys; as a result, small, relocatable plots have been introduced to help monitor moorland change.

3.4.1.3 Woodland

The survey of the English Farm Woodland Scheme (FWS) and Farm Woodland Premium Scheme (FWPS) was focussed on species composition in 2m x 2m quadrats. Comparable data have also been collected from Scottish ESAs (in both first and second phases of monitoring). In other schemes, different quadrat or plot sizes have been used, although in Northern Irish ESAs species data have also been recorded from a 2m x 2m nest within a larger plot. However, data on tree regeneration have been collected from all schemes apart from the FWS/FWPS. The weakness of this method is that 2m x 2m is often considered too small to adequately monitor woodland (the reason why CS quadrats are so large is to adequately monitor woodland plots).

3.4.1.4 Other habitats

Methods used for monitoring of other habitats, as in the English AE schemes, have tended to vary according to the specific objectives of the monitoring programmes.

4 RESEARCH ON MONITORING METHODS

4.1 AIM AND SCOPE OF THE REVIEW

This review covers research carried out to develop field methods for collecting botanical monitoring data. Descriptions of monitoring studies where novel methods have been applied, and might be relevant to AE schemes are also included. Literature searches were carried out using the DialogSelect™ electronic database. Unpublished research reports were also reviewed where relevant.

4.2 REVIEW TABLE

A description of research papers examining botanical monitoring methods in AE schemes is presented as a table in which papers are grouped by research theme (Table 4.1). This table also provides details of the parameters measured, the method used, and the results of the research.

4.3 OVERVIEW OF THE TABLE

Different methods have been developed and used for a variety of different scales, sample sizes and most importantly for different objectives. Some parameters and techniques that have been examined for use in monitoring the botanical characteristics of AE land are:

Species presence and abundance
Grazing pressure
Sward height and structure
Near infra-red reflectance spectroscopy
Remote sensing

4.3.1 Species presence and abundance

Botanical survey methods that measure the relative importance of different species in vegetation samples are described in many textbooks e.g. Kershaw & Looney (1985); Causton (1988); Goldsmith (1991). Examples include methods for measuring density, cover, biomass, performance and frequency. However, these methods (described in Table 4.1) have been developed to describe rather than monitor vegetation and are often limited in their use when trying to detect small changes over time (Dallmeier *et al.* 1992), not least because different species need to be monitored at different scales in order to detect change (Greig-Smith 1983).

Estimates of cover by eye, including those made on the Domin or Braun-Blaunquet (relevé) scales, are insensitive to small changes and observer variation is high unless work is carried out by pairs of observers (Nilsson 1992; Poulton & Critchley unpubl.; Poulton, *et al.* unpubl.).

Frequency measurements within quadrats are less subjective, and have been modified to overcome the problem of monitoring over different scales by using nested quadrat designs, in which vegetation is recorded within subsections of the quadrat of increasing size (Bunce & Shaw 1973; Winward & Martinez 1983; Maslov 1990;

Hodgson *et al.* 1994; Critchley and Poulton 1998). For example, the standard main quadrat of CS (Bunce & Shaw 1973) is nested, with each nest centred on the same point. The outer quadrat is 200m^2 (14.14 x 14.14m), there are four more smaller quadrats with the smallest being 4m^2 (2 x 2m). The percentage cover of each species is noted in the inner quadrat. Additional species are noted in the innermost quadrat in which they appear, and the species cover within the largest quadrat estimated by eye. The 'ADAS plot' method (Critchley & Poulton 1998) is similar, but is based solely on species' presence, thus increasing precision by avoiding the use of subjective cover estimates. The fixed unit is a plot consisting of 32 subunits (nests) arranged contiguously in an 8 x 4 grid (usually 8m x 4m). Each nest consists of nested cells of increasing size, in which species are recorded cumulatively. This includes an estimate of top cover using pin hits.

Hodgson *et al.* (1994) developed a method capable of dealing with larger scales by dividing the area to be monitored into five strips. In each strip, six 1m x 1m quadrats were randomly located; each quadrat consisted of a series of nested quadrats in which species were recorded cumulatively. It is suitable for monitoring individual fields, especially where within-field spatial variation in the vegetation is not high. However, a large sample of quadrats would be required if small changes in the vegetation were to be detected.

All nested quadrat methods address the problems of recording a wide range of species with varying scale and pattern of spatial distribution, and inter- and intra-observer variation are reduced considerably in comparison with subjective cover estimates. However, as with all quantitative methods, it can be labour intensive, taking up to 2-3 staff days to relocate and record a single plot. There is a balance between recording effort and survey effectiveness; Burke & Critchley (1999) found that 16 nests each containing 10 cells was adequate in most cases and would reduce the monitoring time, on each plot, by 40% compared with the usual ADAS nested plot.

Methods used specifically for monitoring changes in plant communities in heathland vegetation in recent DEFRA (MAFF) funded research projects, at species and community levels, have been described and assessed (Gardner *et al.* 1999). Methods included various cover and frequency techniques. Of the methods tested, it was concluded that first hit using cross-wires was the most consistent and sensitive technique, though it was not good at detecting understorey vegetation or species present at low densities.

4.3.2 Grazing assessments

Many of the AE schemes have prescriptions that are designed to enhance floristic diversity by controlling grazing. Estimating the intensity of grazing is therefore of some importance. For upland moors and heaths, methods to assess the utilisation of dwarf shrub and graminoids by grazing animals were initially developed in the UK by the HFRO and latterly the Macaulay Land Use Research Institute (MLURI). Shoots were allotted subjectively to one of four classes and an arbitrary weighting (in brackets) given to each grazing level (Grant *et al.* 1976):

(i) removal of leaf/shoot tip (0.25)

(ii) less than half leaf/shoot removed (0.5)

(iii) more than half leaf/shoot removed (0.75)

(iv) grasses grazed to stubble, heaths grazed to previous season's wood (1.0)

This method was adapted in later studies to apply only to heather shoots. The first class (removal of shoot tip) was abandoned and weightings were amended (Grant *et al.* 1981). In another study, grazing on *Nardus* was estimated by counting the number of grazed tillers out of a random selection of tillers (Grant *et al.* 1996).

An alternative method to measure grazing on heather was developed specifically for English AE schemes, to reduce the problems encountered by inexperienced observers when required to make subjective judgements in the field (Poulton 1991). This method involves only the collection of a random sample of heather shoots in the field. In the laboratory, the proportion of grazed shoots is counted (Grazing Index). This is then converted to a value of Biomass Utilisation. However, this method has been described and criticised under MAFF contract BD00114 (Gardner *et al.* 1998). The relationship between the Grazing Index and Biomass Utilisation, and the threshold levels used for measuring suppression of heather growth by grazing, were based on data collected from a restricted set of environmental conditions, and so the validity of applying them elsewhere is uncertain (Kirkham & Wilson 2000; Gardner *et al.* 1998). In addition, the validity of the statistical method used for converting Grazing Index to Biomass Utilisation has been questioned (Kirkham & Wilson 2000).

4.3.3 Sward height, structure and other characteristics

Kirkham *et al.* (2001) reviewed and assessed methods to be applied in AE schemes for estimating sward characteristics such as height, structure, bare ground and litter. Methods of height measurements included (i) the HFRO sward stick (Barthram 1986), (ii) drop disc (Holmes 1974; NCC 1986), (iii) plate meters (Holmes 1974), (iv) ruler, (v) point quadrats (Grant 1993), (vi) electronic capacitance probes (Frame 1993) and (vii) visual estimates (which have also been used to estimate herbage mass).

The HFRO sward stick is a graduated stick with a sleeve from which projects a clear Perspex ledge. The sleeve is slid down the stick until the Perspex hits vegetation, at which point the vegetation height is recorded (Barthram 1986). The drop disc has a disc with a central hole, of specified diameter and weight, which is allowed to fall down a graduated stick; again, the height to which it falls is recorded (Holmes 1974; NCC 1986). Plate meters are similar to drop discs but are combined with an estimate of herbage mass (Holmes 1974; Frame 1993; Grant 1993). Methods (v)-(vii) are not commonly used. Recommendations of Kirkham *et al*. included using the HFRO sward stick rather than the drop disc as the best method for measurement of sward height.

Stewart *et al.* (2001) also compared measuring sward height with a ruler, the drop disc method and the HFRO sward stick. The sward stick gave the most variable results; it was the best method for measuring the architecture of the sward surface, but was less useful for measuring short swards. The drop disc method was not good for measuring sward architecture or short swards, but was useful for measuring productivity. The ruler method was suitable for short swards. The sward stick consistently gave the highest and the drop disc the lowest readings. For larger scale monitoring the drop disk is the most useful technique as it gives a good indication of height quickly in a variety of vegetation types. Obviously the required sample size varies greatly with vegetation type and management; the more uniform the vegetation structure, the more appropriate these methods are.

If data are to be compared with those previously collected, the method used in the previous study should be used. If information about sward heterogeneity is required, the HFRO sward stick is recommended. In other situations the drop disc has the advantage of having high observer consistency and being quicker to use than the sward stick as fewer readings are required.

4.3.4 Near Infrared Reflectance Spectroscopy (NIRS)

NIRS involves the scanning of dried samples of vegetation in terms of the properties of reflected radiation, and is commonly used in the food and agricultural industries (Osborne *et al.* 1993). Coleman *et al.* (1985) used NIRS to estimate the composition of grasslands which contained between two and four species, whilst a later study (Garcia-Criado *et al.* 1991) looked at the potential of NIRS to distinguish between species groups, e.g. legumes or grasses. The feasibility of using NIRS for assisting in monitoring species-rich grassland was investigated (ADAS, 1996h; Atkinson *et al.* 1996). Although it showed some promise, further work is required before the method could be applied to vegetation monitoring. Potentially, it could be used in conjunction with field surveys. It is unlikely that this method would be useful for monitoring changes in species composition of complex communities such as species-rich grasslands because the system is unlikely to prove sensitive enough to distinguish between all species. Moreover, conversion from the proportions of taxa within the samples to those in the field is sensitive to small variations in sample preparation, and to variations in moisture content of the vegetation.

4.3.5 Remote sensing

Aerial photography has been used extensively in English AE schemes to map land cover, and can provide a quick and permanent record of coarse vegetation structure over large areas (Hooper 1992). It is suitable for monitoring change on a large scale (e.g. heather cover (ADAS 1997b) or heather burning (ADAS 1997i)), but is not sensitive to small changes in patch size or vegetation structure. It is relatively inexpensive, considering the amount of data collected and can provide a wider context for more detailed ground surveys.

Satellite images record, in digital format, reflected electromagnetic radiation in a number of discrete wavebands (Budd 1991). Many of these bands have been specifically selected to maximise vegetation discrimination. The results of MAFF project BD0323 suggest that it is feasible to use satellite imagery to differentiate between grasslands of various levels of agricultural improvement (ADAS 1996a) whilst the results of a Japanese study suggest that satellite imagery can be used to monitor the status of grassland management (Mino *et al.* 1998). CEH investigated the use of aerial photography and satellite imagery to identify NVC communities on Salisbury Plain with limited success (Gerard *et al.* 1999). This technique could be useful to provide broad descriptions of grassland over wide areas and, like aerial photography, could be used in conjunction with ground surveys. The CEH Land Cover Map uses Landsat imagery to identify land cover classes comparable to many Broad Habitats with a pixel size of 25 m – too coarse for monitoring individual agreements, but suitable for monitoring changes within (e.g.) whole ESAs.

Low-altitude remote sensing (e.g. (Inoue *et al.* 2000)) could also be linked to ground survey, but this would require further development before being considered for vegetation monitoring in AE schemes. CEH and others are investigating the use of airborne CASI/LIDAR to identify vegetation types; this technology generates a fine scale digital map of the vegetation surface (with discrimination in height down to a few cm) and so, like aerial photography, can monitor changes in vegetation structure, rather than species composition. Its cost currently prohibits large scale use.

In general, remote sensing methods are not suited to monitor changes in species composition. However, they have great potential in monitoring habitat structure (e.g. heather mosaics, scrub encroachment, woodland gaps), which is important for many animal species, for example nesting birds. This is especially true in vegetation of non-uniform structure (including woodland and scrub) that cannot be well recorded using ground-based techniques.

4.4 CONCLUSION

There are relatively few examples of research specifically directed at botanical monitoring methods.

Species presence and abundance: There has been relatively little recent research on monitoring methods, although some development of the 'ADAS plot' method has been done since its first inception. Evidence from the literature clearly shows that cover estimates by eye are unreliable if observers work alone.

There are clear advantages of using nested systems compared with the single-scale methods of cover or frequency estimation, as they provide greater sensitivity to change for a wider range of species. They also allow for comparison across surveys even where the maximum quadrat sizes differ – either because of the dimensions of the habitats being surveyed, or the scale of spatial pattern within the vegetation itself – as long as there is a nest size in common (Barr 1997). Such systems have reduced observer variation compared with single-scale and subjective cover estimates, but still require skilled field botanists. It is unlikely that this need will be replaced by technological developments in the near future.

Grazing assessments: This is a specialised topic, and only two main approaches have been identified in this review. Currently, there does not appear to be a single ideal method for direct measurement of grazing intensity on plants. The MLURI method is suitable for use by experienced observers in cases where grazing intensity is not severe. There is also potential for the ADAS Grazing Index to be developed further for monitoring grazing on heather moorland.

Sward height and structure: Ground-based methods are available for grassland and other low vegetation types, but these are ill suited to more complex vegetation that includes scrub and woodland. Some remote sensing techniques show great promise for monitoring changes in vegetation structure, but are currently too expensive for routine deployment in AE scheme monitoring.

5 METHODS FOR DETECTING AND INTERPRETING CHANGE IN ENGLISH AGRI-ENVIRONMENT SCHEMES

5.1 AIM AND SCOPE

The aim of this section is to review indicators and analysis methods that have been used to interpret and detect change in land under English agri-environment schemes. The methods have been listed and characterised in terms of data requirement, interpretation and scope in Table 5.1, while the indicators themselves are evaluated in more detail in Section 7.

5.2 REVIEW TABLE

Table 5.1 shows the review results for the English AE monitoring schemes in terms of the monitoring objectives, the indicators used and the methods of data analysis used. The table entries identify key statistical issues and suitability for objectives, as well as other potential strengths and weaknesses of the monitoring programmes.

5.3 OVERVIEW OF TABLE

Because most of the field methodologies have involved collecting species data within quadrats, the data have been usually analysed and presented in terms of species diversity, vegetation character or appropriateness to the management objectives.

The ubiquitous measure of diversity has been the number of species per quadrat. Vegetation structure has been reported in such terms as height, bare ground and tussockyness for several schemes.

The vegetation data have been classified using one of four general approaches. The first is the NVC, which compares the vegetation with what are often subjectively defined stands of high quality vegetation. This is the most widely used classification, and has been applied to quadrat or plot data (sometimes after classification using TWINSPAN (Hill 1979), and has been used to map saltmarsh (ADAS 1998b). The second is the system of Broad and Priority Habitats introduced as part of the Biodiversity Action Plan. This is more appropriate for areas of land, rather than individual quadrats, and has been used for CSS (Carey *et al.* 2001a). Plot data may be classified into the Countryside Vegetation System (CVS), derived from a statistical analysis of plots from Countryside Survey; this classification is best regarded as a breakdown of the typical vegetation of GB and has also been used for CSS (Carey *et al.* 2001a).

The final general approach is to use some form of index reflecting the relationships between the plant species composition and the environment and management conditions in which the vegetation is found. The most frequently used is the ‘suited species’ system, whereby plant species are allocated scores against a range of environmental and management conditions, and indices derived from the species present in a sample. There are scores for variables such as grazing, low nutrient availability, high prevailing soil moisture levels, acidic soil, etc (Critchley *et al.* 1996b; Critchley 2000).

A further method to consider vegetation is to relate its character directly to environmental conditions using statistical approaches (such as Partial Canonical Correspondence Analysis (PCCA) (Ter Braak 1988) or ANOVA) that do not involve a prior classification of individual plant species characteristics. For the pilot Arable Stewardship Scheme, species distributions at the Pilot Area scale were predicted using models incorporated in a GIS (Sanderson & Staley 2001).

Change in vegetation has been assessed in a number of ways. The simplest is to consider trends in individual species or in indices derived from the species present. It is also possible to analyse changes in vegetation character in terms of changing towards some pre-defined endpoint, such as shifts towards a high quality NVC class or an increase in Ellenberg (Ellenberg 1979; Ellenberg 1988) or suited species Scores appropriate to management targets (Critchley *et al.* 1996a). In the Former Set-aside option of the Habitat Scheme, the SETSARIO model of community development in set-aside land was used to predict species distributions (ADAS 1998i). Monitoring change in uplands has also involved using indicators of grazing and condition noted earlier (Poulton 1991); in the Lake District ESA, mean BU was regressed against average stocking densities for each fell (ADAS 1997i).

6 METHODS FOR DETECTING AND INTERPRETATING CHANGE IN AGRI-ENVIRONMENT SCHEMES IN OTHER UK COUNTRIES

6.1 AIM AND SCOPE OF THE REVIEW

The aim of this section is to review the indicators used to detect and interpret change in vegetation in the other countries of the UK.

6.2 REVIEW TABLE

Table 6.1 summarises information from Scotland, Wales and Northern Ireland On the same basis as Table 5.1.

6.3 OVERVIEW OF TABLE CONTENTS

Generally, indicators used to detect and interpret change in vegetation monitoring schemes in other UK countries were similar to those used in the English schemes.

Most schemes used variables such as species richness, cover and height, with adaptations to specific habitats such as heather moorland (again addressing grazing) and woodland (addressing regeneration) (Henderson *et al.* 1994a; Henderson *et al.* 1994b; Nolan *et al.* 1994; ADAS 1998a; ADAS 1999a; ADAS 1999b; ADAS 1999c; ADAS 2000a; ADAS 2001a). Scottish studies have used controls, first with sites inside and outside ESAs, and subsequently with trends in CS data (Cummins *et al.* 2000).

Scottish and Welsh ESA vegetation data have been classified using suited species scores along with other measures, including Simpson’s diversity index (Cummins *et al.* 2000), and change reported in terms of individual species (Entec 1997; Entec 1998) and other categories, including the CSR system of Grime *et al.* (1988) (QUB 1993; QUB 1994; QUB 1997b; QUB 1998a; QUB 1998b; QUB 2000).

It has been proposed that monitoring of the Tir Gofal scheme should use a condition assessment method. In each habitat, data will be collected that are linked to particular objectives (e.g. in woodlands, number of seedlings and amount of dead wood). Target values will be set (e.g. 75% cover of dwarf shrub), and changes in the abundance of particular species assessed (ADAS 2001b).

7 RESEARCH ON METHODS FOR ANALYSIS AND INTERPRETATION OF CHANGE

7.1 AIM AND SCOPE OF THE REVIEW

The aim is to review research relating to indicators for assessing botanical changes. This has been extended to the wider scientific literature to understand how they have been used in different contexts. The strengths and weaknesses of each approach have been evaluated in the context of AE scheme monitoring objectives.

7.2 REVIEW TABLE

References used in the review are documented in Table 7.1. The different uses of indicators are demonstrated to assist in evaluating their effectiveness for measuring changes in vegetation condition. This summary relates to information in the table and to those indicators used in AE scheme monitoring programmes in England and other UK countries.

7.3 REVIEW OF METHODS

7.3.1 Suited species scores

The ESA schemes mostly use the suited species scores* method of vegetation quality assessment (Critchley *et al.* 1996a; Critchley *et al.* 1996b; Critchley 2000). Specific objectives have been set for each ESA for both maintenance and enhancement of vegetation types. Low intensity agriculture produces the preferred conditions for vegetation of conservation value, such as low nutrient availability and moderate grazing pressure. The goal vegetation can be defined as a specific biotope that is limited by a set of biophysical conditions. Species suited to specific conditions can be defined by applying rule sets to a matrix of species with their traits and habitat preferences compiled from a range of sources. Autecological information was compiled for vascular plants based mainly on those in Ellenberg (1988); Grime *et al.* (1988); Hodgson *et al.* (1995) and Fitter & Peet (1994). For each criterion a score is calculated as a measure of the relative contribution to the total vegetation of species suited to a specified condition. Suited species scores can be derived for each site or for each sampling unit. The scores for the G, Nu and W criteria were calculated as the difference between the scores for the extremes of the condition. Habitats assessed by suited species score include grassland, arable reversion, heathland, upland rough grazing, banksides, arable field margins and set-aside land.

Scores are calculated using presence/absence or abundance data (e.g. Domin, percentage cover). For an ADAS plot, the local frequency of each species at its optimum scale in the plot (defined as the scale at which its cumulative nest frequency is closest to 16) was used.

*suited species scores:
G- suited to grazing
Nu- suited to low nutrient availability
A- suited to acidic soil conditions

W- suited to high soil moisture content
P- suited to poached conditions
T- tussock forming
D- suited to disturbance
M- suited to high summer soil moisture deficit
C –suited to calcareous soil conditions

7.3.1.1 Strengths

Suited species scores have been used throughout the ESA monitoring to define the goal vegetation and to assess whether this goal has been achieved by comparing the proportions of suited species with the predicted values. They can also be used to measure change by assessing how the proportions of suited species have changed over time. Suited species scores are a repeatable, accountable method as rules for each criterion are defined and applied systematically. When tested, there was a good correlation between the judgements of experts and site scores (Critchley 2000).

Suited species scores can be used to predict variation in biophysical conditions between sites. The suited species scores were explicitly designed to be sensitive to ecological conditions considered ‘good’ or ‘bad’ in terms of specific ESA vegetation management objectives (e.g. G – linked to over- or under-grazing; W – linked to water levels; Nu – linked to consequences of fertiliser application). Hence there is a close relationship between suited species scores and site management. This relationship with management has been validated using independent experimental datasets (Critchley *et al.* 1999a). Other indicators also provide information on plant attributes and can be associated with environmental conditions (e.g. Ellenberg scores and CSR) but not all are so closely related to management issues. Suited species scores can also detect functional change in the vegetation additional to that explained by the direct effects of management applied (Critchley *et al.* 1999a).

The status of the vast majority of vascular plant species occurring in the UK has now been determined for this system, as far as existing autecological information allows. A number of alien and rare species are not included, but this could be achieved by adding the required autecological information to the species-trait matrix.

7.3.1.2 Weaknesses

Suited species scores are not based exclusively on plant traits (because of shortfalls in current knowledge), but also incorporate information on habitat preference and so rely on interactions between plants and environmental conditions. Some adjustments may be needed when applied in other geographical regions as habitat preference can vary in different parts of their range. The status of some species was modified for Scottish ESA monitoring to account for geographical variation in their association with environmental conditions. However, this is now less of an issue as the system has since been improved by regular extension and updating of the species-trait matrix. Variation in performance across different environments is seen across a range of traits and plant functional types (Weiher 1999) so this problem is a general one (see Ellenberg values below) and does not specifically affect suited species scores.

This method will be more successful in some habitats than others, for instance where a lot is known about the relationship between species assemblages and management strategies. In species-poor vegetation, change in a single species can have a large effect on scores. As with all indicators, careful interpretation of the nature of any changes might be necessary. For example, in the South Downs ESA, suited species scores were used to assess the reversion of arable land to calcareous grassland. Although the C score declined, this was not considered to be detrimental because it indicated a loss of calcicolous arable weeds, rather than a loss of desirable calcicolous grassland species.

Species for which no relevant autecological information is available are allocated neutral status. As with Ellenberg scores, bryophytes are not included.

7.3.1.3 Issues

How well do suited species scores measure change?

The suited species scores are sensitive to change in environmental conditions. There may be some variation in their usefulness between habitat types and they are dependent upon the rules used to assign scores.

Can they be applied universally or are other methods such as Ellenberg scores more widely acceptable? Can they be used to compare with control data?

They have been used mainly to assess whether specific management objectives are being achieved. They can also give a more generic impression of the relationship between species composition and environment, as Ellenberg scores do, and comparisons with control data could be made readily. However, there may be a trade-off, i.e. if indicators are explicitly developed to address particular objectives then these indicators might be less applicable as a common cross-scale and cross-biotope indicator of change, for example between control data and smaller-scale impact monitoring. If this is the case then it is unlikely that a catch-all indicator that achieves all objectives is ever possible.

What is their compatibility with JNCC common standards monitoring (JNCC 1998)? Would it be possible to define condition using pre-determined suited species scores?

Suited species scores could be used to measure condition as they are closely related to the management prescriptions for a site. In a report validating condition assessment (Robertson *et al.* 2000) on calcareous grassland sites, detailed monitoring and condition assessment were carried out and compared. Sites with lower Nu suited species scores also had more community character species, and so could be said to be indicating favourable condition. In another study indicators were calibrated using data from English Nature grassland and other surveys (Critchley *et al.* 1999a; Fowbert & Critchley 2000). It was found that suited species scores could be used with other indicators to distinguish between sites of varying quality. For example Nu scores tended to be higher in damaged sites and low G scores were associated with under-grazing. A similar approach could be used to calibrate scores against pre-determined JNCC condition categories.

7.3.2 Ellenberg Scores

Ellenberg, in a series of publications (Ellenberg 1979; Ellenberg 1988; Ellenberg *et al.* 1991), defined a set of indicator values for the vascular plants of central Europe. These have now been derived/calibrated for the British Flora (Hill *et al.* 1999). The relation between Ellenberg values and a measured environmental variable has been calculated for a restricted range of habitats.

Although Ellenberg values contribute to the suited species scores they have not been widely used in measuring vegetation change in agri-environment schemes. However, they have been used in vegetation analysis of CS2000 data to detect trends, interpret change and also to assist in characterising CVS classes. In the wider literature they have been used in a number of ways to interpret vegetation – environment relationships, e.g. to look at historic data to suggest previous environmental conditions and to characterise a site in terms of environmental conditions.

7.3.2.1 Strengths

Ellenberg values have been characterised and tested in many European countries. In some cases this has involved re-classifying values. They have been widely used to compare ecological conditions across habitats and communities at different scales.

Values are available for all species in the GB flora. Ellenberg values relate species composition to environmental conditions in the plot. Some studies have combined physical measurements and plant Ellenberg values to:

study autogenic succession (Sorensen & Tybirk 2000);
indicate soil nutrient status by looking at vegetation (Wilson & Lee 2000);
gain knowledge of habitat quality by combining Ellenberg values with Habitat preferences and other functional traits (McCollin *et al.* 2000);
determine which species are available to the target community from a regional species pool by using them as a filter (Dupre 2000);
relate distance from an ancient woodland boundary and changing environmental conditions with species distribution and to achieve monitoring of SSSI change (Smart 2000);
assess subtle changes in ground flora vegetation resulting from a slight change in canopy cover.

They are a relatively sensitive method of detecting temporal and spatial change, which can be interpreted in the context of prevailing environmental conditions.

7.3.2.2 Weaknesses

Bryophytes are not included; indicator values do exist but have not yet been applied (Siebel 1993). The Ellenberg system does not take account of interactions between environmental variables. Species' distributions are controlled by a combination of environmental variables. Indicator scores tend to be inter-correlated, and so changes in one score may actually be the indirect result of changes in another environmental characteristic (e.g. increasing nutrients and decreasing cutting can both give rise to a taller vegetation stand that displays increased fertility and decreased light scores). Species are not always constant in ecological requirements, some have different indicator values in different parts of their range (Hill *et al.* 2000) reflecting differences in realised niche dimensions from one biogeographic region to another (see also above for suited species scores). This is also influenced by varying intensity of competition from other species under different environmental conditions. Indicator values summarise a complex of parameters associated with the factor of interest, so additional weighting with species tolerances might be required (e.g. species with pH optima near the extremes show narrow tolerances while species with intermediate pH optima show wide tolerances) (Schaffers & Sykora 2000). Ellenberg N values are only weakly correlated with soil parameters (Ertsen *et al.* 1998).

7.3.2.3 Issues

Can they be used to assess whether particular objectives have been met as successfully as suited species scores do?

They can be used to define current and predicted environmental conditions on a site and so do have a relationship to management objectives.

Can Ellenberg scores be used to compare with control data?

Ellenberg values are available for all species so can be readily compared with control data.

What is their compatibility to JNCC common standards monitoring? Would it be possible to define condition using pre-determined Ellenberg scores?

Ellenberg values could be calibrated against condition categories in the same way as for suited species scores.

7.3.3 Functional Interpretation of Botanical Surveys (FIBS)

This is a method for analysing functional changes in vegetation (Hodgson *et al.* unpubl.) based on the plant strategies developed by Grime (1979). Plant functional attributes (including CSR radii (Thompson 1994), canopy height and structure, regenerative strategies, flowering time, seedbank type) can be used to interpret the distribution and population dynamics of species and to predict the consequences of changes in their environment or management regime. The theory is based on three primary axes of specialisation in plant species – competitors, stress tolerators and ruderals. Competitive species are adapted to productive environments and where competition is the limiting factor. They tend to be perennials with high relative growth rates and large canopy structures. Stress tolerators are adapted to unproductive conditions and are slow growing and short lived. Ruderals are species adapted to productive but disturbed environments.

7.3.3.1 Strengths

This method can be used to interpret botanical composition and management regimes of plant communities by functional attributes. It is possible to use an incomplete dataset to gain some understanding of community function. Once species have been characterised the method is straightforward to use. Indices can be calculated using a database of functional traits, although it does require skill for interpretation (Hodgson *et al.* 1999). The method was used in a historical study to look at differences in weed floras associated with different scales of cultivation, related to differences between plots in the degree of fertility, disturbance and watering. Using functional attributes it was possible to discriminate between plots cultivated at different levels of intensity.

7.3.3.2 Weaknesses

Measurement of some species traits is difficult in practice, so data have been collected from the literature for a large number of species. There are many gaps in the current dataset; bryophytes are missing and information is not available for all species in the

GB flora. No account is taken of variation within species, for example variation in genotypes or in life-histories between locations. However, this also applies to other indicators reviewed here. CSR strategy theory is the only attribute in the FIBS system that identifies eutrophication. Current understanding of factors affecting regeneration are incomplete. There is an extensive literature arguing for and against this approach to vegetation analysis, and despite its strengths and utility in applied ecology, it has not gained universal acceptance. Wilson and Lee (2000) give a recent and incisive critique of CSR theory

7.3.3.3 Issues

FIBS data are not available for all species, restricting its current applicability.

Can FIBS be compared with control data?

> Similar to Ellenberg scores - it is straightforward to apply trait data to control data provided there is a database of plant traits and strategies.

What is the compatibility of FIBS analysis to JNCC common standards monitoring?

> CSR radius values have been calibrated against sites of known quality for a range of vegetation types (Critchley *et al* 1999a; Fowbert & Critchley 2000) and so could contribute to determining the condition of a site.

7.3.4 Species richness

Vegetation change may be conveyed in terms of the number of species present in sampling units. The advantage of this measure is its simplicity, although the interpretation of changes in species richness is not straightforward because the measure takes no account of the identity of the species concerned (Smart *et al.* 2002 in press). For some habitats (e.g. heathlands) an increase in species richness may be undesirable, depending on the identity of the species. Moreover, species richness per unit area is a function of plant size, and so can be misleading if the vegetation is undergoing succession to scrub or woodland. Species richness has been used as an indicator in most of the agri-environment monitoring schemes. It is easy to calculate and provided care is taken in interpretation, it can be a useful way of presenting otherwise complex information to non-specialists.

7.3.4.1 Issues

Should other measures of diversity that compensate for species composition (e.g. Shannon Weiner index) be used in preference to species number?

> Changes in the diversity indices can be difficult to interpret, reflecting either a reduction in the number of species or a reduced evenness in species distribution.

How does species richness compare in compatibility with control data to other methods?

> Mean number of species can only be compared between samples at a constant spatial scale. However, species richness at the constant scale of $1m^2$ has been calibrated against sites of known quality for a range of vegetation types (Critchley *et al.* 1999a; Fowbert & Critchley 2000).

7.3.5 Changes in Abundance of Individual Species

In most of the monitoring programmes, changes in the abundance of individual species were assessed. This makes use of standard botanical data, and is usually is relatively simple to analyse using univariate statistical tests. If the ecology of individual species is well understood, interpretation of change can be relatively straightforward. However, individual species might need to be given differential weightings, which is a subjective process. There may be too few records of the chosen species for statistical analysis. In species-poor communities (e.g. saltmarsh) it may be more appropriate to analyse individual species rather than community variables, as it might be easier to relate species change to plant community function than in more complex communities.

If an agri-environment scheme agreement has the objective to protect a particular rare species it would be logical to monitor that species in detail.

7.3.6 Indicator species

Changes in habitat indicator species can be used to detect change in the quality of a habitat. The indicators could be key species that characterise NVC communities, indicator species lists based on expert judgement, published plant community profiles, rare species, or food plants for animals. Notable changes in certain key species can provide a general indication of changes in quality.

This method is most useful for distinctive communities such as calcareous grasslands, where certain species are exclusive to the vegetation type. For communities comprising only generalist species, it may be more difficult to identify key indicators. There are difficulties with the choice of indicator species as this is usually subjective, with conflicting views from experts about which species ‘indicate’ a particular community. It is also necessary to decide how many such ‘indicator species’ are required to characterise a community (See Section 5).

One example is the use of salt marsh indicator species in the Habitat scheme. Species restricted to saline habitats were identified, and their contribution to the total vegetation calculated in the same way as suited species scores. There are relatively few saltmarsh species, and they form a distinct group that is readily identified.

7.3.7 Heather condition

A combination of methods have been used to assess heather condition, percentage cover, age and growth stage. A method was developed specifically for the English ESAs (Poulton 1991) to assess the impact of grazing on heather condition, which has been discussed in Section 2. This method involved collecting heather shoots, determining a grazing index (GI, percentage of shoots grazed) in the laboratory and calculating biomass utilisation (BU) using a calibration expression determined from a separate sample of heather stems. The BU estimates were then applied to suppression thresholds from previous studies by MLURI.

By measuring heather condition, the index has been used as an indicator of quality, and how it changed in relation to grazing prescriptions. Differences in BU have been investigated using ANOVA with the factors, year, agreement class, grazing unit and transect. Differences in responses among agreement classes were assessed by considering year x tier interactions and the significance of differences in proportions of suppressed quadrats using Fisher exact tests. The relationship of BU with environmental and biotic variables has been investigated using stepwise regression. Simple linear regressions have been used to regress stocking rate against BU. Spatial patterns in BU have been analysed using Mantel tests.

7.3.7.1 Issues

The method requires further development to address weaknesses that have been identified (see Section 4.3.2).

Can Grazing index and BU be compared with control data?

> In theory, it should be possible to compare these indices between agreement and control samples. However, this would require heather samples to be collected from control samples specifically for this purpose.

7.3.8 Indices derived from the ADAS plot method

7.3.8.1 Scale-based diversity indices

Ten indices of vascular plant diversity were developed, which were derived from records of species frequency, richness, scale and distribution within ADAS plots (Poulton 1999). These indices measured properties such as dominance, abundance, evenness and scarcity, without reference to species identity. These were selected from an original long list of 18 indices, following tests of their ability to discriminate between different NVC units, their sensitivity to change over time and their robustness to observer-induced variation. The indices were tested on a range of grassland and upland vegetation types. The indices were considered to have potential for describing community structure in terms of species scale, dominance and richness. They could also have potential for highlighting misclassification of NVC communities and for characterising unusual plots. They can also be used for detecting change in community structure that might not otherwise be detected using other indices. For example, two of the indices suggested that calcareous grassland in the South Wessex Downs ESA had become coarser over time, a trend not detected by analysis of species richness or suited species scores. It was noted that some further work might be necessary, including testing the predictive power of the indices on unseen data.

7.3.8.2 Indices of spatial dynamics

A ‘community stability index’ was developed, based on the consistency of species’ spatial locations within an ADAS plot between surveys (Burke *et al.* 2000). The index was tested and showed significant differences between community types. Arable plant communities were shown to be most dynamic in species composition whilst mires, heaths and acidic grassland were the least dynamic. Calcareous and mesotrophic grassland had intermediate index values. Analysis of changes in the index over successive surveys showed that vegetation recovering from major disturbances or flooding showed gradual increases in stability of composition over time, which concurred with the known changes that had occurred within the specific test datasets. The community stability index provides a useful measure of rate of change in species composition within ADAS plots, and could potentially be used to characterise rates of change for different vegetation types. This could also be useful when making decisions about the frequency at which vegetation surveys should be carried out within agri-environment monitoring programmes.

An index of consistency for individual species was also developed, based on continuity of nest occupancy within a plot between survey years. Its purpose was to measure the extent to which species that showed little change in frequency had changing spatial distributions within the plots. There were a number of constraints on the distribution of the index and the precision with which it could be measured. These constraints were associated with nest frequency in each survey year and the fact that there is an upper limit to a species' frequency in an ADAS plot. Taking account of these constraints, relatively few plots yielded data suitable for analysis. However, for a minority of plots it could provide a useful tool to determine the extent to which species populations are dynamic and therefore potentially sustainable.

7.4 DISCUSSION

There is no single best method of abstracting indicators of vegetation character from quantitative plot data. This is because different sets of variables can be used to indicate different attributes of vegetation in a sample. However, all of these variables are derived from the same data, and so are intercorrelated to a greater or lesser extent. Risks of data misinterpretation are therefore inevitable.

Some indicators tend to be interpreted in terms of intrinsic vegetation character. Species richness is a widely-used measure of diversity, but also requires careful interpretation. The FIBS approach provides a potentially powerful functional description of vegetation, although it requires expert interpretation and data are lacking for some species. By contrast, other indicators are used to interpret properties of the environmental and management context of the vegetation. Thus suited species scores are closely related to scheme objectives via the management prescriptions, and can also give a more generic impression of the extant environment. Ellenberg values also indicate the underlying environmental conditions, and can be related to scheme management and objectives. The dangers of mis-interpretation are probably less when these scores are used to indicate a measure of closeness to a desired state (this can be done at the site level) than if they are used to interpret causes of vegetation change (that requires data across very large scales).

All these community variables can potentially be compared with control data, and calibrated into JNCC condition categories. Change in individual species, and indicator species, can also be useful in specific cases. Current methods for measuring heather condition require further research. Indices of diversity or spatial dynamics potentially provide additional information using data from ADAS plots.

8 EVALUATION OF POTENTIAL CONTROL DATA

8.1 AIM AND SCOPE OF THE REVIEW

The aim is to investigate the potential to compare botanical quality and change of agri-environment scheme data with other sources. The two main issues are 1) comparing vegetation condition against external standards and 2) comparing trends in AE schemes with those in the wider countryside. This part of the review looks at potential data sources and considers their application as controls to agri-environment scheme data. It raises issues that need to be considered when establishing controls and discusses some issues relating to statistical procedures and formal tests of difference.

8.2 REVIEW TABLE

Table 8.1 contains references to different data sources, groups them by habitat, characterises them in terms of field method, quadrat size, indicators, analysis, comparability to AE data and other data.

8.3 OVERVIEW OF TABLE

8.3.1 Control Data

Control data are comparable data collected outside a scheme, and are required to answer two types of questions:

- Are there differences in character of vegetation on land entered into the scheme compared with land not entered?
- Are changes in vegetation within the scheme different to those taking place outside the scheme?

The first question relates to selection of land, the second to the management. The interpretation of the comparisons depends upon the objectives of the scheme, and even the individual site; thus, the objective of targeting and maintaining high quality sites is achieved if the vegetation is of desirable character when entered and remains that way. By contrast, a site with the objective of improvement may have a typical vegetation character when entered, but the vegetation increases in conservation quality more than comparable land outside the scheme. Ideally, then, vegetation data are required at the start of the agreements and some time into the agreements, both within and outwith agreement land.

Starting points should be characterised by locating them within the range of floristic variation across a biotope at an appropriate spatial scale (Smart 2000). This range of variation should include intact ‘good quality’ examples as well as communities in a less pristine condition. This can be done using systems such as the CVS and NVC; the former has been used more widely. This approach has been used to calibrate AE scheme samples against independent samples of known quality (Critchley *et al* 1999a; Fowbert & Critchley 2000).

Change data can be analysed using change in CVS or NVC classes, or by direct gradient analysis techniques (Jongman *et al.* 1995; Smart 2000). However, a simpler approach is to summarise this variation using indicator scores, notably suited species and Ellenberg indicators (see Section 7). These indicators provide information about the position of a community along a gradient of change that is both related to management objectives and comparable with other vegetation stands.

There are methodological considerations to take into account in comparing samples with control data. For example, differences in quadrat/plot size can be compensated for to some extent, although it might not be possible to make quantitative comparisons at different spatial scales. Species richness is particularly affected by scale, but other variables such as suited species scores can be as well (Critchley *et al* 1999a). There may be a need to account for the statistical design of site and quadrat selection. The quality (rigour of data collection and validation) of the datasets should also be considered.

8.3.1.1 Establishment of control sample points

Control sampling positions can be established at the time of the AE scheme monitoring, thus ensuring comparability of data in terms of survey methods and quality control. However, this can be problematical for a number of reasons (Critchley 1997). The uptake of a particular type of land into agreement may be so high that non-agreement land becomes a scarce commodity. There is often a fundamental difference between agreement land and non-agreement land in an AE scheme. For example, in the Pennine Dales ESA, most non-agreement land was intensively managed grassland situated at lower altitudes in the ESA, whilst the unimproved hay meadows located further up the valleys, which were of greater wildlife conservation value, were more likely to be entered into ESA agreement. As ESA boundaries normally encompass all land of a certain type that exists in the area, comparable non-agreement land outside an ESA is seldom available for sampling. A further problem common to all AE schemes is that any non-agreement land sampled may be subsequently entered into agreement.

In a number of ESAs, including Breckland, West Penwith and North Peak, livestock were re-introduced to lowland heaths as a result of the land being entered into scheme agreement. This enabled comparisons to be made between fenced plots (simulating the effects of the lack of stock in the absence of ESA management) and unfenced plots (agreement land) (ADAS 1997b). Also in Breckland ESA, conservation headlands were compared with normally cropped headlands on the same farm (Hodkinson *et al.* 1997). In Scottish ESAs, the problem is being addressed by comparing trends between agreement land, land in the whole ESA, and national trends (Cummins *et al.* 1997).

8.3.1.2 Countryside Survey (CS)

Countryside Survey involves the repeated survey of vegetation, land cover and landscape structure of the whole of GB using fixed locations selected at random. It therefore has the potential to be a very powerful set of control data for a wide variety of land management programmes, including AE schemes.

The CS sample design is based on a series of stratified, randomly selected 1km squares. Stratification of sample squares was based on the ITE land classification, taking into account topographic, climatic and geological attributes (Bunce *et al.*

1996). Vegetation plots are arranged within the squares again on a random basis, targeting areas of land, field boundaries and other features, and are relocated at each survey. Data from each plot at each time (1978, 1990 and 1998, with an increase in plot number at each survey) have been classified into CVS classes. Vegetation change is reported by individual country (England, Wales and Scotland) as well as by aggregations of land classes into environmental zones (Firbank *et al.* 2002 in press), Broad Habitat, plot type and major vegetation type (defined as aggregate classes within the CVS). .

Vegetation data are reported for a number of indicators, including Ellenberg scores, CSR strategies, the mean number of species present per plot, the mean species number per plot type, per landscape type, changes in cover of individual species, changes in habitat indicator species and changes in NVC indicator species. Indicators of habitat quality for butterflies and lowland farmland birds are also analysed.

The overlap between Countryside Survey squares and land under agreement in Agri-environment schemes is currently being examined as part of a contract for DEFRA; interim results suggest that it is low. The degree of overlap would be expected to increase substantially under a high take-up entry level AE scheme.

Countryside Survey data are invaluable as time series data representative of the wider countryside. They have been collected using repeatable, carefully designed methods, subjected to quality controls, and uses stratified random sampling. A range of indicators has been used to analyse the data that could be easily calculated for Agri-environment scheme data. There are few data available elsewhere on poorer quality habitat but as CS samples the wider countryside randomly it also contains habitat in less favourable condition. It is not useful as a comparison to all habitats; rarer habitats are unlikely to have been sampled using this method. There was an additional survey (the Key Habitats survey) which used the same methods and some of the same squares but concentrated on five key habitats (Lowland heath, Calcareous grassland, Coastal, Upland, and Waterside) and sampled additional squares. Species have been allocated to habitat indicator groups and species indicator groups. However, this survey has not been repeated so there are only data from 1993.

An example of the use of CS as a control data set comes from the CSS monitoring programme, designed to assess the quality of the land under Countryside Stewardship Scheme agreements and established a baseline for future monitoring (Carey *et al.* 2001a; Carey *et al.* 2001b). The survey used Countryside Survey (CS) methods. Land under agreement was compared with the wider countryside using CS data. The vegetation from each quadrat was categorised in terms of the CVS and NVC. The quality of the habitat was also assessed by mapping Broad and Priority habitats according to field keys to estimate the proportion of land that came into each category. The distribution of CVS classes and Broad Habitat classes were compared with the results from CS2000, showing that vegetation within the scheme was typically richer in infertile grassland than outside. In the absence of baseline data, however, it was not clear whether these differences were due to selection or management; a follow-up survey timed to coincide with the next Countryside Survey (potentially in 2006) will be needed to demonstrate any benefits of management within the Scheme.

8.3.1.3 EN data for monitoring grassland BAP

Currently, a joint English Nature/DEFRA project (AE08) is setting up a national monitoring network of 500 BAP non-designated grassland sites, stratified by agri-environment agreement status (half under agreement). The sample has been drawn from EN Grassland Inventory sites, i.e. unimproved grassland (see 8.3.5.1 below). This will in future provide a comparison between agreement and non-agreement sites.

8.3.1.4 Other sources

Monitoring results from AE schemes can also be compared with those from other independent studies. In the ASPS, the vegetation established under ASPS management options was compared with that from previous experiments and surveys where similar management techniques were used (Critchley *et al.* 2001). Species lists and quadrat data collected from any given habitat have the potential to be used as control data for comparing with that from AE monitoring schemes. Issues such as sampling design and methodology should be taken into account. In particular, the representativeness of the data should also be considered, as many habitat surveys only encompass a small number of sites or a restricted geographic region, reducing the validity of the comparison. Some upland grassland communities represent degraded examples of other communities (such as heathland), and so a number of communities might need to be compared together.

8.3.2 DISCUSSION

Control data are vital to distinguish between change within agreement land and within land beyond, and are vital for the evaluation of any AE scheme. There are two fundamental approaches. The first is to include controls explicitly within the design, thus ensuring that the methods are comparable. The second is to use existing data; CS is appropriate for large scale evaluations of rather frequent vegetation types, but scarcer vegetation is little represented. Therefore there is value is considering more specialised habitat surveys. In both cases, it is easier to ensure comparability of methodology than it is to ensure that like habitats are being compared with like.

The introduction of an entry level AE scheme poses special problems for acquiring and interpreting control data, given its anticipated high take up. Land could be kept outside the scheme to act as controls (in which case, how would changes on such land be interpreted in the future?) or, alternatively, land within the scheme could be considered as the baseline control level for higher tiers.

9 REVIEW OF CONDITION ASSESSMENT

9.1 AIM OF REVIEW

There has been a growing interest, primarily among the statutory conservation agencies, in developing and testing rapid methods of site assessment. Given resource constraints in terms of time and money, and the number of sites to be monitored, there is a need for assessment methods which are quick, simple, repeatable, do not require high levels of expertise and provide effective assessment of site condition. These methods are still in development and few data are yet available to assess their performance. This review provides an overview and discussion of rapid assessment methodologies and begins to explore their applicability to agri-environment schemes.

9.2 CONDITION MONITORING METHODOLOGIES

The statutory nature conservation agencies (English Nature, Countryside Council for Wales, Environment and Heritage Service (Northern Ireland) and Scottish Natural Heritage), co-ordinated through JNCC, are developing a common approach to assessing the condition of Sites (Areas) of Special Scientific Interest using rapid monitoring methods. The production of these common approaches has been delayed and the draft versions, which were originally expected March 2002, are now expected before the end of 2002. Progress on production of methodologies differs between habitats. A methodology for assessment of woodlands has been produced, which represents a common standard for all agencies (Kirby *et al.* 2001). This is being used as the basis for further training of agency staff and is linked to a validation programme over the next two years. For other habitats, however, monitoring methodologies currently differ in some respect between agencies. The methodologies reviewed here are therefore in different stages of development, and some (e.g. for assessment of ponds) are not yet available for comment.

Prior to the work co-ordinated by JNCC on common standards methods, English Nature had developed and published protocols for rapid condition assessment of most habitats (English Nature 1999).

9.3 A FRAMEWORK FOR MONITORING

The overall framework for monitoring sites has been agreed between agencies and is outlined in *A statement on Common Standards Monitoring* (JNCC 1998) This framework involves firstly identifying the feature of conservation interest in a site. *Conservation objectives* are decided, to determine the definition of ‘favourable condition’ for a feature. *Attributes* are then determined which indicate the condition of the feature. Finally, *target* ranges for these attributes are set that represent favourable condition for the feature. The condition of the feature can be monitored by examining the values of the attributes, with reference to their target ranges.

- Features

These are the interest features for which the site has been notified or designated and may consist of habitats, species or geological features. For example, for a chalk grassland site, the CG2 vegetation and a population of early spider orchids may both be features of the site.

- Conservation objectives

Conservation objectives are set for each feature to define what constitutes favourable condition for that feature, by describing broad targets that must be met. Objectives are expressed in terms of attributes and targets. For assessment of designated sites, the objectives are used in two ways: 1) as the basis for monitoring - to define condition status; and 2) as part of the process to evaluate proposed management changes or other impacts to the site - to determine whether these are acceptable or not in terms of nature conservation.

- Attributes

An attribute is described by the JNCC Common Standards framework as “a characteristic of a habitat, biotope, community or population of a species that most economically provides an indication of the condition of the interest feature to which it applies”. It is a measurable characteristic of the vegetation or of the site as a whole. Attributes for habitats may include the area or extent of that site, species composition and structure. They may also include essential processes that determine habitat quality. For example the draft *Conservation objectives for maritime cliffs, sand dunes and vegetated shingle* includes coastal processes, and hydrological regime among a number of selected attributes for these habitats.

- Targets

A target is a range of values for a particular attribute, which represents favourable condition for the interest feature. The target encompasses the range of acceptable fluctuation of the attribute while still considering the interest feature to be in favourable condition. Targets should describe the state of a particular feature and not the management systems or operation leading to that state. Kirby *et al.* (2001) note that targets should be capable of being assessed consistently in a relatively brief visit to the site (for a 10-20 ha site - 2 - 5 hours). As far as possible these should have a wide time window for recording and should not rely too heavily on specialist experience.

9.4 SCOPE OF THE REVIEW

The following methodologies have been considered in this review. Examples of attributes, targets and a brief description of the sampling methodology are included for most methods in the accompanying table (Table 9.1):

- Woodlands - all agencies – Kirby *et al.* (2001) *Objective setting and condition monitoring within woodland Sites of Special Scientific Interest*

- Upland habitats - English Nature – Jerram *et al.* (2001) In: Backsall *et al The upland management handbook - Information note 1- assessing vegetation condition in the English uplands*

- Uplands - DEFRA Rural Development Service and the National Assembly for Wales Agriculture Department – Glaves *et al.* (2001) - *The moorland appraisal pilot project (MAPP) (draft)*

- Uplands – Scottish Natural Heritage – MacDonald (2002). *Draft UK Guidance on Conservation Objectives for Monitoring Designated Sites: Dry heath (upland).* Uplands and Peatlands Group Advisory Services

- Lowland grassland - English Nature - Robertson & Jefferson (2000) *Monitoring the condition of lowland grassland SSSIs - Part 1 English Nature's rapid assessment method*. English Nature research reports Number 315.

- Lowland grassland – English Nature - Robertson *et al.* (2000) *Monitoring the condition of lowland grassland SSSIs - Part II A test of the rapid assessment approach*. English Nature research reports Number 315

- Lowland grassland – English Nature – Robertson *et al.* (2002) *Monitoring grassland Biodiversity Action Plan Targets: condition and restoration assessment methodologies for non-statutory grasslands.*

- Lowland grassland – MAFF – Kirkham *et al.* (2001) *Development of sward-based guidelines for grassland management in ESAs and Countryside Stewardship.*

- Lowland heath - English Nature - Alonso (2001) *Common standards for monitoring lowland heathland*

- Arable habitats – MAFF – Firbank *et al.* 2001 *Development and validation of a methodology for the condition assessment of extensively managed arable habitats.*

- Restoration monitoring (many habitats) - Burch *et al.* (1999) *Habitat restoration monitoring. Development of monitoring methodologies within the Ouse and Alde trial areas*. Peterborough. English Nature Research Reports, No 321.

- Restoration monitoring (many habitats) - Mitchley *et al.* (2000) *Habitat restoration monitoring handbook.* Peterborough. English Nature Research Reports, No 378

- Monitoring methodologies (many habitats) - Countryside Council for Wales - Hurford & Perry (2001) *Habitat monitoring for conservation management and reporting. 1. Case studies.*

- Monitoring methodologies (many habitats) - Countryside Council for Wales - Brown (2001) *Habitat monitoring for conservation management and reporting. 3. Technical guide.*

- Agri-environmental scheme monitoring - Tir Gofal monitoring - CCW - ADAS (2002) *Performance indicators for Tir Gofal habitat management prescriptions. Draft 5*

- Agri-environmental scheme monitoring - Environment and Heritage Service (Northern Ireland) - Corbett, P. (2002) - personal communication

9.5 REVIEW TABLE

The new methods reviewed in this document are summarised in Table 9.1. Methods are described giving details of authorship, habitats covered, attributes assessed, management targets, survey method used and any other relevant information.

9.6 ANALYSIS OF METHODOLOGIES

9.6.1 Choice of attributes and targets

A number of attributes are common to many of the habitat types. For example, extent of the interest feature is included in all SSSI condition assessments, while components of vegetation composition (e.g. positive and negative indicator species) and structure (e.g. sward height, bare ground) are included in many habitat monitoring methods (e.g. Burch *et al.* (1999); Robertson & Jefferson (2000); Alonso (2001)). Other attributes may be very habitat specific. For example ponds and ditch restoration include bank profile as an important attribute, while woodlands include targets for ride structure and dead wood under the attribute 'natural processes and structural development' (Kirby *et al.* 2001).

In grasslands, field methods for assessing sward attributes have been developed to some extent within existing methodologies, e.g. Robertson & Jefferson (2000); Burch *et al* (1999). In addition to this work, Kirkham *et al* (2001) developed sward-based guidelines for assessment of grasslands in agri-environment schemes. Their recommendations included the use of the HFRO sward stick rather than the drop disc method for measurement of sward height. They also found that visual estimates of sward height and herb, weed and tussock cover were feasible at the field scale. However, they concluded that visual estimates of bare ground at the field scale were more difficult, requiring a more systematic approach. They also identified the need for more reliable methods for measuring litter cover and for assessing sward heterogeneity.

Where target species are used as performance indicators of good condition these are typically based on NVC communities, although species used are generally limited to those that can be easily recognised, to minimise recorder error. While this is tenable for SSSIs, this approach is less suitable for agri-environment re-establishment/restoration sites where the starting point may bear little relation to the desired community endpoint and vegetation may develop in an unpredictable way. Rigid NVC-type targets do not allow for this and may result in failing a site which in fact is developing into a community of considerable conservation value. Burch *et al*. (1999) provide guidance lists for recorders of target species based on NVC constants and other species known to be characteristic of restoration swards.

English Nature has begun to define "restorability indicators" for lowland grassland (Robertson *et al.* 2002). Restorability indicators include species that may be useful indicators of favourable substrate conditions for re-establishment, such as lower nutrient levels or a suitable hydrological regime, but may not be constants of the target grassland community and, in some cases, may be a potential problem later in the restoration (e.g. *Deschampsia flexuosa* in acid grasslands). The current list is still in preparation and no testing has been carried out so far, but it is expected to be use in conjunction with the positive indicators already identified for established grasslands (Robertson & Jefferson 2000). Examples of the proposed species are given in Table 5.2 below.

Wet grassland *Cirsium palustre* *Pulicaria dysenterica* *Juncus conglomeratus* *Carex riparia*	**Neutral grassland*** *Veronica chamaedrys* *Prunella vulgaris* *Crepis capillaris* *Potentilla reptans*
Acid grassland* *Deschampsia flexuosa* *Luzula multiflora* *Hypochoeris radicata* *Potentilla anglica*	**Calcareous grassland*** *Brachypodium sylvaticum* *Daucus carota* *Galium mollugo* *Medicago lupulina*

Table 5.2: Examples of "Indicators of potential for re-establishment"

* NB Moist and dry grasslands have been combined here to simplify presentation

The Moorland Appraisal Pilot Project (draft report (Glaves, *et al.* 2001)) is in the process of testing a number of attributes which could be indicative of grazing pressure on moorland vegetation types and determining thresholds for those which are indicative of over-grazing. The fifteen attributes currently being tested include many related to vegetation cover and structure, as well as attributes such as bare ground and faecal events. The full list is given in the accompanying table.

English Nature has also produced interim result of a monitoring methodology for non-statutory lowland grassland sites (Robertson *et al.* 2000). This approach utilises the same attributes set out in Robertson & Jefferson (2000), but adapts target thresholds to account for the generally poorer quality of these sites. They conclude that appropriate thresholds for attributes defining favourable condition should be the subject of further discussion among partners from the grassland Habitat Action Plan group (Robertson *et al.* 2002). They also conclude that field testing and validation of rapid assessment of restoration (re-establishment) potential is required (Robertson *et al* 2002).

9.6.2 Sampling methodology

The majority of condition monitoring methodologies (e.g. Mitchley *et al.* 2000; Robertson & Jefferson 2000; Kirby *et al*. 2001) utilise some form of structured walk in order to assess condition. In most cases, a W-shaped or other walk is suggested with a number of pre-determined sampling positions (typically 10 or 20) evenly spaced along the walk. However, CCW are intending to use random spacing for Tir Gofal monitoring (K. Austin in litt. to RDS). In Northern Ireland, the Environment and Heritage Service are utilising GPS to accurately record and thus relocate these points for subsequent recording (Corbett 2002 pers. comm.). A similar approach is suggested for the trial of Tir Gofal performance indicators in Wales (ADAS 2001b).

At each of the sampling points attributes are either assessed against the given targets or the attributes are measured/estimated, although in most cases it is also expected that the condition should also be assessed between sampling positions. Some methodologies detail the size of area to be assessed at each sampling position. For woodland a 50 x 50 m square is suggested (Kirby *et al*. 2001) , for lowland grassland a 3 - 4 m^2 in front or around the recorder (Robertson & Jefferson 2000). For re-establishment/restoration sites, Mitchley *et al*. (2000) suggest the 1 m radius semi-circle directly in front of the recorder.

Mitchley *et al*. (2000) also differentiate between "straightforward" and "complex" restoration habitats in terms of sampling methodology. The former includes habitats such as woodlands, hedgerows, field margins and coastal grazing marsh, where it is felt that the recorder can make an overall assessment of the site during the structured walk without the need for individual sampling positions. The latter group includes habitats such as grasslands and heathlands where it is felt that more detailed examination of the vegetation at sampling positions is required to identify critical species. Even in these habitats, not all attributes are assessed at the sampling position level and the recording form indicates those, such as litter cover, which are to be assessed for the site as a whole and those, such as positive and negative indicator species, which are recorded at each sampling position.

In contrast to the above methodologies, more rigorous sampling approaches have also been suggested, especially for more extensive habitats such as moorland. These include a SNH proposal to sample moorland using random points (28 to detect a 10% 'failure' rate) within each interest feature (MacDonald 2002). CCW suggest a gridded approach to sampling sites, which is termed a "mapping" approach (Brown 2001). It is argued that structured walks, as detailed above, sample far too little of the site in question and carry the significant risk of coming to false conclusions about site condition. The mapping approach utilises a grid of evenly spaced points, close enough together to consider that the whole feature has been sampled. Although this sounds daunting, Brown (2001) points out that a survey of the whole site may not be necessary. For example if a lower limit for a feature sets a target of at least 80% of points to pass and after visiting 30% of points all have failed, then it can be concluded that the feature is in unfavourable condition. This, however, would generate relatively little data on the site, for example for determining subsequent change. An alternative "selective" approach is also discussed which relies on expert judgement to select diagnostic areas of the site to be sampled in order to determine feature condition. This may be, for example, the most damaged part of the site or the least damaged, but such an approach is only suitable with extensive site knowledge.

In the mapping approach, the initial grid layout is calculated according to the time available, and a GPS system used to locate points. Recorders are expected to check habitat variation between sampling points once in the field and adjust spacing if necessary. The mapping approach "depends on making sure that the grid scale is finer than the scale of habitat variation between points in the field" (Brown 2001). Finer scale habitat variation is dealt with by ensuring that the sampling position is of an adequate size. In general, a circular plot within 1 m of the sampling point is suggested. Assessment is made both through formal recording at the sample points and, like other methodologies, informal observations in between.

Each sample point is assessed and classified in terms of habitat type according to a number of site-specific habitat definitions, rather than assessing a number of attributes against their targets at each point. Thus favourable condition is determined for each feature on a site-specific basis, with lower and sometimes upper limits defined according to vegetation type e.g.:

> "Lower limit - the coastal and maritime heaths comprise a vegetation where: >60% of the heath is open heath which includes >20% open, species-rich heath and where *Pteridium* or scrub covers <20% of the section"

(Source: Hurford & Perry 2001)

Thus if more than the 60% of sampling positions conform to this description, then the feature can be considered in favourable condition.

It must be noted that while CCW's argument may be valid and 10-20 sampling positions may not represent a full assessment of site condition in isolation, most methodologies also require the recorder to take into account the site as a whole as they complete their structured walk. Thus general site observation may also be taken into account in assessing feature condition and equally it is likely that sample positions that are considered very unrepresentative of the site as a whole may be either relocated or that information not utilised. In fact, this requirement of the recorder to consider overall site condition can be considered a significant advantage of such methodologies. It ensures that maximum use is made of the field visit and equally draws on the knowledge of the recorder, who on visiting many such sites would be expected to develop some expertise in assessing overall site condition. However a number of authors have suggested that there is a limit to the area that can be covered by a structured walk (e.g. Robertson & Jefferson 2000) suggest a maximum area for grassland of 15-16 ha).

9.7 DISCUSSION

9.7.1 Site specific vs. generic attribute and targets

A significant issue for discussion during the development of these methodologies has been the wisdom of adopting a generic or site-specific approach to developing attributes and targets.

For example, English Nature's current methodology for Robertson & Jefferson (2000) adopts both generic attributes and targets for each grassland type. Three broad attributes: extent, sward composition and sward structure are applied to all grassland types, with the latter two divided into several components for each type (typically defined by NVC categories) with detailed targets in terms of the acceptable range for particular attributes or maximum / minimum thresholds of species occurrence. In the Upland Management Handbook, Backsall, *et al*. (2001) also prescribe carefully worded but generic attributes and targets for each upland habitat type.

In contrast, Kirby *et al*. (2001) have adopted a methodology for woodlands which utilises a limited number of broad attributes which are then assessed using site-specific targets, with several typically associated with each attribute. The restoration monitoring methodology of Burch *et al.* (1999) and Mitchley *et al*. (2000) also adopt a site-specific approach with opportunities for both attributes and targets to be adjusted to accommodate individual site conditions. Site specificity enables factors such as past site history, the location of the site (particularly in terms of colonisation sources), restoration method and particular problem species to be taken into account (Mitchley *et al*. 2000).

This debate has yet to be resolved. Nonetheless there is still the prospect of a common model being adopted which, like that proposed for woodlands, uses generic attributes for each habitat to be assessed against site-specific targets. This ensures some consistency between sites and agencies while allowing for regional variation and local distinctiveness. JNCC support a limited degree of flexibility to account for geographical or other variation for designated sites. There is a stronger case for generic targets for a national monitoring programme especially when sites may not have site-specific objectives. There may not be a single answer to this issue since it depends upon the use to which the data is to be put.

9.7.2 Categorising site condition

Common standards monitoring requires that all features be assessed according to the JNCC condition categories as set out in JNCC (1998):

Favourable - maintained
Favourable – recovered
Favourable - declining
Unfavourable - recovering
Unfavourable - no change
Unfavourable declining
Partially destroyed
Destroyed

These condition categories provide a UK wide standard against which habitat, species and geological features can be assessed and related to BAP targets, and used to fulfil European and International reporting requirements.

Scoring systems have been adopted in some methodologies. For example, Burch *et al.* (1999) and Mitchley *et al*. (2000) adopt a scoring system, with targets, which are met scoring 2, those almost met - 1 and those not met - 0. The value of this scoring system is not discussed however, with no indication of the level of score required to determine favourable site condition, or degrees of failure. There is also a grey area in deciding which targets are almost met and thus deserve a score of 1.

Jerram *et al*. (2001) also adopt a weighted scoring system in their methodology for assessing upland condition. In this approach the scoring system is used to distinguish between degrees of unfavourable condition, thus enabling managers to direct scarce resources to those features / sites most likely to yield results. A score is given for each attribute failed, with additional weighting given to those attributes considered to be of particular importance in determining feature condition. In these cases, scores are sub-divided with more points awarded to poorer examples of a particular condition.

There is a danger in using a scoring system of adopting a pseudo-quantitative veneer to what is essentially a qualitative form of assessment. Unless there is a strong justification for scoring and thus ordering sites or features, as suggested by Jerram *et al*. (2001), then scoring as a record of condition assessment should be avoided. However, condition categories provide a more effective and transparent method of assessment.

9.7.3 Evaluation of populations of individual target species

Sites in the AE schemes with populations of rare species are a special case. While habitat condition may be critical for species survival, it may also be desirable to provide some assessment of individual species success. To some extent condition assessment can be used as a surrogate for species population assessment e.g. by monitoring habitat components such as vegetation structure and the presence of food plants. A study by Firbank *et al.* (2001) explored the validity of habitat assessment as a method of forecasting species occurrence within the Pilot Arable Stewardship Scheme. While habitat assessment provided a useful forecast for two invertebrate groups (Carabids and Heteroptera) little correlation was found for both birds and rare arable plants. Thus, habitat condition assessment in isolation must be used with caution as a method for monitoring individual rare species populations. Methodologies do exist with Common Standards Monitoring e.g. counting numbers of individuals, reproductive success and survival, but further analysis of this issue is beyond the remit of the current study.

9.8 EVALUATION

In order to evaluate these methodologies a number of predetermined criteria were set before commencing on this review, these are discussed individually below:

9.8.1 Time taken per site

A critical factor in evaluating a rapid method of assessment must be the time taken per site A number of authors provide some indication of the likely time needed for carrying out the methodology. For example, for woodland Kirby *et al*. (2001) suggest 2-3 hours for a straightforward site up to about 20 ha and for larger or more complicated sites, a whole day; for lowland grassland Robertson and Jefferson (2000) suggest 30-45 minutes if no structured walk is done and an additional 30-60 minutes to be allowed for the structured walk; for upland habitats Jerram *et al*. (2001) suggest half a day to one day; restoration sites (Burch *et al.* 1999) - typically one hour or less.

The rapidity of many of these methods and their comparative simplicity in the field belies the expertise required in setting them up. In terms of time and expertise this is very much a ‘front-loaded methodology’, with large inputs required at the outset, in devising the methodology, determining suitable attributes, typically on a generic basis for a particular habitat and then defining suitable targets. Once this process is completed, however, the methodology has the potential to provide a simple, repeatable and rapid method of monitoring sites.

9.8.2 Qualitative vs. quantitative data

Many methodologies include the collection of some quantitative data, such as the frequency of indicator species at a number of sampling positions. However, assessment is largely based on a qualitative judgement of site condition, albeit one which is made within certain pre-determined criteria (attribute and targets). Only the CCW and MAPP mapping methodologies provide a more quantitative approach, given the number of sampling points recorded.

9.8.3 Amenability to statistical analysis

In general most of these methods are unsuitable for statistical analysis. Where sample positions are used to collect information, these are not randomly selected and the number recorded too small to be statistically valid. In most cases an element of subjectivity is included in the assessment and observations made between sample positions are taken into consideration in determining feature condition. Both the CCW mapping approach utilising a large grid of points and the SNH random sampling method provide information potentially amenable to statistical analysis.

9.8.4 Provision of management information

Most of the methods examined provide a rapid assessment of management needs which is determined in the field at the time of recording. Information such as the over-abundance of negative indicator species, inappropriate sward height etc. can be used to trigger changes in management prescriptions for the site. Rapid assessment provides the opportunity to monitor these changes and ensure that the management is appropriate for site objectives. The CCW mapping approach however, may only answer the question - is the site in good condition? – if as is suggested recording can cease once this question has been answered. Thus little or no information may be gathered on the particular management needs of the site. In contrast, Jerram *et al*. (2001) methodology for uplands provide the opportunity to score ‘unfavourableness’ and thus to prioritise management needs across a number of sites.

9.8.5 Level of expertise required

All methodologies require some botanical expertise in recording key indicator species. However the list is typically limited and it would be expected that recorders would soon become familiar with the identification of these critical species. In general, attributes and species that require specialist identification skills are avoided. Unlike conventional quadrat recording there is no requirement for all species to be identified and recorded, thus avoiding identification problems. In contrast however, these methods typically require some level of subjective recorder judgement of site condition. While this is framed within given criteria for the particular feature, the recorder is expected to make an overall assessment of the site, or in the CCW mapping approach an assessment of each recording point. It would be expected that the recorder would initially bring some level of expertise to such a task and develop this expertise as more sites are visited.

A critical factor in terms of expertise is who will carry out the monitoring work. There is a marked difference between the statutory agencies in this respect and thus a difference in the finer detail of their methodologies. At one extreme, English Nature proposes to use conservation officers to carry out condition monitoring of at least a proportion of SSSIs, thus restricting the choice of indicator species to those which can be easily and reliably identified. In contrast, the Environment and Heritage Service (Northern Ireland) will carry out all monitoring using a dedicated recording and monitoring team. This allows more sensitive and hard-to-identify indicators to be utilised and more complexity added to the methodology where necessary.

9.8.6 Scientific validity

Validation of these methodologies using quadrat recording is essential to ensure that they are assessing condition effectively and picking up critical components of the vegetation that would be detected using more rigorous methods. In many cases it will only be through repeated condition monitoring and associated validation that the choice of attributes and target levels can be properly assessed and adjustments made for future recording. To date, few of the methodologies have undergone rigorous validation testing, although work is in progress to develop a network of validated sites to test the methodologies in the future. Only English Nature’s lowland grassland methodology has undergone a more rigorous validation Robertson *et al*. (2000), with three grassland types tested on a total of 15 sites. Overall this demonstrated the rapid assessment method to be robust between different recorders and allowed the relationship between selected indicator species and site condition to be examined, leading to further refinements of the methodology. Testing has also been carried out of the woodland methodology although the results are not yet published. Validation of some sites in the restoration monitoring project Burch *et al.* (1999) showed approximately 50% agreement between quadrat and rapid assessment methods in determining attribute condition. Where anomalies were identified, changes to the monitoring methodology or targets set were suggested for future monitoring.

9.8.7 Ability to cope with site heterogeneity

Site heterogeneity can be a significant problem in setting out an appropriate monitoring methodology. For example, the NVC-driven approach utilised by Robertson & Jefferson (2000) may be difficult to apply in vegetation that does not conform to any particular NVC community. In many cases habitat mosaics or transitions complicate the picture and may require separate recording forms and zoning of the site to provide adequate coverage of the different communities. This adds to the argument for site specificity, where adaptations for heterogeneity can be written into the monitoring scheme from the outset. For example, where colonisation from an adjacent source is an issue, a site may be zoned into margin and core for some attributes to take account of this. The CCW mapping approach is particularly well suited to coping with habitat mosaics, as for example; a target percentage can be set to allow for a mosaic of two or more habitat types.

9.9 ISSUES FOR FURTHER DISCUSSION

9.9.1 Comparing condition assessment with conventional quadrat recording

While validation is essential to assess condition monitoring against conventional quadrat recording, another important question is whether condition assessment provides additional information that a more rigorous quadrat method does not. Clearly, in many ways the type of information picked up in a condition monitoring approach would equally be picked up via quadrats e.g. frequency and broad cover estimates of bare ground and individual species. What quadrat recording does not typically allow for is the scope for the recorder to make an overall assessment in the field. Sometimes a visual assessment of what is happening in the field as whole, framed within the criteria set out within the attributes/targets, can be as useful as detailed species information provided within quadrats.

Another important distinction between quadrat and condition monitoring is the point at which an assessment of site condition is made. In conventional quadrat methods, data is collected in the field and then analysed later to provide an assessment of sward development. In condition monitoring, an assessment of feature condition is typically made immediately in the field, although some additional information may need to be obtained after the visit. This offers the scope for some further assessment of management needs to be made, if condition is judged unfavourable, at the time of recording, as well as the considerable saving in terms of data entry and analysis.

Quadrat data could be used to assess against JNCC condition categories if clear objectives, attributes and targets are set. However there is a danger that this method may result in collecting far more information than is necessary to answer the question. In all monitoring projects, the amount of data recorded should depend on the question being asked.

In this respect, once condition categories and targets have been set in relation to site or scheme objectives, the RCA data will answer the questions set. However the RCA cannot easily be reassessed against changing criteria or objectives. This is a major strength of quadrat data, which does provide this kind of objective flexibility to adapt to changing priorities and objectives and to address new questions as they may arise.

9.9.2 How often should sites be monitored?

The Common Standards Monitoring Cycle states that all features on all sites should be monitored within consecutive six-year periods. However several authors advocate more frequent visits than this. Robertson & Jefferson (2000) suggest that visiting frequency should be determined on a site-specific basis - “as often as necessary to secure favourable condition”. CCW’s Tir Gofal methodology suggests monitoring at the commencement of the agreement and then in years 4/5 and again in years 9/10 at the end of the ten-year term. The restoration monitoring methodology of Burch *et al.* (1999) and Mitchley *et al.* (2000) adopts a similar pattern although an additional recording period is included in years 2/3. This is perhaps unnecessary and also unlikely given resource restraints. An argument for this however would be the ability to pick up management problems early in the restoration, rather than waiting until half way through the agreement.

10 EXISTING AND POTENTIAL ADDITIONAL ENVIRONMENTAL DATA

10.1 AIM AND SCOPE

The aim of the review is to evaluate the importance of environmental data additional to botanical monitoring, with particular reference to data collected within agri-environment schemes of England and other UK countries. Such data include field level information on soil, topography, weather, management practices, ditch physical and chemical properties, farm socio-economic characteristics and data on atmospheric deposition of pollutants.

10.2 OVERVIEW

10.2.1 Soil

Vegetation character is intimately dependent upon soil pH, drainage, nutrient status, organic matter and structure. Soil data can therefore be used to interpret present patterns of vegetation, and also to identify potential constraints against achieving some desirable vegetation condition. Soil data have been collected as part of many AE monitoring programmes.

In English ESAs, soil samples were collected from botanical monitoring sites in grasslands and related vegetation under DEFRA-funded research project BD1429 (Chambers *et al.* 1999; Critchley *et al.* 2002; Critchley *et al.* in press). Soil samples were taken from 16 ESAs during 1995-1997 and analysed for pH, extractable phosphorus (P), potassium (K) and magnesium (Mg), total nitrogen and organic matter, and assessed for texture. Such data are also available from the Arable Stewardship Pilot Scheme (ASPS) (Critchley *et al.* 2001). Soil samples from the Habitat Scheme Saltmarsh Option monitoring sites were analysed for were pH, salinity (exchangeable sodium (Na) %), concentration of the electrolytes potassium (K), Na, calcium (Ca), magnesium (Mg) and chlorine (Cl), and redox potential (ADAS 1998b).

In the Moorland Scheme monitoring programme, soils were sampled (ADAS 1998h) but the data had not been reported on before the monitoring programme was discontinued. No soil sampling has been carried out in the monitoring programmes for the Countryside Stewardship Scheme and the Farm Woodland/Farm Woodland Premium Schemes.

In all six Welsh ESAs, a similar sampling programme to that in English ESAs was carried out during 1997-1999 under project BD1429 (Chambers *et al.* 2000). In addition, soil samples (0-15cm depth) have been taken adjacent to plots at the same time as each botanical survey in the monitoring programme (Table 2.1). Over a 3-4 year period, some significant changes in soil properties were detected, but these were small in magnitude. In Northern Ireland, soil samples have been collected from ESAs as part of the monitoring programme, and in the Republic of Ireland from the Rural Environment Protection Scheme (REPS) (Table 3.1). In the first phase of monitoring of Scottish ESAs, soil type was also recorded.

All of these sampling programmes have the potential to be used as baselines for changes in soil properties. Moreover, soil samples were collected during the Countryside Surveys of 1978 and 2000 and provide a control dataset that shows the changes in soil condition over that period for the wider countryside, using a range of potential indicators currently under development.

Analysis of English and Welsh ESA samples have revealed clear relationships between species composition and sets of soil variables, and relationships were also detected in other AE schemes. Soil data are often important explanatory variables in accounting for variation in vegetation encountered in AE schemes. Particular plant communities will therefore be sensitive to changes in soil properties, especially pH and nutrient status. The raising of soil nutrient status would be likely to have a rapid detrimental effect on most semi-natural vegetation. The response of vegetation will often lag behind changes in soil properties, and so measurement of soil properties might give an early warning of the likely response of the vegetation. However, changes in soil properties are only likely to take place slowly. For example, in the absence of fertiliser N additions, soil pH decreases of c. one pH unit only occur over a period of several decades (Johnston *et al.* 1986). Similarly, soil total P can still be declining 45 years after the last application of fertiliser (Olff *et al.* 1994). Only small changes to soil properties have been detected to date in the monitoring programme for Welsh ESAs. Therefore, soil sampling need not be done frequently.

10.2.2 Physical and chemical properties of ditches

Just as soil properties influence vegetation, so do other parameters (including water width, depth, flow, colour, visibility and conductivity, bank depth and slope, and dyke bottom substrates) influence the vegetation in and at the edges of ditches.

Such data have been collected from appropriate ESAs, i.e. the Broads, Somerset Levels, South Downs and North Kent Marshes (ADAS 1991c; ADAS 1991d; ADAS 1996b; ADAS 1997j). The water conductivity measurements collected in the Broads ESA were used to try to explain changes in vegetation, although changes in conductivity and vegetation did not always correlate. In the North Kent Marshes the conductivity was measured in one year only, therefore changes over time could not be determined.

In the Somerset Levels and South Downs ESAs rhyne/ditch monitoring was carried out on small samples therefore it was difficult to draw firm conclusions. The only trend observed was that of declining water levels in the Somerset Levels, though it was not possible to relate these to species diversity for which there was no evidence of change. In these and the Broads ESAs, the other measured parameters were not formally used in the interpretation of the results, though they might have provided useful background information.

The most useful environmental parameter recorded in ditch surveys was water conductivity. Eutrophic status is linked to conductivity levels and, generally, dyke vegetation quality deteriorates as the conductivity and/or nutrient levels in the water increase. However, brackish communities associated with high conductivity and/or nutrient levels can also be of conservation importance. Other data such as water depth may also provide useful interpretative information but their value should be weighed against cost of collection.

10.2.3 Topography

Slope and aspect were collected as part of the survey for the first stage of the Scottish ESAs and also, along with altitude, in conjunction with the GI/BU data for the English ESAs (ADAS 1997c; ADAS 1997h; ADAS 1997i; ADAS 1997l; ADAS 1998f). In the English ESAs the relationship between the environmental data and BU was determined using stepwise regression. The results varied between ESAs, but with the exception of altitude in Exmoor, altitude, aspect and slope were not, however, powerful predictors of BU. Altitude and topography were noted by surveyors as part of the CSS (Carey *et al.* 2001a).

Topography data are also available from national digital terrain models at several resolutions. While the value of such data in AE monitoring has not been demonstrated, they may be useful to help target site selection for new agreements.

10.2.4 Meteorological data

Weather exerts great influence on plant growth and community dynamics. Meteorological Office temperature and rainfall data have been used to interpret some vegetation changes in some ESAs; thus, in tier 2 of the South Downs ESA, (semi-improved mesotrophic (river valley) grassland) there was a decrease in the W score (species suited to prevailing high moisture content) (ADAS 1996f). This decrease was attributed to the dry weather. Dry weather was also used to explain the decrease in height in tier 1(3) of the South Wessex Downs ESA (ADAS 1997k) (unimproved, calcareous downland). In the Suffolk River Valleys ESA, dry weather inhibited maintenance of high water levels of the wet grasslands, and the W score decreased in the fen meadows (ADAS 1997e).

It has been shown that the weather is an important factor when trying to explain changes in vegetation in the short term, and it is, potentially, even more important in the long term. Weather data is readily available. More importantly, the Environmental Change Network (ECN), the DETR indicators of climate change (DETR, 1999) and the UK Phenology Network provide national control data on the responses of vegetation to weather, and have the potential to help interpolate between CS surveys. The ECN has a network of sites across Britain that regularly record data on a daily/seasonal basis for a range of standard variables, including meteorological ones. The network has been specifically designed for the early detection of environmental trends such as climate change. There are 12 terrestrial sites and the network began in 1992 (Tinker 1994). ECN sites particularly useful for comparison against AE botanical data are those that have historically been managed for agriculture and currently have rough grazing, improved pasture or arable land uses, and vegetation at ECN sites are monitored and reported in ways comparable with CS. This would be especially useful for indicating the effects of severe drought on grassland. In the longer term, the ECN data will also provide an important control data set for the detection of global climate change signals.

The DETR indicators of climate change are only of limited use for comparison with agri-environment scheme botanical monitoring, since the measurements rely on condition of species and timing of events rather than population levels. Similarly data from the Phenological Network cannot readily be related to AE monitoring until relationships between species phenology and population levels and distributions can be established.

10.2.5 Field management practices

Management of land under agreement is the mechanism by which the agreements are assumed to influence vegetation. Therefore, data on the relationships between management and vegetation are essential to ensure the development of agreement prescriptions, and to assess the contribution of management to vegetation change compared with other factors, such as weather.

Within the English ESAs, information on the management history of many of the grassland and heathland monitoring sites (see Table 2.1) was obtained by questionnaire from agreement holders. The information covered all aspects of management and included cropping, grazing regime, cutting regime, fertiliser applications and other chemical treatments. Data on the history of drainage, re-seeding and liming practices were also collected. Quantitative analyses to relate management data to vegetation condition or change were not generally done (apart from agreement status or management option), because of the difficulty in standardising management data, but management data were useful for interpreting the potential causes of vegetation change.

In the South Downs ESA, in the permanent grassland option, the sites were classified into endgroups. In the ‘well-grazed unimproved chalk grassland endgroup’, calcicoles decreased in the sward, consistent with the reported reduction in grazing pressure and a shift from sheep to cattle grazing. In the ‘under-grazed unimproved chalk grassland’ endgroup, species suited to high nutrient availability was seen to decrease. This was related to the management data, which showed that half of the fields concerned had received nutrient enrichment prior to but not after entry into the scheme (ADAS 1996f). In the Pennines Dales ESA, reductions of Nu scores corresponded with a reduction of fertiliser inputs (ADAS 1996d).

In the Suffolk River Valleys ESA, an increase in G score (species suited to grazing) was detected in two endgroups, ‘semi-improved dry acid grassland’ and ‘grass/heath scrub developing on former arable land’(ADAS 1997e). The introduction of grazing by livestock at the start of the ESA probably contributed to the increases in G scores observed. Summer drought, in acting as a disturbance and favouring certain annual species which are also suited to heavy grazing, may have contributed to the high G scores, which highlights how management might interact with weather. Relatively high G scores in the first year were attributed to rabbit grazing.

In the Pennine Dales ESA, an attempt was made to formalise the relationship between management and vegetation communities (Askew 1994), although the management data had to be standardised into broad categories.

Management data may be less valuable than might be expected, as the data are taken from agreement holder records rather than from independent observations, and so may be inaccurate or incomplete. In spite of this, the information can provide useful contextual and background information when interpreting the results of the monitoring, even where analysis of the data is not possible. It is possible that these links could be more formalised in order to maximise the usefulness of the collected data. Moreover, as farms are required to maintain better management records as part of quality assurance schemes and other parts of their business, it may prove easier to obtain high quality and consistent management data from farmers.

10.2.6 Social and economic data

Socio-economic monitoring was carried out in the early years (1987-1990) of the English ESAs. Changes to the farm businesses e.g. cropping or livestock systems, in a sample of scheme participants and non-participants were investigated, the financial effects on farmers and on Exchequer were examined, and farmers' attitudes to the scheme were studied (ADAS 1991a; ADAS 1991c; ADAS 1991d). The Environmental evaluation of the Countryside Stewardship Scheme: Module 1 (Carey *et al.* 2001b) had a large socio-economic component. This survey of 500 new CSS agreements assessed the capabilities of the agreement holder to carry out the work prescribed along with ecological and landscape surveys. If the sites were resurveyed the socio-economic impacts could be assessed. An economic evaluation of the CSS was carried out by ADAS and the CCRU of the University of Gloucestershire (Crabb *et al*. 2000) but this work is not be amenable to ecological assessment.

While socio-economic circumstances may well influence whether land enters in the scheme and the choice of prescriptions, it is hard to envisage a major additional effect on vegetation change. Certainly, socio-economic information has not been useful to help to explain change in vegetation with AE schemes to date.

10.2.7 Atmospheric deposition of pollutants

Vegetation is influenced by the deposition of N and sulphur from the atmosphere from industrial and transport sources. It has been shown that there is a correlation between N deposition and shoot N concentration for some herbaceous species, e.g. *Calluna vulgaris* (Pitcairn *et al* 1995; Kirkham 2001). There is also evidence that nitrogen has detrimental effects on some species, particularly bryophytes, lichens and mychorrhizal fungi. *Sphagnum* species are particularly sensitive to even low levels of nitrogen (Bell 1994). Critical levels of N deposition have been identified for different vegetation types, above which botanical change can occur (Grenfelt & Thornelof 1992). Increased nitrogen levels can also interact with other factors such as climatic or grazing stress, or heather beetle *Lochmaea suturalis*, which can exacerbate the negative effects (Heil & Diemont 1983; Kirkham 2001). Temporal trends in S deposition have differed from those of N, with S generally declining in recent years (RGAR, 1997). Interactions between these two plant nutrients may well exist in their effect on vegetation.

Atmospheric deposition data are collected by various bodies including the Atomic Energy Authority. As part of the UK acid deposition monitoring network they collect data on sulphur dioxide, particulate sulphur, nitrogen dioxide, ammonia, nitrous and nitric acid. Nitrogen and sulphur deposition levels have been modelled and mapped for the UK to a 20 km square resolution (RGAR, 1997), and more recent modelling by CEH has produced data, to a 5km resolution. Such resolution is too coarse to establish potential effects of pollutants on individual fields, especially when considering pollutants from point sources, such as pig and chicken units.

It would be valuable to obtain data on the deposition of pollutant nitrogen for monitoring sites, partly to understand failures to maintain low-fertility vegetation, and partly to develop a better understanding of the interactions between N and S deposition, management and vegetation dynamics. If deposition data were to be obtained from only a sub-set of sites, it would be important to ensure that the sample encompassed both a range of habitats – including sites supporting particularly susceptible species - and also the range of deposition levels encompassed by each habitat type.

10.2.8 Discussion

There is a wealth of additional environmental data that can be collected in the field or obtained from national data. However, the record of such data having been used to increase understanding of vegetation change at the agreement or scheme levels is poor: there has been a tendency to collect data in the faith that it will prove useful, rather than collecting data to parameterise specific models or to act as covariates in particular analyses. There is also a grey area here between collecting data necessary for monitoring and for research. Soils, hydrology and management data may well of value in primary monitoring, by indicating change before it becomes apparent in the vegetation. Data from ECN may have a similar role, albeit over much longer timescales. Other data, however, are probably of greater importance for research into factors influencing vegetation dynamics, but only if the research is well specified.

CHAPTER 3

DATA CLASSIFICATION AND POWER ANALYSIS

1 INTRODUCTION

Since the launch of the first AE schemes in 1987, much progress has been made with classifying vegetation and habitats in the UK. For example, the National Vegetation Classification (NVC) for grassland was first published in 1992 (Rodwell 1992), while more recently the Countryside Vegetation System (CVS) was developed for monitoring of change in the wider environment through the Countryside Surveys (CS) of 1978 and 1990 (Bunce *et al.* 1999). Many of the earlier AE monitoring programmes were launched before these developments, although in many cases these classifications have been used subsequently.

UK Biodiversity Action Plan (BAP) Broad and Priority Habitats are presently seen as an important policy framework for the reporting of vegetation change, including that which occurs in AE schemes. Details of BAP Habitats were first published in 1995 (Anon 1995b) – the final round of ESAs was launched prior to this in 1994.

The Countryside Stewardship Scheme (CSS) monitoring programme was set up after the development of the BAP framework and CVS, so both these classification systems were used in the monitoring programme (Carey *et al.* 2001a). The use of land cover data was investigated for allocating ESA monitoring samples to BAP Habitats. However, very few ESA land cover classes were found to be directly related to Priority Habitats (Critchley *et al.* 1999). Moreover, it was also clear that there were Priority Habitats within ESAs for which there was little or no biological monitoring data. The use of CVS for ESA monitoring was also assessed. The agreement between CVS classes and ESA vegetation types was low in most of the lowland grassland sample, but slightly better for upland vegetation (Critchley & Burke 1999).

There are therefore three main objectives in this chapter:

1. The classification of AE botanical datasets into the main frameworks used today for the analysis and reporting of change. This will enable the continued usefulness of the datasets to be assessed.

2. A program of power testing to enable the detectable change to be estimated for different sample sizes.

3. The calculation of sample sizes needed to detect progression towards provisional targets representing pristine and degraded habitats.

2 DATA CLASSIFICATION

2.1 METHODS

ESA monitoring has been carried out using two main techniques; 1m x 1m quadrats were used in the early ESAs, whilst 4m x 8m ADAS plots (Critchley & Poulton 1998) were employed in later ones. In addition, sampling strategy also varied primarily due to local objectives (see Chapter 2). CSS monitoring used two types of nested quadrats; random quadrats were 200m^2 whilst targeted quadrats were of a size appropriate to the vegetation (Carey *et al.* 2001a).

Data were collated from the DEFRA AEMA database and from the CSS database currently held by CEH into three datasets: Countryside Stewardship Scheme (CSS) data, ESA plot data and ESA quadrat data. Only the main grassland and upland botanical datasets were utilised from ESAs. Data from other habitats were excluded (see Appendices 1.1 and 1.2). Also excluded were the Indicative and Extension grassland datasets from the Pennine Dales (because they were not available at the time of the analysis). All data were classified by NVC, CVS and where possible Broad Habitat and Priority Habitat. In addition, GIS information was used classify the data to county level (for categorisation by Region), and to determine the correspondence, if any, of AE plot/quadrats with statutory designations (*e.g.* SSSI, SAC *etc.*). Classifications were slightly different for each dataset.

2.1.1 National Vegetation Classification (NVC)

CSS data had been classified previously using a program (SIMIL) provided by the Unit of Vegetation Science at the University of Lancaster (Carey *et al.* 2001a). SIMIL works in a similar way to the MATCH (Malloch 1992) program, using species abundance or frequency data to calculate similarity coefficients for each plot based upon their similarity to NVC constancy tables.

The ESA plot data had also previously been classified to NVC level and this information was also used. However, three plots had no NVC information (two in the Lake District ESA and one in the South Wessex Downs ESA), and in one ESA (Clun) the majority of plots had not been classified to one NVC level.

The ESA quadrat data had been classified using Twinspan (Hill 1979) and the NVC communities or sub-communities of the end-groups determined using a combination of MATCH (Malloch 1992) and constancy tables. Individual quadrats had not been directly classified into the NVC.

NVC classification of the missing ESA plot data and the ESA quadrat data was therefore carried out using the SIMIL programme. Classification of these data provided the top ten matches with a similarity score (0-100%). Generally, the top score was chosen, particularly if it was high (> 60%). However, the scores were often very low, in which case the frequency of occurrence of NVC communities in the SIMIL output for a quadrat or plot was also referred to (*e.g.* a single plot may be categorised to MG6, MG6a and MG6b). If two NVC communities were found to be equally frequently recorded, in the output, then that with the higher similarity score was chosen. Occasionally, a plot would have a very high score (*i.e.* > 50%) for a particular community – this was almost always also the most frequent community. Some allowances were made for vegetation types where there were no sub-communities, *e.g*. MG8, and in those cases where the classification was thought to be particularly unusual; for example SD17 (*Potentilla anserina – Carex nigra* dune-slack community) appeared a number of times. Rodwell (2000) indicates that this community is very similar to MG8 (*Cynosurus cristatus – Caltha palustris* grassland) and it is possible that the lack of/inclusion of a single species can change the classification of such plots/quadrats significantly. For the purposes of this project, samples were only classified to community level.

2.1.2 Countryside Vegetation System (CVS)

The existing classification of CSS data into the CVS was used. CVS classification of ESA data was carried out using a program developed by CEH and available on the Internet at:

http://www.ceh-nerc.ac.uk/products_services/software/cvsflier.htm

The program allocates plots and groups of plots to one of the hundred vegetation classes that make up the classification. A full list of classes and their descriptions can be found in Bunce *et al.* (1999). Allocation of plot data uses a binary decision tree developed from the original Twinspan classification of the Countryside Survey plots recorded in 1978 and 1990. The program does not use cover or constancy data to allocate plots.

2.1.3 BAP Broad Habitat

Classification by Broad Habitat was done using the tables produced by the Joint Nature Conservation Committee (JNCC) (Jackson 2000). Many NVC categories had one core vegetation class and one or two associated classes, whilst some had more than one core class. If an NVC had more than one core class, it was deemed to be unclassifiable. This mainly affected the MG6 group (found in Neutral Grassland and Improved Grassland), but also M25 (found in Fen, Marsh & Swamp and Bogs).

The most frequently recorded associated classes were Boundary & Linear Features and Built Up Areas & Gardens. These were discounted as the data being classified was from AE schemes and so these features were unlikely to be represented. However, a few NVC communities had an associated vegetation type that might be found in an AE scheme; M16 was found in the core vegetation of Dwarf Shrub Heath but also in the associated vegetation of Bogs. These communities were also unclassified.

This exercise was carried out for all datasets, even though land cover data (in the case of ESAs) and Habitat data (in the case of CSS) were also available. This was partially so that all data could be treated equally, but also because of the influence of scale on the classification. The ESA land cover information and the CSS Habitat data were carried out at a different scale than the allocation of individual plots to Broad Habitats by NVC. A comparison of the original CSS BAP classification with that determined by NVC was carried out.

2.1.4 BAP Priority Habitat

Classification by Priority Habitat using the NVC alone was more problematical as some habitats are at least partially defined by their landscape context. However, from the Tranche 1 Actions Plans (Anon 1995b) and the Tranche 2 Action Plans downloaded from the internet (Anon 1998, 1999), http://www.ukbap.org.uk), it was possible to classify eight priority habitats using the NVC (see Table 1). In addition the Purple Moor Grass & Rush Pastures Priority Habitat was classified using the information detailed in Burke & Critchley (2001).

Table 1. BAP Priority Habitats and associated NVC communities.

Priority Habitat	Vegetation types
Lowland Calcareous Grassland	CG1 – CG8, CG9[1]
Upland Calcareous Grassland	CG9[1], CG10 – CG14
Lowland Dry Acid Grassland	U1[1], U2[1], U3[1], U4[1], SD10b[2], SD11b[2]
Lowland Meadows	MG4, MG5, MG8
Upland Hay Meadows	MG3
Lowland Raised Bog	M1 – M3, M18 (M15, M19, M20, M25, U4)[3]
Blanket Bog	M1 – M3, M15, M17 – M20, M25
Upland Heathland	H4[1], H8[1] – H10, H12, H16, H18, H21, M15, M16
Purple Moor Grass & Rush Pastures	M22 – M26

[1]Straddles lowlands and uplands
[2]Inland examples only
[3]These five communities *may* be found in Lowland Raised Bog

No core vegetation communities of Lowland Raised Bog (M1 – M3, M18) were recorded in the datasets. CG9 (*Sesleria albicans – Galium sterneri* grassland) is indicated as occurring in both lowlands and uplands. One only example was found of this community, in the Pennine Dales ESA, and as a result it was not included in the analyses. M25 (*Molinia caerulea – Potentilla erecta* mire) is a core vegetation of both the Fen, Marsh & Swamp Broad Habitat and the Bogs Broad Habitat. Therefore, as well as occurring in the Blanket Bog Priority Habitat (associated with the Bogs Broad Habitat), it could also occur in one of the Priority Habitats associated with Fen, Marsh & Swamp which include the Purple Moor Grass & Rush Pastures Priority Habitat. The M25 records were therefore left unclassified. Such a situation also affected other mire communities; M15 (*Scirpus cespitosus – Erica tetralix* wet heath) was recorded in both Blanket Bog and Upland Heathland Priority Habitats, for instance.

2.2 RESULTS

2.2.1 NVC classifications

From the 533 CSS plots classified, seventy-seven NVC categories were recorded but only six contained twenty or more records (twenty being the cut-off used for power testing). There were seventeen quadrats of CG2 for example and only two of MG3 (upland hay meadow). Of the six communities with greater than twenty records (Table 2), five were mesotrophic grasslands, with MG6 clearly the most frequent, representing nearly 20% of the CSS dataset; this was followed by MG5 and MG7. The sixth community was OV23 (*Lolium perenne – Dactylis glomerata* community), a community of coarse weedy vegetation in which the two grass species make up the bulk of the vegetation. Together, all six communities accounted for 54.5% of the data. In total mesotrophic grassland (MG) made up 58% of the data, whilst OV communities accounted for another 13%.

Table 2. Most frequently recorded NVC vegetation types in CSS.

Community	**Name**	***n***
MG6	*Lolium perenne – Cynosurus cristatus* grassland	106
MG5	*Cynosurus cristatus – Centaurea nigra* grassland	68
MG7	*Lolium perenne* leys and related grasslands	48
MG10	*Holcus lanatus – Juncus effusus* rush-pasture	26
MG1	*Arrhenatherum elatius* grassland	22
OV23	*Lolium perenne – Dactylis glomerata* community	21

Thirty-eight NVC categories were recorded from the 1614 records in the ESA quadrat dataset, with nearly 90% of the quadrats classified as mesotrophic grassland. Calcareous grasslands were the next most frequent, but they accounted for less than 4%. Overall, the most frequent community was MG7 (Table 3), followed by MG10 and MG6. Only ten NVC categories contained twenty or more quadrats; CG3 (*Bromus erectus* grassland) and OV23 (*Lolium perenne – Dactylis glomerata* community) were the only two non-mesotrophic grassland communities in this list and accounted for 2.4% and 1.5% respectively. The OV23 community occurs on mesotrophic and eutrophic soils in areas that have been re-seeded and that are generally subject to infrequent management, other than periodic mowing (Rodwell 2000). Nearly 3% of the data were classed as OV vegetation.

Table 3. Most frequently recorded (> 20 quadrats) NVC vegetation types in ESA quadrat data.

Community	**Name**	***n***
MG7	*Lolium perenne* leys and related grasslands	549
MG10	*Holcus lanatus – Juncus effusus* rush-pasture	312
MG6	*Lolium perenne – Cynosurus cristatus* grassland	230
MG11	*Festuca rubra – Agrostis stolonifera – Potentilla anserina* grassland	99
MG9	*Holcus lanatus – Deschampsia cespitosa* grassland	94
MG13	*Agrostis stolonifera – Alopecurus geniculatus* grassland	50
CG3	*Bromus erectus* grassland	39
MG1	*Arrhenatherum elatius* grassland	34
MG8	*Cynosurus cristatus – Caltha palustris* grassland	32
OV26	*Epilobium hirsutum* community	24

Of the 591 ESA plots, thirty-three NVC communities were recorded with mesotrophic grasslands the best represented (62%) followed by upland grassland communities (14%) and mires (10%). Calcareous grasslands made up 9% of the data. Only nine communities contained greater than or equal to twenty records (Table 4). MG6 was the single largest group (144 records, 24%), followed by MG7 and MG5. However, communities such as U4, CG2 and H4 were also represented (8%, 6% and 3% respectively). There was no OV vegetation represented in the ESA plot data.

Table 4. Most frequently recorded (≥ 20 quadrats) NVC vegetation types in ESA plot data.

Community	**Name**	***n***
MG6	*Lolium perenne – Cynosurus cristatus* grassland	144
MG7	*Lolium perenne* leys and related grasslands	63
MG5	*Cynosurus cristatus – Centaurea nigra* grassland	52
U4	*Festuca ovina – Agrostis capillaris – Galium saxatile* grassland	47
MG10	*Holcus lanatus – Juncus effusus* rush-pasture	39
CG2	*Festuca ovina – Avenula pratensis* grassland	36
MG9	*Holcus lanatus – Deschampsia cespitosa* grassland	35
M23	*Juncus effusus/acutiflorus – Galium palustre* fen-meadow	22
H4	*Ulex gallii – Agrostis curtisii* heath	20

Mesotrophic grassland communities were highly frequent in all three datasets accounting for 75% of the combined records, but there were relatively more in the ESA quadrats (88%) than in ESA plots (62%) and in the Countryside Stewardship Scheme (58%), (Figure 1). However, the CSS data contained a lot of OV communities, whilst the ESA plots contained none. This is a reflection of the nature of the datasets. The Countryside Stewardship monitoring contained a proportion of random plots in addition to plots targeted at priority habitats, whilst the ESA monitoring was targeted at particular vegetation types or tiers depending on local objectives. The CSS data and the ESA plots also contained a number of records classified as heath vegetation, a type that was absent in the ESA quadrats. Mire and montane communities were also relatively poorly represented in this dataset.

A number of minority communities were also found in the three datasets, including Aquatic, Maritime Cliff, Sand Dune and Salt Marsh communities (Figure 1). Most of these communities (twenty-one of twenty-three) were from the CSS data.

Full details of communities recorded can be found in Appendices 1.3 and 1.4.

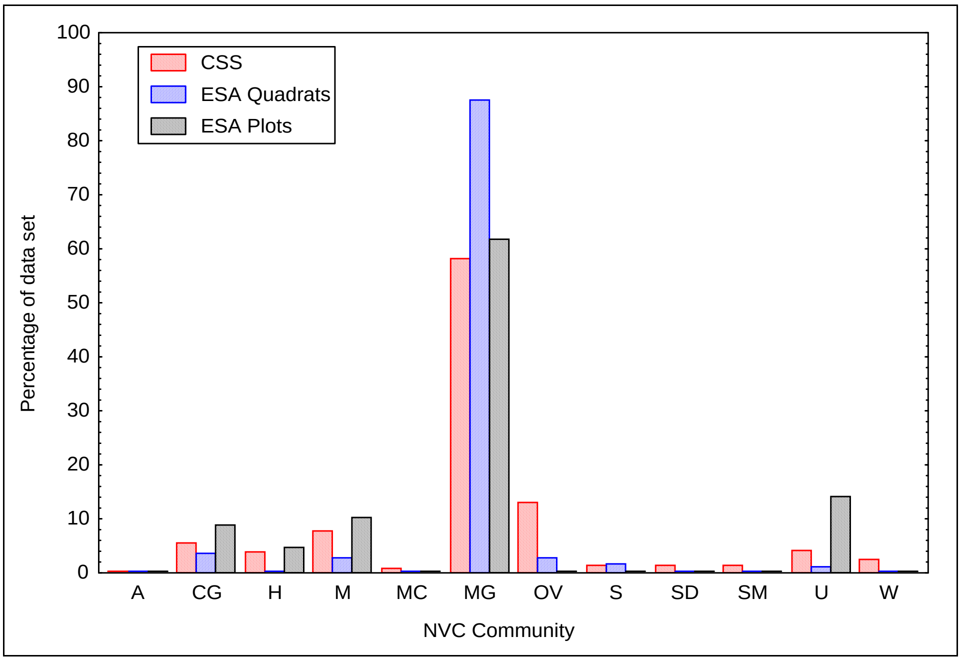

Figure 1. Representation of vegetation classes in the three datasets.

2.2.2 CVS classification

Sixty-one CVS vegetation classes were recorded from the CSS data with the highest number (113, 22%) from the Rye-grass/Yorkshire Fog grassland category (class 40). Five classes contained twenty or more plots and these were all from two aggregate classes, Fertile Grassland and Infertile Grassland (Table 5). In addition, these two aggregate classes accounted for 74% of the plots overall.

Table 5. Most frequently recorded CVS vegetation types in CSS.

Aggregate class	**Vegetation class**	**Community**	***n***
4	40	Rye-grass/Yorkshire-fog grassland	113
3	30	Fertile mixed grassland	80
4	44	Calcareous grassland	38
4	43	Rye-grass/Bent Grass grassland	34
4	51	Wet rushy grassland	24

Thirty-seven different CVS vegetation types from nine aggregate classes were recorded in the ESA quadrat data, but Fertile mixed grassland and Rye-grass/Yorkshire Fog grassland made up the majority of the vegetation at over 55%. Wet rushy grassland accounted for another 14%. Only nine classes contained 20 or greater records (Table 6).

Table 6. Most frequently recorded CVS vegetation types in ESA quadrat data.

Aggregate class	**Vegetation class**	**Community**	***n***
3	30	Fertile mixed grassland	484
4	40	Rye-grass/Yorkshire-fog grassland	411
4	51	Wet rushy grassland	219
4	43	Rye-grass/bent grass	141
4	44	Calcareous grassland	76
3	29	Rye-grass grassland	66
3	31	Rye-grass/clover G	42
2	10	Tall grassland/herb boundaries	24
4	41	Species-rich stream-sides/wet grassland	20

Forty CVS vegetation classes were recorded from the ESA plot data with seven having twenty or more records. The Rye-grass/Yorkshire Fog grassland category was the most abundant (Table 7). Fertile mixed grassland and Calcareous grassland were also well represented and, in addition, Wet heath/moorland grass and Bracken/acid grassland were also present.

Table 7. Most frequently recorded CVS vegetation types in ESA Plot data.

Aggregate class	**Vegetation class**	**Community**	***n***
4	40	Rye-grass/Yorkshire-fog grassland	164
3	30	Fertile mixed grassland	69
4	44	Calcareous grassland	67
4	51	Wet rushy grassland	51
8	90	Wet heath/moorland grass on variable soils	25
3	31	Rye-grass/clover grassland	23
6	64	Bracken/acid grassland	20

A comparison of the CVS vegetation classes was difficult due to the large number and wide range found. However, Table 8 shows the data broken down by aggregate class. Infertile grassland in all three datasets occurred at a similar level and accounted for over 56%. However, the ESA quadrat data contained more Fertile grassland, whilst the CSS data had more Tall grassland/herb data, although the numbers were relatively low. Heath/bog did not occur in the ESA quadrats but was relatively frequent in the ESA plot and the CSS data, Moorland grass/mosaic was also uncommon in the ESA quadrats. Overall, the CSS data contained a wider range of classes than the other two datasets.

The single largest CVS class was class Rye-grass/Yorkshire-fog grassland (class 40) with 688 records, followed by Fertile mixed grassland (class 30, 633 records). However whereas the former occurred at a relatively high frequency in all three datasets, the latter was found mainly in the ESA quadrat dataset. The other two largest classes Rye-grass/bent grass grassland and Neutral grassland (classes 43 and 51 respectively) also had a large component from this data source. Complete lists of the CVS categories recorded can be found in Appendices 1.5 and 1.6.

Table 8. Percentage of Records by CVS Aggregate class in CSS and ESA Quadrat and Plot data.

CVS Aggregate Class		CSS	ESA quadrats	ESA plots	Mean
I	Crops/Weeds	1.50	0.06	0	0.52
II	Tall Grassland/Herb	7.50	4.09	0.17	3.92
III	Fertile Grassland	21.58	37.24	16.75	25.19
IV	Infertile Grassland	52.53	57.50	58.21	56.08
V	Lowland Wooded	1.50	0	0	0.50
VI	Upland Wooded	4.32	0.06	3.38	2.59
VII	Moorland Grass/Mosaic	6.38	1.05	10.83	6.09
VIII	Heath/Bog	3.94	0	10.66	4.87
	Unclassified	0.75	0	0	0.25

2.2.3 BAP Broad and Priority Habitats

Of the 533 quadrats in the CSS data, only 353 (66%) were classified according to BAP Broad Habitat (Table 9). Of the ESA quadrat data, Broad Habitat categories could be assigned to 82% records, whilst 70% of the ESA plot data was classified. Many of the quadrats and plots remained unclassified as they fell into more than one Broad Habitat (as determined by NVC). Other NVC classes (such as the OV classes) were not possible to assign to Broad Habitats.

Table 9. All recorded Broad Habitats (as classified by NVC) in CSS and ESA quadrats and plots.

Broad Habitat	CSS	ESA quadrats	ESA plots	Total
Neutral Grassland	156	635	158	949
Improved Grassland	48	549	63	660
Fen, Marsh & Swamp	47	61	24	132
Calcareous Grassland	29	59	52	140
Acid Grassland	22	17	84	123
Dwarf Shrub Heath	20	0	27	47
Supra-littoral Sediment	8	1	0	9
Littoral Sediment	7	0	1	8
Supra-littoral Rock	5	0	0	5
Broad-leaved, mixed and yew woodland	3	0	0	3
Bracken	3	0	2	5
Bogs	2	0	5	7
Inland Rock	2	0	0	2
Water	1	0	0	1
Unclassified	180	292	175	647

Fourteen Broad Habitats were identified in the CSS data with Neutral and Improved grasslands the best represented – Neutral Grassland alone accounted for 29% of the quadrats (44% of the classified sample). Only five Broad Habitats had twenty or more quadrats.

It was possible to assign Priority Habitat status (based on NVC) to 129 plots (22% of the sample, see Table 10) and of these Lowland Meadows was the largest group (seventy-six quadrats) followed by Lowland Calcareous Grassland (twenty-six quadrats).

Table 10. All recorded Priority Habitats (as classified by NVC) in CSS and ESA quadrats and plots.

Priority Habitat	**CSS**	**ESA quadrats**	**ESA plots**
Lowland Meadows	76	32	67
Lowland Calcareous Grassland	26	58	52
Lowland Dry Acid Grassland	11	15	61
Upland Calcareous Grassland	3	0	0
Upland Hay Meadows	2	2	0
Upland Heath	9	0	27
Blanket Bog	2	0	5
Unclassified	415	1507	411

In the ESA quadrat data, out of six identified Broad Habitats, Neutral grassland and Improved grassland were the most common (73% of the total, 90% of the classified sample, Table 9). From this, four Priority Habitats were identified; Lowland Calcareous Grassland, Lowland Meadows, Lowland Dry Acid Grassland, Upland Hay Meadows. Only 139 quadrats (8%) could be classified to Priority Habitat level and only the first two habitats contained at least twenty records – the Upland Hay Meadows Priority Habitat contained only two (Table 10). Coastal and Floodplain Grazing Marsh could not be identified because it is dependent on the geographic location, and encompasses other Priority Habitats and more than one Broad Habitat.

Nine Broad Habitats were recorded from the ESA plot data (Table 9), but only three Priority Habitats. Neutral grassland accounted for 27% (of the total) with Acid grassland equivalent to 14% (of the total). Only 180 plots (30%) could be classified down to Priority Habitat level (Table 10). Lowland Meadows was most frequent (67 plots) followed by Lowland Dry Acid Grassland (61 plots) and Lowland Calcareous Grassland (52 plots).

The CSS dataset had the widest range of Broad Habitats identified, with the ESA quadrats the least. However, the Neutral Grassland Broad Habitat, was the most frequent in all three datasets, and was highest in ESA quadrats and least in ESA plots. The ESA quadrats also had a larger number of Improved grassland records, such that these two categories made up 90% of the data, although all three datasets had similar amounts of Improved grassland (14-15%). The CSS data had a higher number of Fen, marsh & swamp records, whilst the ESA plots had a greater amount of Acid grassland. No Dwarf Shrub Heath Broad Habitat was found in the ESA quadrats, but it was recorded in the CSS dataset and in the ESA plots (6% in both cases).

The majority (74%) of unclassified quadrats and plots had been classed as MG6 grassland (Table 11). The remainder was a mixture of OV, M, S and W communities representing a range of Broad Habitats.

Table 11. Table. AE quadrats and plots not able to be classified to a single Broad Habitat level. A&H = Arable & horticulture, B&L = Boundary & linear features, BMW = Broad-leaved, mixed and yew woodland, Bogs = Bogs, BUA = Built-up areas and gardens, CW = Coniferous woodland, DSH = Dwarf shrub heath, FMS = Fen, marsh & swamp, IG – Improved grassland, NG – Neutral grassland, OW = Standing open water & canals and R&S = Rivers and streams.

NVC	**Broad Habitat**	**CSS**	**ESA quadrats**	**ESA plots**	**Total**
MG6	IG, NG	106	230	144	480
OV	A&H, CW, B&L, BUA	56	21	0	77
M	B&L, FMS, Bogs, DSH	11	9	31	51
S	FMS, OW, R&S	0	29		29
W	BMW, B&L	7	3	0	10
Total		180	292	175	647

In total, seven Priority Habitats were recorded from the data. All were recorded in the CSS data, with the least number of habitats recorded from the ESA plots. In general lowland communities were better represented than upland communities. All three lowland communities were found in similar numbers in the ESA plot data, whereas the CSS data had a large number of Lowland Meadows and the ESA quadrats a large number of Lowland Calcareous Grasslands. Lowland Dry Acid Grassland was found only at low levels and in both the CSS and the ESA quadrat data. However, the ESA plot data did have a larger number of Upland Heaths than the other two data sources. None of the upland communities were identified in the ESA quadrat data.

It is possible that more of the samples could be classified as Priority Habitat with the use of additional spatial data perhaps using a GIS. This might at least help determine where to place samples that could fall into more than one Priority Habitat based on NVC community. An example would be the use of the MAFF moorland line to split upland and lowland habitats (e.g. upland heath and lowland heath and blanket bog and purple moor-grass and rush pastures).

2.2.4 Government Office Regions and Statutory Designations

Although grid references were used to determine this information, for the ESA grassland data, many grid references in AEMA were either missing or incomplete. However, some ESAs, such as the Clun ESA, are entirely in one region, whereas the Pennine Dales ESA is split between three regions (North West, North East and Yorkshire and Humberside); this allowed the more records to be categorised than would otherwise be possible. Some grid reference information was also missing from the CSS data. It is understood that work has subsequently been done to input and correct grid references in AEMA, which would enable the classification to be completed.

Table 12 shows the number of records in each scheme in the various Government Office Regions. The majority of the unclassified ESA quadrat data was from the

Pennine Dales ESA, whereas unclassified data in the ESA plots dataset were from the Avon Valley and South Wessex Downs ESAs. Data for the ESA quadrats are based upon the number of fields, not the number of quadrats.

Whilst CSS data were from all the English regions, the majority was in the South West and South East Regions. The ESA data are obviously biased due to the location of individual ESAs. Quadrat data were recorded from only six of the twenty-two ESAs found in England and so none were recorded from either the West Midlands or East Midlands regions. ESA plots were not recorded from either the North East, Yorkshire and Humberside or Eastern regions – three areas where the Tranche 1 ESAs were launched. Overall, therefore, the South West clearly has the greatest concentration of AE botanical monitoring sites (27%) followed by the South East and Yorkshire and Humberside (both approximately 15%). The East Midlands region had the least number of sites (3%). Unclassified data accounted for 7% of the total.

Table 12. Number of quadrats and plots in the three schemes in each Government Office region. ESA quadrat figures are based on the number of fields, not the number of quadrats.

Government Office region	**CSS**	**ESA quadrats**	**ESA plots**	**Total**
North East	26	162	0	188
North West	36	59	24	119
Yorkshire & Humberside	63	226	0	289
West Midlands	50	0	138	188
East Midlands	51	0	8	59
Eastern	61	99	0	160
South West	132	100	309	541
South East	104	110	82	296
Unclassified	3	109	30	142
Total	526	865	591	1982

The missing/incomplete grid references presented a greater problem for the classification by statutory designations. Only 545 of the 865 fields with ESA quadrats could be classified (63%). This compares with 75% for ESA plots and 99% for the CSS data (see Table 13).

Of the CSS data, eighty-three sites had statutory designations, of which all were SSSIs. Of these, a further twenty-one sites were SPAs and thirteen of these were also Ramsar sites. Nineteen of the eighty-three sites were SACs and two were NNRs. However, in some cases, some of these designations refer to the same holding.

Many more of the ESA grassland sites had a statutory designation than the CSS sites. This is reflects the targeted nature of ESA scheme, whereas CSS monitoring was random (in terms of site selection) and partially random (in terms of plot selection). However, no ESA grassland sites appeared to coincide with NNR sites, whereas two of the CSS sites did.

Over 66% of the ESA quadrats were SSSIs compared to 22% for the ESA plots and less than 16% of the CSS data. SACs were the next most frequent designation, although the table (Table 13) clearly shows that they were relatively less frequent in the CSS and ESA plot data. However, the widest range of designations was found in CSS, with all five designations recorded; the ESA quadrats had the least – only SSSIs, SACs and SPAs were recorded here. Ramsar sites are poorly recorded in agri-environment schemes. This is firstly because the definition of wetlands as "areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres" (Convention on Wetlands, Ramsar, Iran, 1971), means that little of it would be found in AE schemes and secondly because only 79 Ramsar sites have so far been designated in England (Anon. 2002).

Table 13. Number of statutory designations found in the CSS and ESA quadrat and plot datasets.

Statutory designation	**CSS**	**ESA quadrats**	**ESA plots**	**Total**
SSSI	49	155	61	265
SSSI NNR	1	0	0	1
SSSI SAC	12	125	25	162
SSSI SPA	6	0	6	12
SSSI SAC SPA	2	80	0	82
SSSI SPA RAMSAR	8	0	8	16
SSSI SAC SPA RAMSAR	4	0	0	4
SSSI SAC SPA RAMSAR NNR	1	0	0	1
Total designated sites	83	360	100	543
Total classifiable	523	545	449	1517

No Ramsar sites were recorded in ESA datasets but thirteen were found in the CSS dataset, although some of these were on the same holding. However, the Avon Valley is a Ramsar site designated on 02/02/1998 and encompasses the lower reaches of the Avon between Bickton and Christchurch and thus would cover the same area as part of the Avon Valley ESA. However, this ESA was also one where only incomplete grid references were available. This problem also seems to effect the Broads ESA and the Somerset Levels and Moors ESA parts of which are covered by the Broadland and Somerset Levels and Moors Ramsar sites.

2.2.5 Comparison of CSS BAP classifications

In the current study, the allocation of CSS plots to BAP Habitats was carried out using NVC classifications only. Allocation of CSS plots to BAP Broad and Priority Habitats was also carried out in the field at the time of survey and whilst there is some correspondence between the two classifications, overall it is quite poor (see Appendix 1.7). In addition, some of the categories originally allocated in the field survey were combinations of more than one habitat, for example 'Lowland Dry Acid Grassland/Upland Heath'. Some groupings showed better correspondence than others did. Of the twenty-nine plots classed as Calcareous Grassland based on their NVC, twenty-four of them had originally been identified as being that Broad Habitat, with the remainder a variety of communities including Improved Grassland and the combination of Broad-leaved Mixed Woodland/Calcareous Grassland.

The Cereal Field Margins Broad Habitat was not used or identified in the current work. Thirty-six examples of it had been found which, when the plots were classed by NVC, where either left unclassified for Habitat (many of the OV communities), or were categorised mainly as either Neutral Grassland, Improved Grassland or Fen, Marsh and Swamp.

The Neutral Grassland group as classed by NVC, corresponded with twenty-five of the original vegetation classes – but only 3% of the group were in the original Neutral Grassland class; 44% were in the Improved Grassland Broad Habitat and 16% in the Calcareous Grassland / Lowland Calcareous Grassland classes.

Only two of the plots had been placed into the Purple Moor Grass & Rush Pasture Priority Habitat at the time of survey. As classed using NVC, these came out as Fen, Marsh & Swamp or Neutral Grassland.

In formulating the future recommendations for monitoring (Chapter 4), the NVC classifications have been used to allocate existing samples to BAP habitats. This ensures that a standard approach has been applied across all the datasets. However, there will be instances where a quadrat or plot is located in a particular habitat, but the quadrat or plot data are classified as a different habitat due to differences in spatial scale. In neither NVC nor BAP is spatial scale well defined, because patch size varies for plant communities and habitats. Potentially, individual samples could be allocated to BAP habitats at the two different scales, i.e. at the plot or quadrat scale using the NVC classification of the botanical data, and at scale of the whole site or vegetation patch using a habitat classification as was done in CSS.

3 POWER ANALYSIS

3.1 METHODS

3.1.1 Community variables

In the CSS data, bryophyte and lichen species were frequently recorded. In the ESA data, lichens and bryophytes were rarely recorded except where certain species or groups were of concern *e.g. Sphagnum* species. All lichen and bryophyte species records were therefore deleted from all datasets before analysis.

The following community variables were calculated; species richness, British Ellenberg Nitrogen and G and Nu suited species scores. Suited species scores were developed for the evaluation of vegetation in ESA monitoring relative to ESA management prescriptions, objectives and performance indicators. The relevant ecological conditions are identified and species can then be classified according to a set of criteria. Analysis of these 'suited-species' can subsequently be carried out based on the changes in the proportions of these species. A single species can have a status for a particular criterion of –1, 0 or +1 (Critchley *et al.* 1996b; Critchley 2000).

The G score (species suited to grazing) uses information on canopy height and structure and on life history to determine suited-species (Table 14). The higher the score, the higher the level of grazing. The Nu score uses information on Stress radius (Grime *et al.* 1988), Ellenberg Nitrogen Index (Ellenberg 1988), Fertility score (Wheeler & Shaw 1992) and Ecoflora Fertility (Fitter & Peat 1994). A high Nu score represents a high nutrient availability.

Table 14. Definitions and ecological information required for the G and Nu scores.

Criterion	Definition	Data sources/information
G score	Grazing	Canopy height/structure, life history
Nu score	Soil fertility	Stress radius, Ellenberg N Index, Ecoflora Fertility

The average British Ellenberg Nitrogen scores were calculated with the species values taken from Hill *et al.* (1999).

Quadrats in the CSS dataset were of two types, Random and Targeted (see Carey *et al.* 2001a). In the random quadrats, species were recorded according to the nest and the cover of all species was estimated over the 200m^2 in 5% bands. In the targeted quadrats, presence/absence was recorded only for all species. As a result, all community variables were weighted by presence/absence.

In the ADAS plot method (Critchley & Poulton 1998), a fixed 4m x 8m plot is established, containing 32 x 1m x 1m nests. Species are recorded from within these nests at different scales (1-10) with scale 1 being a random pin hit in the smallest nest (2cm x 2cm). This was used in all ESAs except the Cotswold Hills ESA where 2m x 4m nests were used resulting in 32 x 0.5m x 0.5m nests. Community variables were calculated at maximum scale (scale 10, equivalent to presence/absence) and at optimum scale. Species richness and Ellenberg N were calculated at scale 10 (i.e. $1m^2$).

Burke & Critchley (1999) had previously found that it was possible to record from only sixteen nests from an ADAS plot without unduly compromising sensitivity. As a result, community variables were calculated for thirty-two nests and for sixteen nests. Data for nest numbers 1-16 in each plot were used for the latter.

Quadrats in ESAs were 1m x 1m and species were recorded from them using the Domin scale. All community variables were calculated at the presence/absence level whilst G and Nu scores were additionally calculated using Domin weighting.

Optimum scale data was used for the power analysis of the ESA plot data; both Domin weighting and presence/absence weighting were used in the analysis of the ESA quadrat data.

3.1.2 Power testing

To get some idea about the magnitude of change that can be detected for a given sample size a series of power calculations have been conducted. These were done 1) using variability between plots or quadrats in one year of survey and 2) using variability of the difference between repeated surveys. For this purpose the standard deviation of the difference (SD diff) has been used. It is assumed that this will also be typical of surveys done in the future. For any given variable the SD diff varies considerably so power calculations have been undertaken at average SD diff as well as for the smallest and largest observable values of SD diff. Using this information the magnitude of change has been calculated that could be detected for a range of different sample sizes and these results tabulated.

Calculations were done using Minitab software.

3.2 RESULTS

The CSS data showed the widest range of species richness whilst the ESA grassland quadrat and plot data exhibited similar ranges. However, all three datasets had a modal species richness in the 10-20 range. Lowest G scores were observed in the CSS dataset, whilst high G scores were recorded in both ESA datasets. The CSS dataset also had low Nu scores, along with the ESA plot data, whilst high scores were recorded in the ESA quadrat dataset.

British Ellenberg Nitrogen indices exhibited similar trends to the Nu scores. They were also highly correlated, with r^2 = 89% for the CSS data, for example. This is not surprising as the Nu score incorporates some information on species' Ellenberg N values.

The correlations of Nu and British Ellenberg N index were also significant for ESA quadrats (r^2 = 80% for presence/absence; r^2 = 32% for Domin weighted data) and ESA plots(r^2 = 92% at optimum scale; r^2 = 80% at scale 10).

There was little difference between the results from ESA plots for thirty-two nests and the results for sixteen nests. Correlations of the data between thirty-two and sixteen nests showed that for species richness and Nu score, r^2 = 98%, whilst for British Ellenberg N, r^2 > 99%. The G score gave the poorest correlation although it was still highly significant (r^2 = 89%).

3.2.1 Single surveys

The CSS data consisted of 533 samples, ESA plot data 591 samples and ESA quadrat data 1614 samples.

The desire is to detect change if it occurs in the community variables when sites are categorised by NVC class, CVS class, Broad Habitat or Priority Habitat. Appendices 1.8-1.11 summarise the means and standard deviation by these categories for each variable and each source of data. Results are limited to categories where at least 20 samples were present. This still presents an enormous quantity of results and standard deviations (sd) have been summarised (across categories) further in the following table.

Table 15. Summary of standard deviations across all categories.

	Mean sd	**Smallest sd**	**Largest sd**
Richness (n=96)	5.138	1.344	11.869
Ellenberg N (n=96)	0.479	0.195	1.238
Nu (n=122)	0.168	0.076	0.461
G (n=122)	0.147	0.045	0.409

The power of a test can be defined as the ability (probability) of the test to declare a result as significant when a true change has occurred. In the following examples a power of 85% is used, i.e. when true differences occur we have a 85% probability of detecting them. To simplify presentation, power curves have been calculated for the smallest, mean and largest sd based on a two sample t-test (e.g. random quadrats at two time points).

Figures 3-6 represent the situation for differences in species richness, British Ellenberg N, Nu score and G score respectively. These provide a guide to the likely sample size necessary to detect a given difference if a random sample or plots or quadrats was to be re-selected at each survey. For example, in an average situation, a sample size of 10 could detect differences of 7.3, 0.68, 0.24, and 0.21 with 85% power respectively for the four variables.

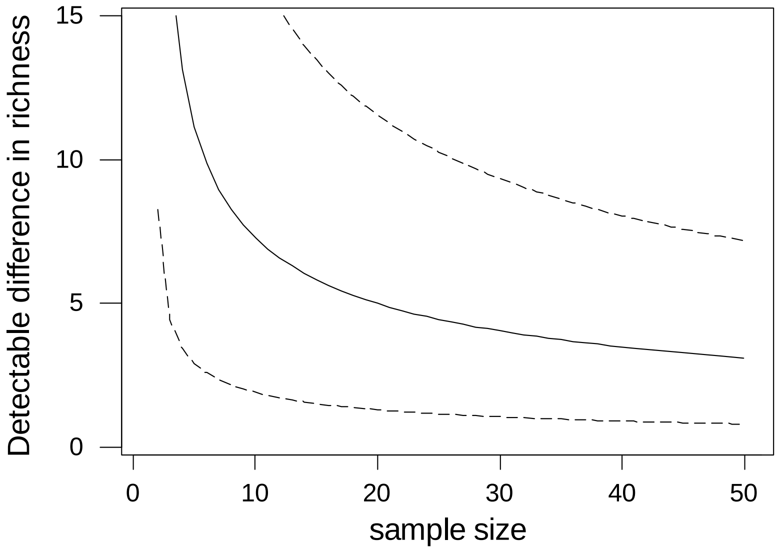

Figure 2. Detection differences in species richness for various sample sizes based on three sd situations; minimum sd (lower line), mean sd (solid line) and maximum sd (upper line).

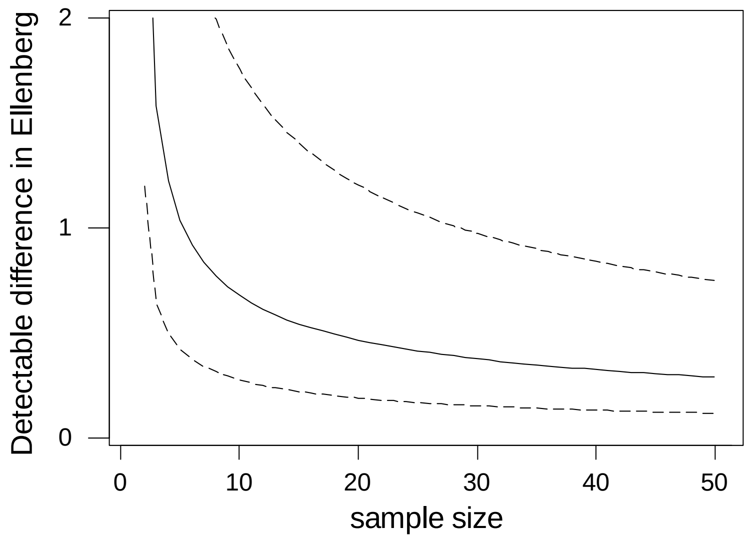

Figure 3. Detection differences in Ellenberg N for various sample sizes based on three sd situations; minimum sd (lower line), mean sd (solid line) and maximum sd (upper line).

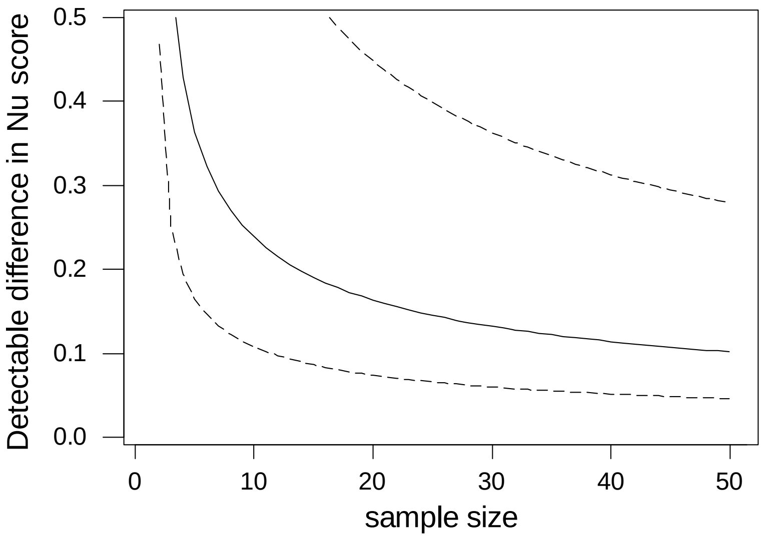

Figure 4. Detection differences in Nu score for various sample sizes based on three sd situations; minimum sd (lower line), mean sd (solid line) and maximum sd (upper line).

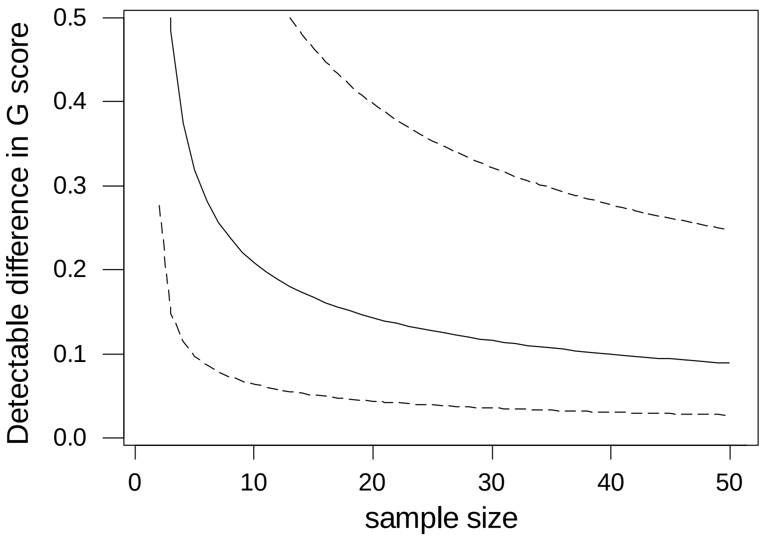

Figure 5. Detection differences in G score for various sample sizes based on three sd situations; minimum sd (lower line), mean sd (solid line) and maximum sd (upper line).

However, in AE monitoring programmes, permanent plots or quadrats have mostly been used rather than random quadrats at each of two time points. The data used here to estimate variability are measuring spatial variability within a category rather than temporal variability between the same positions. Measurements of the same quadrat at discrete time points are likely to be more correlated than would two random quadrats and an adjustment is necessary. The likely method of analysis between two years in this situation is the paired t-test rather than the two sample t-test used for the above figures.

For species richness and British Ellenberg N, the following show how correlation within a quadrat over time improves the level of change that can be detected. Calculations have been based on correlation coefficients of 0.5, 0.7 and 0.9. Figure 6 and Figure 7 show the situation for average sd with random quadrats (identical to the solid line in Figures 3-6) and for paired quadrats where the autocorrelation is 0.5, 0.7 and 0.9. It is clear that at high autocorrelation the detection difference for a given sample size can be halved. As an example the difference detectable for British Ellenberg N at sample size 10 is 0.51, 0.40 and 0.23 for the three levels of autocorrelation.

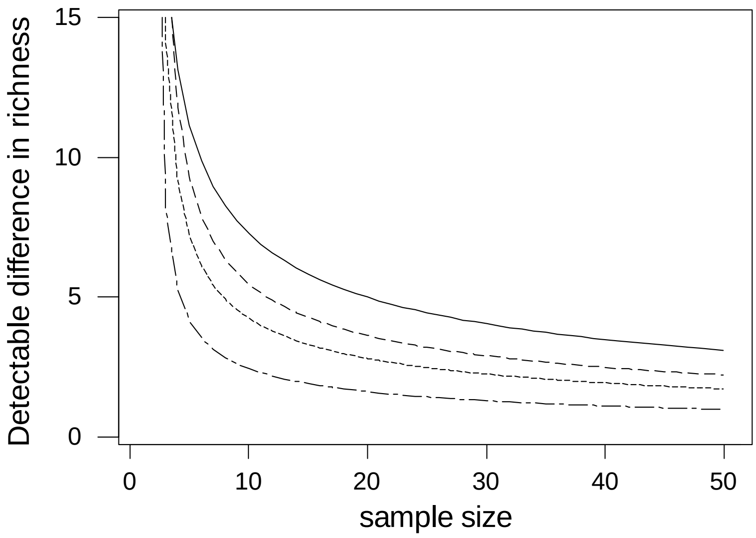

Figure 6. Detection differences in species richness for various sample sizes based on two sample t-tests (repeat random quadrats, solid line) and for paired t-tests (permanent quadrats) where correlation between time points equals 0.5 (dashed line), 0.7 (dotted line) and 0.9 (dash-dot).

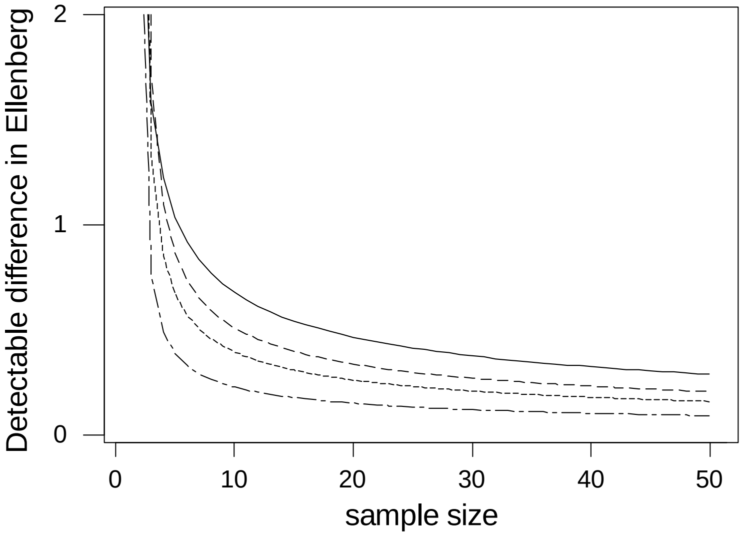

Figure 7. Detection differences in Ellenberg N for various sample sizes based on two sample t-tests (repeat random quadrats, solid line) and for paired t-tests (permanent quadrats) where correlation between time points equals 0.5 (dashed line), 0.7 (dotted line) and 0.9 (dash-dot).

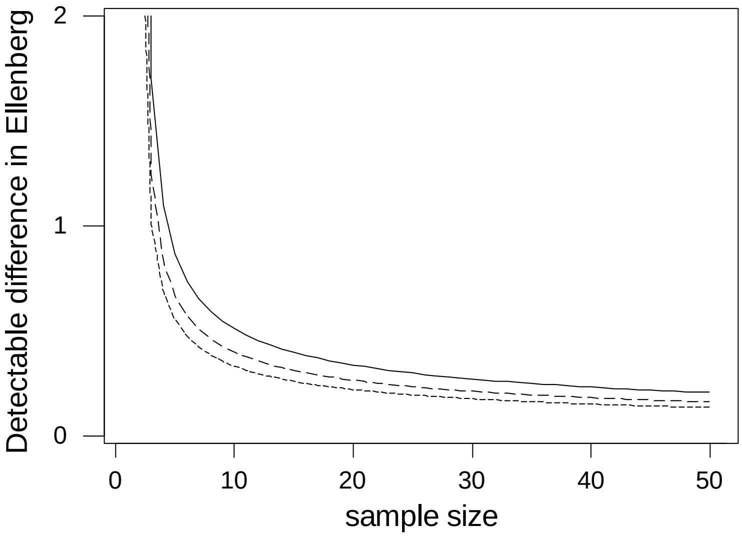

Figure 8. Detection differences in Ellenberg N for various sample sizes based on permanent quadrats with a autocorrelation of 0.5. The three curves represent power of 50% (lower), 65% (middle) and 85% (upper).

Figure 8 demonstrates the effect on detectability of reducing power using the British Ellenberg N mean sd as an example. For a sample size of 10 the 0.51 difference detectable at power of 85% is reduced to 0.33 at 50% power. However it is undesirable to reduce power to this level as half of the true differences would not be detected.

3.2.2 Repeated surveys from fixed units

In practice, data from repeat fixed point surveys were available and it was possible to examine how variable the community variables (species richness, British Ellenberg N, Nu and G scores) were over time. Appendices 1.12 and 1.13 summarise the correlations and standard deviations of the difference between repeat surveys for ESA quadrat data (4548 pairs) and ESA plot data (252 pairs) respectively. Once again these are summarised by categories where there are at least 20 pairs of values. The sd(diff) from ESA plots would appear to be lower than that from ESA quadrats. A further distillation of the data is given below where the correlation and sd(diff) is summarised across all the categories (Table 16 and Table 17). It is surprising that the correlations between repeat pairs can be negligible, even negative, in some instances but it should be remembered that these data contain repeats surveys from sites where the vegetation is undergoing change. Ideally these data would be restricted to sites which are considered to be stable as inclusion of other data will inflate the sd(diff), but in monitoring data sets the stability will inevitably vary from site to site.

Table 16. Summary of correlations for community variables across all categories.

	Mean corr	**Smallest corr**	**Largest corr**
Richness (n=71)	0.67	-0.01	0.94
Ellenberg N (n=71)	0.77	-0.05	0.98
Nu (n=116)	0.63	-0.20	0.94
G (n=116)	0.57	-0.01	0.94

Table 17. Summary of sd (diff) for community variables across all categories.

	Mean sd-diff	**Smallest sd-diff**	**Largest sd-diff**
Richness	3.79	1.20	7.68
Ellenberg N	0.30	0.06	0.92
Nu score	0.15	0.04	0.37
G score	0.14	0.03	0.39

Table 18. Detectable change at mean, minimum and maximum sd (diff) at a variety of sample sizes

	Species richness			**Ellenberg N**			**Nu score**			**G score**		
n	**mean**	**min**	**max**	**mean**	**min**	**max**	**mean**	**min**	**max**	**mean**	**min**	**max**
10	4.04	1.28	8.19	0.32	0.06	0.98	0.16	0.04	0.39	0.15	0.03	0.42
20	2.68	0.85	5.43	0.21	0.04	0.65	0.11	0.03	0.26	0.10	0.02	0.28
50	1.64	0.52	3.32	0.13	0.03	0.40	0.06	0.02	0.16	0.06	0.01	0.17
100	1.15	0.36	2.32	0.09	0.02	0.28	0.05	0.01	0.11	0.04	0.01	0.12
200	0.81	0.26	1.64	0.06	0.01	0.20	0.03	0.01	0.08	0.03	0.01	0.08

In Table 18 the change that can be detected at 85% power and at sample sizes of 10, 20, 50 100 and 200 has been calculated at mean, minimum and maximum sd (diff) as calculated across the category summaries in Appendices 1.12 and 1.13.

If permanent quadrats are to be used to monitor change in vegetation then it is useful to have data on the temporal variation in vegetation considered to be stable. If autocorrelation exists, and it is likely to, then permanent quadrats are more likely to detect change than random quadrats. In the examples used here a power of 85% has been employed. The appendices provide examples of the variation for different community variables in different categories and these can be used to interpolate in the graphs and tables to estimate the sample size necessary to detect change of a given magnitude.

4 PROVISIONAL TARGETS

4.1 METHODS

In this section, community variables calculated using the framework devised from the data classification (Section 2) were compared with community variables characterising sites known to be in favourable condition. This information was used in combination with the power testing results to calculate sample sizes required to be able to determine the change in attaining a favourable condition. This information has been used subsequently in the monitoring recommendations (Chapter 4).

Botanical data collected from quadrats located in pristine sites representing some Priority Habitats had previously been acquired from English Nature (Critchley *et al.* 1999; Fowbert & Critchley 2000). Community variables were calculated for these data sets. The variables were presence/absence weighted because of variations in the method of data collection and to enable comparisons to be made across the three AE data sets. The differences between a pristine target and an existing AE scheme sample were then calculated.

Community variables were also calculated for communities representing an endpoint for deterioration and a starting point for re-establishment of a Priority Habitat. For example, for the Lowland Calcareous Grassland Priority Habitat semi-improved MG6 grassland was used as a potential endpoint of deterioration, whilst MG1, MG6 and MG7 were used as potential starting points.

Graphs were drawn using the information in Table 17 and Table 18 from the power analysis. Figure 9 shows the linear relationships between detectable change and standard deviation at a range of sample sizes for Nu score. Equations for these lines were derived and used to calculate the actual detectable change at one of the sample sizes shown from the known standard deviations. Information for other sample sizes can be interpolated from Figure 9 and Figure 10. Figure 10 shows the relationship between sample size and detectable change at mean, minimum and maximum standard deviations (from Table 18).

The Upland Hay Meadow Priority Habitat had already been the subject of a power testing procedure (Fowbert *et al.* 2002) and the data from this were used in the monitoring schedule for that habitat.

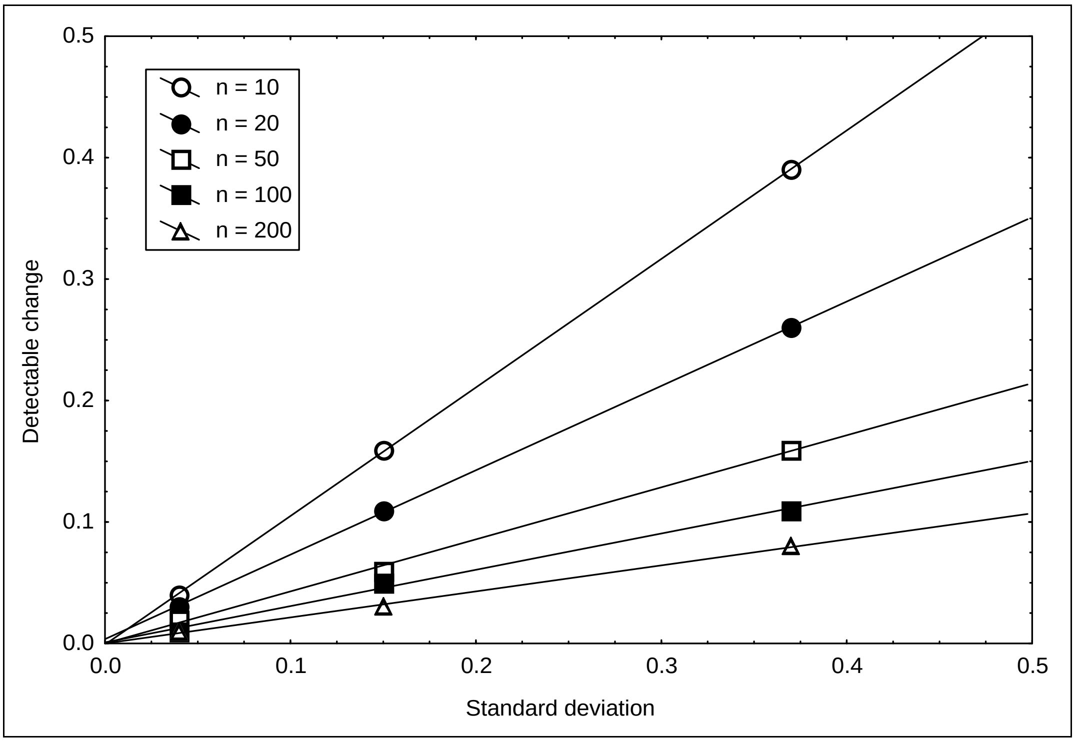

Figure 9. Relationship between standard deviation of differences and detectable change (at an 85% power) for Nu score at a range of sample sizes.

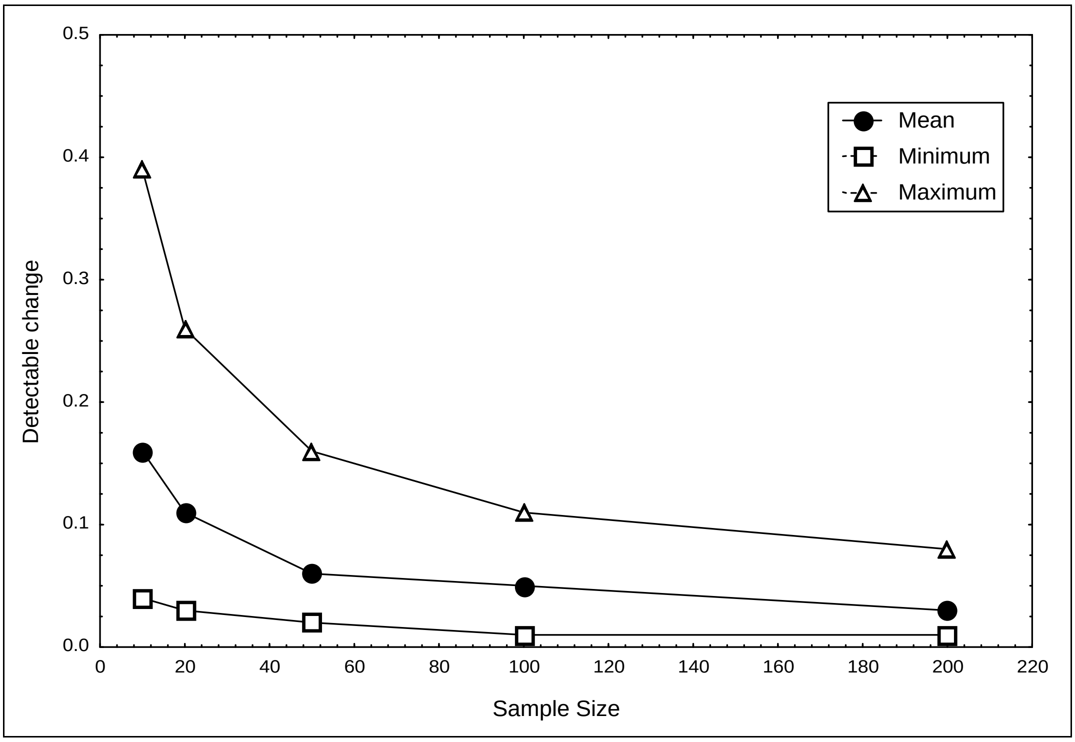

Figure 10. Relationship between detectable change and sample size at mean, minimum and maximum standard deviation of differences for Nu score.

4.2 RESULTS

In the following worked example the Nu score in the Priority Habitat Lowland Calcareous Grassland (LCG) is used. The mean scores together with the detectable change in those scores can be seen in Table 19. LCG in the South Wessex Downs ESA had an Nu score of –0.55 and, with a standard deviation of 0.11, a sample size of 100 is likely to be able to detect a change in the Nu score, if one occurs, of 0.03 (from Figure 9).

Table 19. Nu score (standard deviation in brackets) and detectable change at a variety of sample sizes for Lowland Calcareous Grassland. SD = South Downs, SX = South Wessex Downs, CH = Cotswold Hills.

			Sample Size				
Scheme/ESA	***n***	**Nu Score**	**10**	**20**	**50**	**100**	**200**
CSS	26	-0.34 (0.13)	0.14	0.09	0.05	0.04	0.01
SD Quadrats	49	-0.42 (0.12)	0.13	0.09	0.05	0.04	0.01
SX Plots	39	-0.55 (0.11)	0.12	0.08	0.05	0.03	0.01
CH Plots	13	-0.50 (0.19)	0.20	0.14	0.08	0.06	0.02
All	127	-0.45 (0.12)	0.13	0.09	0.05	0.04	0.01

Pristine CG2 had an Nu score of –0.68 and the differences between the pristine target and the samples from either CSS or the ESAs can be seen in Table 20. This table also shows the actual detectable change, which is the change that is likely to be detectable with the sample size *n* (from Figure 10). The percentage detectable change indicates that in the South Wessex Downs ESA, a change in the Nu score equivalent to 38% of the difference in the score between LCG in that ESA and pristine CG2 is detectable with a sample size of 39.

Table 20. Difference in score from target and the detectable changes in Nu score. ESA scheme codes as in Table 19.

Scheme/ESA	***n***	**Difference from CG2**	**Actual Detectable Change**	**% Detectable Change**
CSS	26	+0.34	0.08	24%
SD Quadrats	49	+0.26	0.05	19%
SX Plots	39	+0.13	0.05	38%
CH Plots	13	+0.18	0.18	100%
All	127	+0.23	0.03	13%

Table 21 shows sample sizes required to detect various levels of change based on the difference between pristine CG2 and LCG in the scheme/ESA. For the detection of a 100% difference in the South Wessex Downs ESA (*i.e.* 0.13, see Table 20), it is possible that a sample size of only 10 may be required (from Table 19). However, a 10% change (equivalent to 0.013) would need a sample size of 100-200 to be detectable.

Table 21. Required change (of the difference to CG2) and appropriate sample size. ESA scheme codes as in Table 19.

Change	CSS	SD	SX	CH	All
100%	<10	<10	<10	<10	<10
50%	<10	10	50-100	20-50	10-20
20%	20-50	20-50	100-200	100-200	50-100
10%	100-200	100	100-200	>200	100-200

These and similar calculations were carried out to provide information feeding into the future monitoring recommendations in Chapter 4. The same method can also be applied to other subsets of the AE monitoring data, using Figure 9 and Figure 10, or their equivalents for other community variables.

CHAPTER 4
RECOMMENDATIONS FOR FUTURE MONITORING

1 INTRODUCTION

1.1 POLICY BACKGROUND

Since the introduction of the first AE schemes under the 1986 Agriculture Act, UK policy for biodiversity and agri-environment measures has evolved, mainly in response to policies initiating from the European Union. A consequence of EU directives is that each nation has to produce its own rural development plan. The England Rural Development Plan was published in 2000, under which AE schemes now reside. The main policy driver for biodiversity is currently the UK Biodiversity Action Plan (BAP) (Anon. 1995a). AE schemes are the main vehicles by which many BAP national objectives and targets are expected to be met and delivered. Equivalent objectives and targets also need to be met and delivered at a local level, including in individual RDR Regions. Individual AE schemes will also have their own objectives. Currently, each ESA has specific objectives related to the local landscape and biodiversity. CSS has overall scheme objectives, with additional ones for specific landscape types and individual counties. Individual sites in CSS and more recent ESA agreements (with management plans) also have specific objectives or targets that might need to be monitored. A full description of the policy background is given in Appendix 2.

At the time of writing, DEFRA is conducting a review of AE schemes. Options under consideration are the continuation or amalgamation of existing schemes, and the introduction of new ‘broad and shallow’ or ‘deep and narrow’ schemes. Irrespective of the structure of the new schemes, the UK BAP will continue to be the driving force for habitat conservation for some time to come. Therefore, the recommendations for future botanical monitoring are structured around BAP objectives for the relevant Priority Habitats. The overall aim of the botanical monitoring programme will be to assess the contribution of AE schemes in meeting objectives and delivering targets for Priority Habitats. This will be aimed primarily across schemes at the country (England) level, although consideration is also given to how the monitoring programme might address these issues at regional and site levels, and within individual schemes.

1.2 APPROACH USED

Recommendations for future botanical monitoring have been made to address the overall monitoring aim, whilst also making optimum use of the existing quantitative samples. The emergence of Rapid Condition Assessment (RCA) methods since the start of the original monitoring programme has also been taken into account. The recommendations include a combination of rapid assessment and quantitative (plot or quadrat based botanical recording) methods. RCA allows individual sites to be sampled and assessed. Quantitative methods are used to sample vegetation types at the scheme or country level. In addition, the use of RCA will allow a large sample of sites to be covered, whilst quantitative methods will maintain the capability for detecting and interpreting vegetation change. Ways of forging links between the two approaches are also suggested.

The review of the previous AE scheme botanical monitoring highlighted the range of habitats being monitored in each scheme. Sampling strategies varied between schemes, but most samples were considered to be representative of the targeted habitat in a particular scheme. Collectively, however, they are not necessarily representative of the range of BAP Priority Habitats under AE scheme agreement across all schemes, so recommendations have been made for restructuring the samples. Recommendations have also been made on ways of using the various existing field methods to ensure, as far as possible, both continuity with the previous monitoring programme, and comparability across all schemes for each habitat. Information from the review on analysis and interpretation methods, and monitoring method development, has also been used.

To make best use of the existing samples each plot or quadrat has been positioned, where possible, within a number of classification frameworks, which has provided an estimate of the size and distribution of the sample between schemes for each habitat. Power analyses have been used to estimate sample sizes required to detect given magnitudes of change. Where data were available, this has also been done against targets representing extremes in condition (pristine or degraded) of the habitat. These results have been used to make recommendations on future sampling strategies.

A considerable pool of expertise and experience on botanical monitoring exists within a range of organisations in the UK. This includes specialist knowledge from different perspectives such as policy, ecology, conservation and field survey. In order to draw on this experience, a workshop was held on 13 May 2002 to which representatives from a range of these organisations were invited. This also ensured that issues relating to botanical monitoring strategies in AE schemes were fully explored, and provided an opportunity for any new issues to be raised. A full report of the workshop is in Appendix 3. Points raised at the workshop have been taken into account in the new recommendations.

The recommendations are for a core monitoring programme of grassland and upland Priority Habitats to be established, with a series of targeted studies in other habitats. The core programme is described in detail, but targeted studies will need to be designed according to their specific objectives, and are outwith the scope of this project. Habitats for targeted study have, however, been identified. Recommendations for the monitoring programme take the following form:

1. A general strategy that outlines the general principles under which the specific recommendations for individual habitats have been drawn up.

2. General recommendations on the application of RCA.

3. A series of habitat schedules. Each habitat or set of habitats targeted for monitoring has its own schedule, which lists the specific objectives and procedures under a standard series of headings.

4. Explanatory notes to accompany the habitat schedules. A set of notes has been compiled to cover all grassland habitats, plus a second set for upland habitats. These notes share the same standard headings as the habitat schedules, and explain the rationale (or methods used) for making decisions on the contents of each schedule.

5. A list of habitats recommended for targeted studies outside the core programme.

6. Some recommendations on practicalities and logistics for the core programme.

1.3 TERMINOLOGY

Terminology relating to the maintenance and enhancement of habitats has, unfortunately, not been standardised within the BAP process. For example, different terminology appears to have been used for grassland and upland Priority Habitats. The Countryside Council for Wales (CCW) is the lead agency for a number of lowland grassland Priority Habitats and has recommended a set of terms that distinguishes re-creation of grassland on arable land from restoration of the biodiversity value of grassland previously subjected to agricultural improvement (see Burke & Critchley 2001). DEFRA currently uses a slightly different set of terms, which are consequently used in this report, as in Table 1.

Table 1. Terminology used for BAP Habitat Action Plan (HAP) objectives, using grassland as examples of management.

<table>
<tr><th>Management</th><th>Published grassland HAPs</th><th>Recommended by CCW</th><th>DEFRA terminology used in this report</th></tr>
<tr><td>The re-establishment of grassland of wildlife value, and broadly relating to one or more of the five HAP types, from arable and other non-grassland precursors.</td><td rowspan="2">Re-establishment</td><td>Re-creation</td><td rowspan="2">Re-establishment</td></tr>
<tr><td>The reversion to grassland of wildlife value from improved grassland or semi-improved neutral grassland precursors (usually MG6/7).</td><td>Restoration</td></tr>
<tr><td>The improvement in condition (and maintenance of the extent) of grassland already conforming to one or more of the five HAP types.</td><td>Rehabilitation</td><td>Rehabilitation</td><td>Restoration</td></tr>
<tr><td>The maintenance of the extent and condition of grassland already conforming to one or more of the five HAP types.</td><td>Maintenance</td><td>Maintenance</td><td>Maintenance</td></tr>
</table>

2 GENERAL STRATEGY FOR MONITORING

Recommendations for the core monitoring programme of grassland and upland habitats are based on the following general strategy. The monitoring is aimed at BAP Priority Habitats, and vegetation that has potential for re-establishment to Priority Habitat.

2.1 MEASURE STOCK

The statistical population to be monitored is the total resource of the target habitat that is under AE agreement. The first stage is therefore to determine the stock of that habitat and its distribution among the current AE schemes. Ideally this would be done using mapped habitat inventories. Unfortunately such inventories are either not available or incomplete for most habitats (although this situation is likely to improve over time through work by the National Biodiversity Network and English Nature). Alternatively, information on the habitat resource could be collected at the time that agreements are established. Currently, this is not done in a rigorous way, although the management tier or option into which land is entered can often give some information about its habitat type. The collection of such information, including setting of objectives, could be incorporated into the revised AE schemes. This information will need to be updated periodically as the number and location of agreements changes.

Another approach is to estimate the stock by sampling. This has already been done for CSS for 1998-99 (Carey *et al*. 2001a) from a random sample of agreements. However, some estimates for habitats that were poorly represented in the sample might not be reliable. This is also currently being done for ESAs under DEFRA project AE02. It is assumed that results from the latter will be available before the new monitoring programme commences, although in most cases the estimates will be for ESAs collectively rather than for individual ESAs. Another problem with the estimates is that they do not provide information on the distribution of the resource; this will hamper the selection of additional sites for both quantitative monitoring and RCA. It is, however, recommended that the distribution of samples between CSS and individual ESAs should be in proportion to the resource under agreement. If it is not possible to obtain accurate inventories or estimates for individual ESAs, alternatives might be to use tiers (as was used in the stratification for AE02) or other data sources such as land cover maps and perhaps an element of local knowledge.

2.2 MEASURE CONDITION

The condition of the habitat of interest needs to be established so that monitoring can be carried out against condition targets. This would be done using RCA on a sample drawn from CSS and ESAs. The aim would be to allocate each site or feature sampled to a condition category, either as specified in the JNCC Common Standards Monitoring or one of the additional categories as recommended in Section 3 below. The sample of sites drawn for RCA will include all those selected for quantitative monitoring. Methodological development still required for RCA could be carried out in 2003, prior to the start of the new monitoring programme.

2.3 ASSESS CHANGE AGAINST TARGETS

Vegetation change will be measured using quantitative methods, based on botanical (species) data collected by repeated observations from fixed, relocatable plots or quadrats. This will be from a proportionate random sample of sites, according to the stock of the habitat in each AE scheme. The sample will include, as far as possible, existing AE monitoring sites or plots/quadrats. Where the power analyses suggest that the existing sample shows an excess, then a sub-sample will need to be selected. Where the existing sample shows a shortfall, it will need to be topped up. In either case, the existing sample will need to be adjusted to ensure that the correct distribution between schemes is achieved.

In each scheme with an existing sample, the field method in current use will be continued, and any new samples in that scheme will use that same method. This will ensure continuity with previous surveys, and comparability across the whole sample within that scheme. Minor modifications to each field method are recommended that enable comparable data to be collected across all schemes and across all grassland or upland habitats sampled.

To enable vegetation changes to be measured against targets representing condition, it will be necessary to calibrate botanical variables from the quantitative monitoring against attributes or condition categories from RCA. This can be done during the monitoring programme itself, using data from sites used for both quantitative monitoring and RCA. If calibration is not successful, the quantitative samples would need to be regarded as a surveillance programme that is not tied to specific condition targets.

Vegetation change between surveys in the new monitoring programme can be analysed across all schemes. A suggested timetable for surveys is provided in Section 5.1 below. RCA and quantitative monitoring would be done at the same time intervals, although RCA could be done more frequently if resources allow. Change can also be analysed in individual schemes with sufficient samples (which can be determined from the power analysis results) from the baseline year of the previous monitoring programme onwards.

2.4 COMPARE TRENDS IN AE SCHEMES WITH THE WIDER COUNTRYSIDE

In a large-scale monitoring scheme it is not feasible to establish control sites in the same way as would be done in a small-scale manipulative experiment. However, it is possible to establish whether temporal changes in vegetation on land under AE scheme agreement differ from those seen in the wider countryside. Countryside Survey (CS) is the most suitable source of information on botanical changes in the wider countryside. CVS classes or aggregate classes can be used to ensure that comparisons are made between similar vegetation types in AE schemes and in the CS sample. With the recommended modifications to field methods in the AE monitoring programme, the CS and AE samples will be compatible, so allowing quantitative comparisons to be made. Ideally, however, survey dates of CS and AE scheme monitoring would need to coincide. Otherwise, trends can be compared on a qualitative basis. Some interpolation will be possible, once the next CS survey has been done. Since the CS sample includes sites under AE scheme agreement, these should be filtered out of the CS sample before making comparisons. With the increasing area of land coming under AE agreements there may be some scope for CS itself to be used to compare agreement and non-agreement land, though the relatively scarce priority habitats are poorly represented in the sample.

The current lowland grassland BAP monitoring programme (AE08) uses a sample of sites that is stratified by their status as AE agreement or non-agreement. This will enable a comparison to be made between AE sites with those on the wider countryside, although the sample might be biased towards the better quality sites, being based on EN's county inventories.

Other potential data sources for comparing trends in AE schemes with those elsewhere are also recommended.

2.5 ASSESS DRIVERS OF CHANGE

Where changes in vegetation are detected, it is necessary to establish as far as possible what are the likely causes. Changes resulting from management imposed by the AE schemes are of primary interest and are an essential part of the feedback loop of monitoring, evaluating, and improving the effectiveness of the schemes. Therefore, management data should be collected from farmers as part of the monitoring programme.

It is also important to assess whether other factors that are not under the direct influence of AE schemes might also be driving vegetation change. For each habitat, potential environmental drivers will be inferred by analysing indicator variables that are known to show consistent relationships with certain potential drivers of vegetation change. A set of indicator variables is recommended for each habitat. Environmental factors can also be analysed using existing data sets, describing either spatial data (e.g. soil type, estimated deposition of nutrients) or temporal data (e.g. annual vegetation data from Environmental Change Network sites). However, it is important that environmental data are collected for a clear purpose, otherwise large datasets can accumulate that are not utilised efficiently. Therefore, it would be more cost-effective to set up a discrete research or monitoring project (or projects), as an add-on to the core monitoring programme, to consider particular ecological processes. Additional environmental data would be collected, and existing national datasets used, as part of that project.

3 APPLICATION OF RAPID CONDITION ASSESSMENT

3.1 INTRODUCTION

A variety of methods has been devised and published for the botanical condition assessment of designated sites and some AE scheme sites in the lowlands of England (Robertson & Jefferson 2000, SNH 2001, Burch *et al*. 1999, Mitchley *et al*. 2000 and CCW 2002). There is an increasing consensus on appropriate methods for SSSIs in the lowlands of England and final recommendations for RCA (Common Standards Monitoring) of a wide range of habitats are now expected from JNCC in 2002. However, there is a lack of consensus regarding appropriate methods for the more extensive habitats in the uplands (SNH 2001, Jerram *et al*. 2001, CCW 2002, MacDonald 2002).

RCA methods represent the outcome of a good deal of expert opinion and judgement but even for the generally agreed approaches in the lowlands, these are so recent that there has as yet been little testing or validation of the methods and results. Notwithstanding this degree of uncertainty and a need for further work, RCA represents a potentially valuable and powerful approach to assessing the success or otherwise of AE schemes. RCA could therefore become an important means of assessing the increasingly critical ecological and agri-environmental policy objective of assessing whether AE schemes actually deliver environmental gains to the wider countryside.

Ultimately, however, the value of botanical condition assessment as a means of monitoring AE scheme success is determined by two factors:

- Clear and unambiguous objectives for sites or features against which condition can be assessed
- The input (in terms of time and expertise) in determining and validating appropriate attributes and targets.

For the former, we are to a large extent dependent on the work of AES project officers on the ground in determining appropriate site objectives and thus agreements. It is recognised, however, that in the existing AE schemes such objectives are often not set at the level of individual habitats or features and that, even when they are, a rigorous national approach has not been adopted. There is clearly a strong case for the adoption of site objectives for individual habitats in any revised AE Scheme (as for example adopted by Tir Gofal). This would also enable monitoring and/or care and maintenance visits to be more closely tied in with individual agreements.

The latter factor highlights the need for further work (as well as drawing on current agency strategies) a topic covered in Section 3.6.

Given these two provisos however, RCA represents a quick, cost-effective and potentially powerful tool for large-scale botanical monitoring of AE schemes.

3.2 GENERAL STRATEGY

3.2.1 Recommended methods

We recommend that as far as possible, condition assessment of AE scheme sites should be tied into the nationally agreed condition monitoring methodologies for designated sites (e.g. Robertson & Jefferson 2000). This is, in the final analysis, a pragmatic recommendation, to draw benefit from the high degree of expertise and time already expended in developing these methods, and to ensure standardisation and compatibility across the range of sites. For example a proportion of AE scheme sites may also be designated sites (see Chapter 3, Section 2.2.4) and are thus, in principal, already subject to this form of monitoring.

This recommendation may inevitably result in a staggered timetable for monitoring different habitats due to differing level of progress and availability of agreed methods for different habitats. While for some habitats (e.g. woodland) a national methodology is already agreed, or close to agreement (e.g. grasslands), for others (e.g. uplands) a final methodology is still under discussion. We recommend that AE monitoring for these latter habitats should be finalised only once a national strategy has been agreed. For uplands, the final results of the current MAP Project (see also Glaves *et al*. 2001) are likely to be relevant in defining appropriate attributes. Equally, for grasslands, the current English Nature/DEFRA/JNCC BAP reporting project on non-designated grassland sites (AE08) may also yield further guidance on appropriate attributes and targets for non-designated sites which may be fed into final methods for RCA monitoring of AE schemes. Indeed there is considerable scope for future collaboration between DEFRA and English Nature in terms of data exchange for designated sites.

3.2.2 Defining condition

We recommend that condition categories for AE sites should be closely tied into the JNCC categories adopted for designated sites. Thus “favourable” condition should be equivalent across both designated and undesignated AE sites. However, there are problems in adopting the current methodology as it stands, as many sites in restoration or re-establishment tiers will inevitably fall into the “unfavourable” category and there will be little or no likely short-term condition improvement, beyond perhaps unfavourable recovering, under AE schemes. We therefore propose, for discussion, a series of additional condition categories to reflect developing vegetation conditions in the wider countryside and these are discussed in Section 3.4. We emphasise that these additional condition categories represent some first thoughts in this area and will require much wider discussion and refinement before they could be utilised for monitoring of AE sites.

3.2.3 Setting attributes

Attributes chosen should in general follow those developed for the agreed methodologies. However, there are situations where adaptations will be necessary:

- A number of attributes may be irrelevant in the early stages of vegetation development. For example in restoration or re-establishment sites positive indicator species of pristine sites are unlikely to be present.

- Additional or adjusted attributes may be valuable on re-establishment sites, to assess the early success of vegetation establishment. For example, on naturally regenerated sites, the recording of indicator species may be zoned in relation to the colonisation source, while for hay strewn or brush-harvested seed, the establishment of species known from the donor site, can be considered an indicator of re-establishment success. Clearly these attributes must be closely tied to establishment and management information for the site.

- A distinction may be required between broad and shallow and narrow and deep schemes in developing the level of condition assessment required. Thus while the latter, typically priority habitats, merit condition assessment using the full set of attributes and targets, a much more limited set of simple and indicative attributes (probably with less NVC specificity) may be appropriate for the former.

- In a number of sites, site objectives may be unclear in the early stages of development and more broad-brush attributes and targets may be appropriate. This issue is discussed in Section 3.5.4.

- There is also some further development work required to refine field methods for certain attributes, e.g. assessment of litter cover and sward heterogeneity (Kirkham *et al.* 2001).

3.2.4 Setting targets

Targets for favourable condition should be drawn from the agreed national methodologies. For the additional condition categories, however, targets will need to be set to reflect vegetation development. We propose that these are developed following consultation with acknowledged experts. Validation of these targets may be achieved using three approaches: expert opinion, from analysis of existing agri-environment monitoring data and from adoption and piloting in future AE scheme monitoring (see Section 3.6).

3.3 FIELD METHODS

3.3.1 The structured walk

Site condition must be monitored from an assessment of the whole site/feature (though sub-sampling can be used), e.g. during a walk across the site assessing a number of attributes according to predefined targets. There are a number of different published field methods for RCA. For example the English Nature rapid assessment method for lowland grassland is based on a structured walk of the site (Robertson & Jefferson 2000) while the SNH method for uplands employs a random sample of points (MacDonald 2002) and the MAP project uses a grid of sample points (Glaves *et al*. 2001). There is not yet universal agreement on one particular method and there are strengths and weaknesses in each approach. The recommendation is, in general and certainly for lowland sites, to adopt the structured walk for a number of reasons:

- The structured walk is the method currently used in England grassland RCA (Robertson & Jefferson 2000) and there is merit in adopting an existing national method notwithstanding the relatively early stages of use and limited validation (see below)

- The structured walk is a comparatively simple method and generally ensures good coverage of the site

- The route of the structured walk can be determined prior to the site visit and marked on the site map.

On the other hand, the structured walk is not random sampling and resulting data are less amenable to statistical analysis. Robertson & Jefferson (2000) recommend a maximum of 16 ha for visual assessment and therefore that larger sites are subdivided. Also where large sites are being assessed, large areas will be unsampled and so a different method may be required, e.g. for moorland sites. As well as size of sites, the degree of variability or heterogeneity of a site is also an important consideration. In general, the more heterogeneous a site the more samples might be required irrespective of size.

3.3.2 Sampling positions – number and size

For some attributes/habitats the structured site walk noting the existence and condition of the attributes is sufficient without individual sampling positions. However where more quantitative information is required, e.g. on the cover and frequency of indicator species, attributes may be assessed by stopping at a number of sampling positions and assessing the attributes at each position. The recommended number of samples or sampling positions varies considerably in published methods:

- Ten – EN Habitat Restoration Monitoring Project (Burch *et al*. 1999; Mitchley *et al*. 2000), English uplands (Jerram *et al*. 2001)

- Twenty – EN Rapid assessment methods for lowland grassland SSSIs (Robertson & Jefferson 2000)

- Twenty-eight – SNH upland designated site monitoring (MacDonald 2002)

- One hundred – CCW Tir Gofal performance indicator monitoring (CCW 2002).

Clearly the larger the number of samples the more precise the assessment of the attributes but the more time is required in the field. Random and grid samples provide potentially the best representative coverage of a site and the former provides greatest statistical rigour. However stopping at sampling positions during a structured walk of the site has the merit of simplicity as well as being the method in current usage in England, at least for lowland grassland SSSIs. Therefore, the recommendation is to assess attributes at 20 predetermined, more or less equidistant sampling positions during the structured walk. It should be noted again that this approach might not be appropriate for all habitats (e.g. moorland) and all attributes (e.g. some may be better assessed at the site level). Further work may be required to assess the optimal number of samples especially in relation to larger and/or more heterogeneous sites.

Some authors recommend the use of a GPS to record locations of the sample positions. Since the objective of RCA is to provide an assessment of the general condition of the features of a site against objectives, we do not think this additional work is generally necessary or justified. However the approach may have value for monitoring extensive upland habitats for example in the relocation of scarce habitats in a habitat mosaic.

Published RCA methodologies also give varied recommendations for the size of individual sampling positions:

- 3 - 4 m^2 area in front of or around the surveyor - EN Rapid assessment methods for lowland grassland SSSIs (Robertson & Jefferson (2000)

- 1 m semi-circle in front of surveyor - EN Habitat Restoration Monitoring Project (Burch *et al*. 1999; Mitchley *et al*. 2000)

- 1 m around surveyor - CCW Tir Gofal performance indicator monitoring (CCW 2002).

- A hierarchy of scales for different features; 4 m^2 – 1 ha – whole site - SNH upland designated site monitoring (MacDonald 2002).

There is merit in varying the size of sampling position depending upon the nature of the attributes. Following the NVC sampling methodology the recommendation is to adopt a sample size of 1 m around the surveyor (i.e. a circle of 2 m diameter) for grassland attributes and 2 m around the surveyor (i.e. circle of 4 m diameter) for dwarf shrub heath, blanket bog etc.

It should be noted again that not all attributes are amenable to assessment at the relatively small sampling positions. Some attributes should be assessed the whole site/feature level following the structured walk, e.g. landscape features in coastal grazing marsh.

3.4 CONDITION CATEGORIES FOR MONITORING AE SCHEMES IN THE WIDER COUNTRYSIDE

3.4.1 Background

There are strong arguments for adopting the JNCC condition categories to assess habitat condition in AE schemes. The UK BAP targets are framed within these condition categories and the strong linkage of AE objectives to BAP targets suggests that AE monitoring should be linked as closely as possible to the same categorisation system. However there are two significant problems with utilising this system:

1. The existing JNCC categories were set up for established designated sites and thus do not reflect the very different conditions of some AE sites e.g. re-establishment/restoration habitats. For many restoration sites, achievement of favourable condition may only be expected far beyond the ten-year agreement term and the most that may be expected may be a move from unfavourable to unfavourable - recovering (CCW 2002).

2. In an initial baseline survey, a site can only be categorised as “favourable” or “unfavourable”. All other condition categories refer to a change in condition from the

previous recording, "unfavourable recovering" "favourable - recovered" etc. To utilise condition monitoring to provide an assessment of BAP habitat condition as suggested it is desirable to have a set of condition categories that will reflect the ongoing nature of restoration from a low baseline condition.

Robertson *et al.* (2002) have discussed some of these issues in an attempt to develop condition and restoration assessment methodologies for non-statutory grasslands. Their work focused in part on the definition of favourable condition for non-statutory sites. Here we propose, for further discussion, a series of additional condition categories which would work in conjunction with the existing categories but which are tailored to reflect vegetation development on re-establishment/restoration sites. In our view, it is essential that the term "favourable" is equivalent across both designated (e.g. SSSIs) sites and AE restoration sites and thus the additional categories reflect vegetation development towards "favourable" condition. It is likely that for most restoration sites, achieving "developing favourable" condition maybe the most realistic goal in the short- to medium-term.

3.4.2 Proposed additional condition categories

- Potential
- Potential developing
- Developing favourable
- Favourable = existing JNCC condition category

Potential

This refers to site condition at the start of the re-establishment process (typically years 1-2) which provides an indication that it has the potential to develop towards the target vegetation. Thus attributes such as the presence of a least 1 or 2 positive indicator species, which may include "restorability indicators" (Robertson *et al.* 2002), and / or a suitable colonisation source adjacent. For re-establishment from improved grassland, it would be expected that the grass sward was sufficiently open, at least in some parts of the site, to favour colonisation by desirable species.

Potential developing

Site condition indicating that re-establishment management is having a positive effect on vegetation composition (for example years 2 - 5). Here there would be the expectation that a greater number of positive indicator species would be recorded and that some may also have increased in abundance, suggesting increasing colonisation of the site by desirable species. Vegetation height may be closer to the target for favourable condition.

Developing favourable

Site condition that is close to favourable but which still reflects restoration development. Here a greater increase in positive indicators would be expected together with an increase in abundance and a more even distribution of species in the sward across the site, although probably more patchy than an established sward. It would be expected that negative indicators, such as weed species or scrub would be at lower frequency/abundance and close to the targets for favourable condition. Equally sward structure should be close to favourable condition. This category is similar to the existing unfavourable recovering category although that term may not be appropriate for re-establishment sites that may never have been favourable. This example illustrates the difficulty of defining appropriate condition categories for re-establishment sites and emphasises the need for further discussion and elaboration on this issue.

However for illustrative purposes, a proposed range of condition categories, including those reflecting other changes since a previous recording would be:

- Potential
- Potential - no change
- Potential declining
- Potential developing
- Developing favourable
- Favourable = existing JNCC condition category

3.5 SPECIFIC ISSUES

3.5.1 Generic vs. site specific attributes and targets

The adoption of a generic or site-specific approach to attribute and target setting has been a significant issue for discussion (see Chapter 2, Section 9). We again recommend following the agreed national strategy which proposes a series of generic attributes and targets for individual habitat types, but with some scope to adjust target levels by agreement to suit individual site conditions. This is perhaps more likely to be desirable for re-establishment/restoration sites than for existing priority habitats. Only in exceptional circumstances would the attributes themselves need to be adjusted.

3.5.2 Dealing with mosaics

Many upland but also lowland AE sites may not consist of single well-demarcated habitats but fall into the category of habitat mosaics.

In some situations the site AE objective may be to prioritise one habitat type over another e.g. in an upland context the promotion of upland heath and associated reduction of acid grassland. In this case the site objectives and thus condition monitoring is focussed on one target habitat (i.e. upland heath) and habitat (upland heath) condition assessed accordingly. In some such sites there may be a desire to shift the balance of the mosaic (e.g. 20% upland heath 80% acid grassland to 40% : 60%) and thus the ratio of the mosaic as a whole may also be assessed following the methodology set out for large scale mosaics below.

For some sites, the AE objective may be better defined as the maintenance of the mosaic. For the purposes of condition monitoring we can distinguish two scales of mosaic:

1. Fine scale mosaics – For example a lowland calcareous grassland comprising both short-sward CG2 and taller CG4 vegetation. Here the intimate mix of habitats means that the existence of the mosaic and individual habitat condition can be assessed at the sampling position scale. We propose that an additional attribute is included (i.e. existence of a CG2/CG4 mosaic) and the presence of the target habitat types assessed at each sampling position. A range of acceptable proportions can determined for each habitat type and mosaic condition thus assessed. Attributes for each habitat type should also be included and habitat condition assessed at sampling points as appropriate. At some points this may necessitate completing some attributes for both habitat types. The lowland grassland BAP monitoring programme (AE08) is using a single generic grassland card, which enables appropriate data to be collected for more than one habitat type.

2. Large scale mosaics – For example an upland site comprising areas of upland dry heath, acid grassland, bog, bracken and rocky outcrops. In these situations, the quantity and distribution of the mosaic is assessed at the whole site scale. In many upland situations it may be possible to assess this from a number of observation points across the site. We propose that for a number of habitat types (e.g. bracken, rocky outcrops) it is sufficient to record presence and distribution (perhaps using a GPS) of the habitat. For other habitats, such as upland dry heath and blanket bog, an assessment of the condition of each individual feature is also desirable and should be made at representative sampling positions across the site, assessing against the standard attributes and targets.

3.5.3 Dealing with multiple interest features

In some cases AE sites may be managed both for the target habitat type and for individual species, for example a particular butterfly or bird. To an extent condition assessment can be used as a surrogate for species population assessment e.g. by monitoring habitat components such as vegetation structure and the presence of food plants, although Firbank *et al*. (2001) found successful correlation limited to invertebrate groups. It is also possible to devise condition assessment attributes and targets for individual species populations, but elaboration of this approach is beyond the remit of this project. Significant work is underway on condition assessment for major species groups by EN and JNCC, although the approaches are still in development stages. We conclude that methods for the condition assessment of species in AE schemes require further development work.

3.5.4 Sites with no objectives or unknown potential trajectories

In many cases, sites may be under AE management with no clear long-term objectives or unknown trajectories of sward development. This may be particularly relevant to vegetation development from arable reversion or improved grassland. Here for example, the short-term objective may be to develop a more species-rich grassland sward, but the target NVC community may be unclear or there may be several possibilities. In this case the attributes and targets need to be sensitive enough to register condition improvement, yet broad-brush enough to allow for different community development. Thus for an improved grassland site possible attributes could be:

- Grass/herb ratio – set at a fairly low level as far as herb component goes but nevertheless indicating a diversification of the sward.

- Presence/frequency of positive indicator species drawn from a wide list e.g. based on “restorability indicators”, suited species etc.

- Negative indicators e.g. pernicious weeds

- Sward structure.

This type of broad-brush approach may be relevant to many AE sites in the early stages of vegetation development.

3.5.5 The role of quadrat/plot data in the validation of condition assessment

Quadrat data can provide information on site condition attributes, e.g. presence of positive/negative indicators species, grass:herb ratio, bare ground, sward height etc. In such cases it should be possible to determine cross-calibration criteria so that quadrat data can be categorised according to condition. The match between RCA and quadrat data can then be assessed.

This approach does not validate the attributes/targets themselves, i.e. we cannot test the validity of the assumptions using quadrat data alone. Certain attributes and targets may be thought to represent a particular condition category, but often these decisions are the result of expert opinion and there may not be objective data to check this against. The recommendation is for further work examining existing AE quadrat data especially where time-series data are available for individual sites. This analysis would allow some *a-posteriori* testing of attribute targets against actual vegetation development in a variety of agri-environmental settings. In effect the time series data might allow the more objective assessment as to previous judgement of condition targets was correct, given the subsequent development of vegetation.

3.5.6 To what extent could RCA eventually replace quadrat monitoring?

It is not possible to recommend RCA as the sole method of AE scheme monitoring because the methods are not universally agreed and there remain issues of validation to be resolved. In addition, there are fundamental differences in the questions addressed by RCA and quantitative plot or quadrat based methods. RCA is designed to gain coverage of individual sites, while plots or quadrats are used to sample vegetation types across schemes. The methods are complementary, with RCA providing a means of covering a lot of ground rapidly, while quantitative methods provide more precision for detecting vegetation change. Quadrat or plot data also provide a level of detailed information on species composition that can become even more valuable in relation to assessing the impacts of unpredictable events (e.g. climate change) and answers to questions as yet currently unforeseen. It is difficult to devise or envisage RCA methods that would provide this level of flexibility.

The best prospect is to utilise nationally agreed RCA methods as they are developed and to subsequently employ validation approaches from studies of existing time series AE schemes and from results of the next round of AE monitoring. In time RCA methods might be refined into three approaches:

Method 1: A truly rapid method designed to be used by POs as part of the care and maintenance assessment; recording attributes against targets at the whole site/feature level from quick whole-site walks

Method 2: A modified English Nature rapid assessment approach utilising a structured walk with 20 sampling positions and assessing attributes against targets at sampling positions or the whole feature level as appropriate

Method 3: A more detailed (less rapid) method utilising more sampling positions possible randomly selected and employing extended lists of indicator species (positive, negative, suited species etc) to provide more robust information on attributes and targets. This approach might also involve the recording of measurements/estimates for individual attributes from individual sample positions.

3.6 RECOMMENDED FURTHER WORK

There are a number of issues relating to RCA for AE schemes which are not yet fully resolved or resolvable with the current information available. The need for agreed methods for the uplands is one major issue and this and other issues require additional work before RCA methods can be finalised for England AE schemes monitoring. These issues are outlined below and the relevant issues for individual habitats are indicated under each habitat schedule.

3.6.1 Checking and agreeing attributes.

Key attributes are listed in each priority habitat schedule derived from various published sources including the EN Condition Monitoring approach to grasslands (Robertson & Jefferson 2000). In general these published protocols could be adopted for AE schemes immediately. However because the attributes were selected for the assessment of established, designated sites, there may need to be some modifications for their application to AE schemes, see for example, the case of positive indicator species below. In upland sites for which a large number of quite complex attributes have been developed (e.g. MacDonald 2002) it will be especially necessary to derive a shorter list of attributes relevant to RCA for upland AE schemes. Field methods for some attributes require further development work (Kirkham *et al* 2001).

3.6.2 Selecting appropriate positive indicators.

Positive indicators have been defined for the EN rapid assessment of grassland SSSIs (Robertson & Jefferson 2000) for each priority grassland habitat and could be adopted immediately for AE schemes monitoring. However the lists of positive indicators may need to be modified for use in AE schemes monitoring where some species listed may not be appropriate indicators for AE scheme sites. For example, this will usually be the case for restoration and re-establishment sites which may take many years (if ever) to achieve the full complement of target species.

Attributes could be measured/estimated more precisely, positive and negative indicator species could both be recorded per sampling point thus giving more robust frequency data on all of these.

There may also be a case to provide expanded lists of positive indicators to enable site assessment against performance indicators. For example the list could include indicators of potential changes in the vegetation such as nutrient enrichment or drying or wetting conditions. Indicators of changing environmental conditions could be drawn for example from suited species (Critchley 2000).

Where grassland sites are in AE schemes without objectives or with no definite trajectory of development there is a need to identify indicators of the potential to develop and improve condition. Some work has been done on such “restorability indicators” by EN (Robertson *et al.* 2002) identifying species typical of early stages of successful grassland restoration and re-establishment but there is a need for more work to be done, especially utilising time series data on grassland restoration and re-establishment e.g. from previously collected AE schemes monitoring data.

3.6.3 Selecting and trialling appropriate targets for attributes.

Targets have been set for attributes in grassland RCA for designated sites (Robertson & Jefferson 2000). Since the outcome of RCA depends on meeting targets set in relation to designated features (i.e. site objectives) this issue is critical and central to a workable methodology. AE schemes do include designated sites but in other cases these targets may be inappropriately high. A balance needs to be struck between common standards and generic targets which facilitate comparative assessments countrywide, and site-specific targets reflecting site objectives and conditions, e.g. the starting point of a re-establishment site. Targets for these attributes need to be linked to condition categories but it is difficult to decide where to draw the boundaries. However this could again be determined from analysis of existing AE quadrat data to attempt to define stages of development.

3.6.4 Determining condition category thresholds for targets.

This is the biggest and most complex area of work and will need some major discussion to ensure that thresholds are appropriate - after all if performance indicators are determined by movement between condition categories then these <u>must</u> be as good as they can be. This could be approached in three ways:

- Testing the targets against an existing database and evaluate how the vegetation has developed over time.
- Utilise expert opinion - e.g. circulate suggestions on attributes and targets in a range of scenarios and elicit feedback.
- Use pilot results as a feedback loop - once the method has run for 10-15 years, use the time series data to assess whether targets were realistic.

In particular for non-statutory sites there is a need to develop additional condition categories for non-designated sites and restoration/re-establishment sites of lower quality but with the potential to develop into better condition. It is suggested that existing AE scheme grassland quadrat data could be investigated in further development work to inform key issues such as the selection of appropriate positive indicators. This will be most valuable where time series data are available for individual re-establishment or restoration sites.

4 HABITAT SCHEDULES AND EXPLANATORY NOTES

Explanatory notes should be read in conjunction with the individual habitat monitoring schedules. These are presented in the following order:

1. Grassland monitoring explanatory notes.

2. Grassland habitat monitoring schedules:

    Coastal & Floodplain Grazing Marsh
    Lowland Calcareous Grassland
    Lowland Dry Acid Grassland
    Lowland Meadows
    Purple Moor Grass & Rush Pastures
    Upland Hay Meadows
    Semi-improved Grassland

3. Upland monitoring explanatory notes.

4. Upland habitats monitoring schedule:

    Upland Heathland and Blanket Bog

4.1 GRASSLAND MONITORING EXPLANATORY NOTES

4.1.1 General

1. BAP Habitats

Schedules have been produced for the following grassland habitats:

BAP Priority Habitats

Coastal and floodplain grazing marsh (CFGM)
Lowland calcareous grassland (LCG)
Lowland dry acid grassland (LDAG)
Lowland meadows (LM)
Purple moor-grass and rush pastures (PMRP)
Upland hay meadows (UHM)

Potential BAP Priority Habitats

Semi-improved grassland

The relevant Broad and Priority Habitats and the corresponding NVC communities are listed in individual schedules.

2. Relevant BAP Objectives and Targets

BAP objectives relevant to the schedule are listed.

Re-establishment from arable reversion is not included in the grassland schedules, being recommended as a separate, targeted study.

3. Principle AE Schemes

AE schemes are listed in which the habitat is important in terms of quality and extent. For ESAs, the main source used is Swash (1997). These are the schemes in which most of the monitoring is expected to be targeted, although other schemes with a more limited stock will also need to be included. Schemes that only contain a small area of the habitat are excluded from this table, some of which might have current monitoring samples. Estimated stock for CSS is for the existing Priority Habitat that was under agreement at the end of 1997 (Carey *et al*. 2001a). No estimates are currently available for ESAs. However, the list can be updated when the results of AE02 are available, indicating which schemes have significant stock of the habitat.

4. Proposed Scheme Objectives and Performance Indicators

These are derived from the relevant BAP objectives and targets. It is accepted that these go beyond current scheme objectives though the approach might be adopted for the new schemes. It is suggested that objectives for AE schemes should refer to the majority of sites under agreement even if the national BAP target is only for a percentage of that habitat. This is because AE schemes are one of the main vehicles for achieving national targets, so the majority of agreement sites are expected to be maintained in favourable condition, or to show improvements. For the DEFRA PSA target for SSSIs (95% in favourable condition by 2010) it has been agreed recently with EN that favourable condition will include unfavourable recovering condition. There is therefore an argument for adopting this approach for AE Scheme objectives. It has also been suggested that the AE Scheme objectives may not need to be as specific in identifying targets by dates as the BAP targets and further that agreements that are very recent (e.g. less than 2 years old) at the time the assessment is made might be excluded.

The first part of each performance indicator refers to RCA, which provides assessments of features at the site level. The second part refers to the quantitative monitoring, which assesses vegetation condition and change at a national level, and across individual schemes. Change is measured by indicator variables, which are specified for each habitat (see below). The utility of these variables will be dependent on successful and meaningful calibration against condition categories or attributes. Therefore, the performance indicators refer explicitly to the indicator variables that can be successfully calibrated for the habitat.

The objectives and performance indicators should be viewed as suggestions only, but are an attempt to link AE schemes and their monitoring programme more closely to the national BAP.

5. 2003: RCA Method Development

The English Nature rapid assessment method for monitoring the condition of lowland grassland SSSIs (Robertson & Jefferson 2000) provides RCA protocols for most English grassland habitats. In general the recommendation is to adopt these protocols for priority grassland habitats in AE schemes. Condition assessment should be carried out on all sites/features for which quadrat data are obtained. In this way, after the first monitoring round, an important database will be available with both quantitative and associated RCA data for further evaluation and refinement of some methodological issues.

Despite the availability of RCA methods for English grasslands, there are still a number of issues relating to RCA for grassland sites under AE schemes that are not yet fully resolved. These issues are outlined below and indicated under each habitat schedule and further details are provided in Section 3. Where additional development work is needed before RCA grassland monitoring can commence, the opportunity to progress this should be made in 2003.

Checking and agreeing attributes

Key attributes are listed in each grassland Priority Habitat schedule derived from various published sources including EN rapid assessment methods for grasslands (Robertson & Jefferson 2000). In general these published protocols could be adopted for grassland AE Schemes without modification. However because in these methods attributes were selected for the assessment of established, designated sites, there may need to be some modifications for their application to AE schemes, e.g. defining appropriate attributes, positive indicator species and additional condition categories for restoration/recreation sites (see below).

Selecting appropriate positive indicators

Positive indicators are a key attribute in RCA and these have been defined in the EN rapid assessment methods for each priority grassland habitat (Robertson & Jefferson 2000). These indicator lists could be adopted immediately for grassland AE scheme monitoring. However the lists of positive indicators may need to be modified for use in AE scheme monitoring where certain species may not be appropriate indicators for AE schemes. For example, in the case of restoration and re-establishment sites which may take many years (if ever) to achieve the full complement of target species of the appropriate priority habitat.

It may also be appropriate to provide expanded lists of positive (and possibly negative) indicators to enable site assessment against performance indicators. For example the list of indicators could include species indicative of potential defined changes in the vegetation such as nutrient enrichment or drying conditions. Indicators of changing environmental conditions could be drawn, for example, from the suited species of Critchley (2000).

Where grassland sites are included in AE schemes without objectives or with no defined trajectory of development there is a need to identify indicators of the potential of the grassland to improve in quality. Some work has been done on “restorability indicators” by English Nature (Robertson *et al.* 2002) identifying species typical of early stages of successful grassland restoration and re-establishment. However, there is a need for more work to be done before final methods can be agreed. This work could be carried out in 2003 and should include evaluation analysis of existing time series data on grassland restoration and re-establishment sites from previously collected AE scheme monitoring data.

Selecting appropriate targets for attributes.

Since the outcome of RCA depends on meeting targets set in relation to site objectives, setting appropriate targets is central to a workable RCA methodology. Targets have been defined and published for attributes in grassland RCA defining favourable condition for designated sites (Robertson & Jefferson 2000). These targets could therefore be applied to designated sites and priority habitats in or close to favourable condition in AE schemes. However, for non-designated sites, including restoration or re-establishment sites, these published targets may be inappropriately high. New targets defining additional condition categories (see below) need to be developed for the wider countryside and which are realistic and appropriate to restoration or re-establishment objectives.

Determining condition category thresholds for targets.

For non-designated sites there is a need to develop additional condition categories especially for restoration/re-establishment sites of lower quality but with the potential to develop. It is recommended that existing AE scheme grassland quadrat data (and possibly set-aside and heathland re-establishment data) could be analysed to assist in the selection of appropriate targets. These data will be most valuable where time series is available for individual re-establishment or restoration sites indicating the speed and trajectory of likely vegetation change.

6. Year 1: Sampling

Year 1 refers to the first year of survey in the new monitoring programme. Year 2 *et seq*. refers to the second and subsequent surveys. Recommendations for timing of surveys are given in Section 5.1.

Recommendations are given for drawing a sample of sites for RCA and quantitative monitoring. This should be drawn from the schemes that contain the most important resource of the habitat (see Principle AE Schemes above). Sites might need to be added for schemes for which there is no current sample. RCA will provide information on the condition of individual sites, and collectively for the whole sample; the quantitative methods will be used to measure vegetation change across the whole sample. A large sample is recommended for RCA, the size of which will be determined by available resources. Sample selection requires information on the stock of each habitat under AE scheme agreement. This information is incomplete at present, although there are a number of potential ways of estimating stock (see Section 2.1). A sub-sample of the RCA sites will be used for quantitative monitoring. In both cases, the sample should be proportionate random according to the known stock of the target habitat across existing AE schemes. Consideration should be given to the cost-effectiveness of sampling from schemes with only limited stock of the habitat. As much of the current monitoring sample as possible will be included to make best use of longer-term monitoring data, and of the previous investment of resources. Sites not currently under AE agreement should not be included because the overall aim is to monitor the target habitats under AE agreement. No stratification by agreement tier is recommended because tier structure and management prescriptions evolve over time. However, management tier might in some cases be an aid to identifying the target habitat type, such as semi-improved grasslands with potential to develop into a Priority Habitat type.

Tables in the schedules show current sample sizes for the habitat in each scheme, and required total (national) sample sizes overall to detect specified magnitudes of change. Based on this, a recommended total sample size is given. It is recognised that a final decision will be dependent on resources available and priorities between habitats. Even if the suggested sample sizes cannot be met within the resource available, they can be used as an indication of the relative effort required for each habitat. Whatever final sample size is used, the detectable change for particular indicator variables can be declared by reference to the power analyses (see Chapter 3).

Recommended sample sizes for quantitative monitoring have been calculated using power analysis of the existing monitoring samples (see Chapter 3). Sampling recommendations for individual habitats are made to enable vegetation change of a specified magnitude to be detected at the national (England) scale. If the same magnitude of change needs to be detected at a smaller scale, for example to address similar policy questions within individual RDR regions or AE schemes, then the same sample size as recommended for the national sample would be required for each region or scheme. If designated sites (e.g. SSSIs) need to be assessed specifically, a separate, targeted sample would also be needed.

Power analysis results from the repeat surveys of ESA quadrats and ADAS plots were used to estimate required sample sizes, as these were the most suitable available data. The average standard deviations of difference for species richness, G score and Nu score were used in the calculations (Nu score was highly correlated with Ellenberg N so the latter was not included).

The target for each Priority Habitat will ultimately be favourable condition. However, the indicator variables cannot be calibrated against condition categories or attributes before RCA has been carried out during the monitoring programme (see Analysis and Interpretation below). Therefore, data from sites known to be in pristine condition have been used as far as possible as provisional targets. These data had been obtained previously for some habitats from the conservation agencies (Critchley *et al*. 1999a; Fowbert & Critchley 2000). The distance of the current AE samples from these targets was calculated, and the required sample size to detect 100%, 50%, 20% and 10% progression of the AE samples towards these target values was estimated for each of the three variables. Similarly, sample sizes for detecting specified percentage deterioration of existing Priority Habitats towards MG6 semi-improved grassland were calculated. In this case, the MG6 sample across all schemes was used as the 'target'. Sample sizes in the habitat schedules are those required to detect the specified percentage changes in the variable judged to be the most important for that habitat. Where two or more variables were deemed to be equally important, the largest sample sizes are reported. Existing Priority Habitats in the current sample tend to be fairly close to the provisional targets (pristine habitat), so 20-50% detectable progression is considered to be satisfactory.

Since the current targets are provisional, the percentage progression and deterioration between condition categories detectable in the new samples should be calculated once the calibration has been carried out.

In many cases, the current samples are believed to be representative of the habitat in each scheme (see Chapter 2). In doubtful cases, a recommendation is made to draw a new sample from that scheme.

Some current samples include non-agreement land. The agreement status of all sites should be checked at resurvey because this can change. If a comparison with non-agreement sites is required in a particular scheme, then non-agreement sites can only be used if they are known to be comparable in other respects with agreement sites.

The recommended sample sizes are the number of sites required, with one ADAS or CS plot randomly located in each. For ESA quadrats, it is recommended that a sub-sample of three (from the current five) quadrats per site are selected, this being the optimum number (Fowbert *et al*. 2002). This is because between-field variation tends to be much higher than within-field variation, and the addition of more than three quadrats per field only has a small effect on the sample size required to detect a given magnitude of change. Because the quantitative monitoring is aimed at habitat types (as opposed to entire interest features in individual sites as in RCA), only quadrats representing the required habitat type should be included in the sample. Therefore, sites with fewer than three quadrats of the required type might have to be rejected. However, in marginal cases it might be preferable to include a quadrat or site, since NVC classification is often imprecise. All plots and quadrats are fixed and relocatable.

At the time of writing, additional CS plots are being set up in ESAs under project AE02. Potentially, these could incorporated into the new monitoring sample in those ESAs for which there is no current sample of a particular habitat.

The samples should be re-assessed at each re-survey to determine whether there has been sufficient uptake of agreements since the previous survey to justify adding new agreement sites to the sample. However, priority should be given to retaining the existing sample if resources are limited.

Recommended sample sizes for quantitative monitoring of grasslands are as follows:

Grassland	**No. of sites**
CFGM	200
LCG (existing)	50
LCG (potential)	150
LDAG	50
LM	200
PMRP	50
UHM (potential)	100
UHM (degraded)	100
Semi-improved	100
Total	1000

7. Year 1: Field methods

The recommended period for grassland monitoring is May-July, and before the prescribed cutting date for hay meadows, unless otherwise specified.

RCA

Attributes are assessed from a structured walk of the site, some attributes (e.g. positive indicators) are assessed at 20 predetermined, more or less equidistant sampling positions each comprising an area of 1 m radius around the surveyor.

For some attributes/habitats a structured walk of the site noting the existence and condition of the attributes is sufficient without individual sampling positions.

Quantitative

Most monitoring of grasslands in AE schemes has been carried out to date using one of three methods. These are the Countryside Survey method (used in CSS), the ESA quadrat method (used in ESA monitoring schemes commenced before 1993) and the ADAS plot method (used in ESA monitoring schemes commencing post-1992). The Countryside Survey method is also currently being used in the ESA ecological characterisation project, AE02. These use either frequency or cover estimates of plant species (and other variables), at a range of spatial scales. Although the three methods are not fully cross-compatible, some simple amendments in future surveys will allow data from them to be combined for analysis, without compromising the continuity with previous surveys. Recommended amendments are

1. in the CS method, record presence of species in an additional 1m × 1m central nest and

2. in the ESA quadrat method, record presence of species in a 2m × 2m quadrat surrounding the existing 1m × 1m quadrat (this has already been done in some cases).

These modifications will allow data to be analysed from species presence/absence at both $1m^2$ and $4m^2$ scales (see below). It will also provide compatibility for future comparisons with Countryside Survey data.

In ESA quadrats, it is also recommended that in future, cover is estimated to the nearest 1%, rather than using the Domin scale. This is currently being done in the 2002 Pennine Dales ESA survey of upland hay meadows to enable cross-compatibility between the various recording methods that have been used in that ESA. This will ensure that all quadrat records are now compatible between all ESAs, as well as with previous Domin scale records.

Cell sizes (m) in which data are recorded in each field method – recommended additional sizes in italics; sizes common to all methods in bold:

Method:	ESA quadrat	ADAS plot	CS plot
Sizes:	**1×1**, ***2×2***	point, 0.06×0.06, 0.09×0.09, 0.12×0.12, 0.18×0.18, 0.25×0.25, 0.35×0.35, 0.5×0.5, 0.7×0.7, **1×1**, **2×2**, 4×4	point, ***1×1***, **2×2**, 5×5, 7.07×7.07, 10×10, 14.14×14.14

Existing monitoring data are highly valuable, particularly where the timescales are longer. To preserve and exploit this value, the current method used in each scheme (with the above modifications) can be continued in the future. This will allow changes in individual schemes to be assessed over longer timescales, and using more precise methods (e.g. optimum scale from the ADAS plot method).

There is an opportunity to reduce the resource required for recording from ADAS plots by reducing the plot size by 50% (to 16 nests) with only a slight reduction in power and loss of information (see Chapter 2). This was also confirmed by the power analysis results (Chapter 3). Therefore, it is recommended that in future plot size in grasslands is reduced to a 4 × 4 grid of 16 nests.

The HFRO sward stick is recommended as the standard method for measuring sward height or structure, as it provides the best compromise in a variety of vegetation types (see Chapter 2).

8. Year 1: Environmental Data

From the results of the review, recommendations can be made on use of environmental data. The quality of management data is dependent on the availability of accurate records from farmers. Although this is usually variable, the information is key to explaining how AE schemes might be influencing vegetation change and condition. Management practices relevant to each habitat are listed. Meteorological data provide contextual background information for interpreting trends that might be attributable to short-term weather effects.

The relationships between vegetation and other environmental factors would be best explored in a discrete project (or projects) that is complementary to the core monitoring programme. Soil properties influence species composition, and can control the rate and direction of vegetation change. Soil analyses should include total nitrogen and sulphur, because atmospheric deposition of both elements might interact in their effects on vegetation. Other environmental data that can be examined in this way are physical, atmospheric deposition and climate change data.

9. Year 1: Analysis and Interpretation

In order to measure vegetation progression towards the BAP targets, it will be necessary to calibrate data from the quantitative monitoring against the condition categories or attributes defined in the RCA. Some calibration has been done previously of community variables against sites of known quality or condition (Critchley *et al*. 1999a; Fowbert & Critchley 2000). This was done for certain NVC communities corresponding to lowland calcareous grassland, lowland meadows, purple moor-grass and rush pastures and upland hay meadows. The calibration was done using reference sites that were either in favourable condition, or degraded by undergrazing, disturbance or eutrophication. However, this has not been done for the range of JNCC condition categories, or the additional categories recommended for the RCA. It is proposed that the calibration will be carried out as part of the monitoring programme. Sites will be allocated to condition categories using RCA, and then community variables derived from quantitative data from the sub-sample of these sites will be calibrated. This will enable quantitative targets to be set for the respective condition categories. The power test results can be used to show how much progression or deterioration between the categories is detectable.

Each AE scheme will need to be analysed separately up to and including Year 1 (using current samples retained in the new sample), because the monitoring timescales and years of survey differ between schemes, as do the field methods used. From Year 1 onwards, schemes can be analysed collectively. Current samples from individual schemes that are retained in the new sample can also be analysed from their baseline year onwards.

Vegetation change can be analysed by both floristics and community variables. Floristic analysis can be used to measure progression towards target community types. This can be done using multivariate analyses and measuring the distance in ordination space from the target communities. Community variables that are most relevant to the objectives for each grassland habitat have been selected from the list identified in the review (Chapter 2). It is recommended that the Ellenberg N (nitrogen) score is used in future in place of the Nu suited species score. The latter was developed for the last round of reporting for ESA monitoring because at that time Ellenberg N values were not available for the full British flora. Although Nu scores are based partly on functional traits of species, which have a more objective theoretical base than Ellenberg values, this had to be supplemented with data on species' habitat preferences due to incomplete functional trait databases. On balance, it is considered that Ellenberg N values have the advantage of simplicity, and can be usefully applied until functional data are more fully expanded. CSR radii can also be useful for assessing change in relation to plant strategy type, although these are more generalised than Ellenberg values and suited species scores. It is suggested that if CSR radii can be successfully calibrated against condition categories or attributes, then they might also be usefully applied in the monitoring programme.

Trends in AE schemes can be put in the context of the wider countryside by comparison with results from Countryside Survey. However, a quantitative comparison is only possible if at least two survey years coincide with those of Countryside Survey. There is an opportunity for AE scheme monitoring and Countryside Survey fieldwork to be synchronised in the future. Currently, however, trends will have to be compared on a qualitative basis. Comparisons will be dependent on an adequate sample being available in CS for each Priority Habitat. The CS samples also include AE agreement sites, which would have to be excluded (e.g. in 1999, 7% of all CS 'X' plots were under ESA and 3% under CSS agreement; 6% of all CS 'Y' plots were under ESA and 3.5% under CSS agreement). The CVS classes or aggregate classes that most closely correspond to each grassland BAP habitat have been identified.

Currently, English Nature/DEFRA/JNCC are carrying out condition assessments of a sample of lowland grassland Priority Habitats from the County Grassland Inventories (project no. AE08), including sites under AE scheme agreement (2002-2003). This will indicate how the condition of AE scheme sites compares with others. Suggestions are made as to which ECN sites are likely to provide information relevant to each habitat. ECN data will be useful for interpreting long-term trends in vegetation that might be attributable to external environmental factors.

10. Year 2 *et seq.*

Recommendations are made for sampling, data collection and analysis in subsequent years.

4.1.2 Notes on Specific Habitats

Coastal and Floodplain Grazing Marsh (CFGM)

CFGM differs from other grassland Priority Habitats in being a physiogeographical landscape type, rather than a particular set of plant communities. CFGM can therefore encompass a range of habitats, including other grassland Priority Habitats, particularly LM and PMRP. Since these Priority Habitats have their own schedules, they are excluded from the CFGM schedule, with only the more species-poor NVC types being included. Semi-improved (MG6) communities could potentially develop into CFGM; these are included in the schedule for semi-improved grassland. Some communities that occur in CFGM are not well described in the NVC, for example transitions between semi-improved grasslands and mires. Sites that fall into this category could be included in the CFGM monitoring sample. AE schemes listed are only those that contain significant areas of CFGM. Although other schemes contain the relevant NVC types in the current samples, these have not been included in the schedule as they are unlikely to be located within CFGM. The current CSS sample will include some not located within CFGM. These will need to be excluded from the new sample by reference to their geographical location; the EN grazing marsh inventory would be a useful information source for this (Dargie 1996).

The BAP objectives and targets for CFGM were set in 1995, and refer to targets for 2000. Suggested objectives and PIs cannot therefore link directly to these, but are consistent with the overall aims for the habitat. Area targets refer to the UK, although most of the CFGM resource is in England.

RCA

RCA methods for CFGM on which the recommendations are based have been published by Burch, *et al*. (1999), Mitchley *et al*. (2000) and CCW (2002).

In most cases these grasslands are not important for their botanical interest *per se*, but as a habitat for breeding waders and wintering wildfowl. Thus, it is the existence and development of attributes such as a varied topography, standing water and a habitat mosaic including areas of short sward and areas of tussocky sward, which determine condition. Many of these attributes are (or could be) recorded during breeding bird monitoring, surveys which include all the major ESAs and other important areas, and so separate RCA may not be necessary for such sites.

In some cases, areas of botanical interest may also be present within the grazing marsh and it is recommended that in these cases, a separate condition assessment for the appropriate NVC community (e.g. MG13) should be undertaken.

The maintenance and restoration of ditches may typically form part of agreements for this habitat type and recommendations for monitoring these would fall under targeted habitats (Section 4.5).

Quantitative

Current sample sizes are for the specified NVC communities only (MG9-13) and so exclude samples located in CFGM but representing other communities. No suitable data of CFGM in pristine condition were available to use as provisional targets. However, this Priority Habitat is primarily of value as habitat for other taxa, and targets relating to high botanical quality are less important than for other grasslands. In contrast, deterioration of CFGM is an issue, and sample sizes for specified percentages to MG6 have therefore been calculated. The Nu score was used for this calculation; species richness tended to be lower in CFGM than in MG6. Although the Ellenberg F (moisture) value is also of direct relevance, it was not included in the power analyses. The sample sizes required are, however, large. Even with the recommended 200 sites, the minimum detectable change is <50% of deterioration to MG6. If the resources that can be allocated to the grassland monitoring programme are insufficient to cover the total sample recommended, it is suggested that quantitative monitoring of CFGM is not carried out, and that RCA alone is used.

The large sample in the Broads ESA was targeted at a small number of holdings and was not considered to be fully representative of CFGM in the scheme. It is recommended that a new sample is drawn from this ESA, which can include some of the existing sample. The samples in the Suffolk River Valleys and Test Valley ESAs were subjectively selected, and the extent to which they are representative of the resource in these schemes needs to be re-assessed once information on the stock of the habitat in these ESAs has been compiled.

Comparison with CS2000 data is recommended at the CVS aggregate class level because CFGM does not correspond exactly to particular CVS classes.

Lowland Calcareous Grassland (LCG)

RCA

RCA methods for LCG on which the recommendations are based have been published by Robertson & Jefferson (2000), Burch *et al*. (1999), Mitchley *et al*. (2000) and CCW (2002).

Quantitative

Provisional targets used for estimating sample sizes were from pristine CG2 on SSSIs provided by English Nature (Critchley *et al*. 1999a). The current sample of LCG in the Cotswold Hills ESA was subjectively selected, and the extent to which it is representative of the resource in that scheme needs to be re-assessed.

For existing LCG, required sample sizes are from power analyses of the Nu score. The recommendation of 50 sites will allow detection of small amounts of deterioration (10% of deterioration to MG6). It will also allow detection of 20-50% progression to the provisional target.

It is assumed that sites with potential for re-establishment of LCG (e.g. those on chalk downland) can be readily identified during scheme operation. This contrasts with other grassland types for which the potential distribution is less easily defined. Sample sizes have therefore been estimated for three potential LCG precursors, namely MG1 (under-grazed), MG6 (semi-improved) and MG7 (improved) grasslands. To estimate required sample sizes for progression to LCG, samples of these communities from the relevant AE schemes only have been used. MG1 and MG7 grasslands occurred mainly in the CSS and South Downs ESA samples. Required sample sizes refer to species richness for MG6 and MG7 because the required sizes for the Nu score are very small, and these two variables were judged to be equally important. For MG1, the G score was used because grazing is likely to be the most important factor in re-establishment of LCG from this grassland type. The recommended sample sizes of 50 sites will enable detection of 20-50% progression towards the provisional target. If the resources that can be allocated to the grassland monitoring programme are insufficient to cover the total sample recommended, it is suggested that the 50 MG7 sites are excluded, as it will be more difficult to re-establish LCG there.

Lowland Dry Acid Grassland (LDAG)

AE schemes listed include those known to have existing LDAG, even if none is represented in the current monitoring sample.

RCA

RCA methods for LDAG on which the recommendations are based have been published by Robertson & Jefferson (2000), SNH (2001), Burch *et al*. (1999), Mitchley *et al*. (2000) and CCW (2002).

Quantitative

The current sample sizes tabulated will include some upland sites (particularly U4), which will need to be removed from the new sample by reference to GIS data. In addition, the extent to which the existing samples are representative of LDAG in the following ESAs will need to be checked: Blackdown Hills, Pennine Dales, Shropshire Hills, Suffolk River Valleys and West Penwith.

No independent data from sites known to be in pristine condition were available, so required sample sizes to detect specified percentage progression to a target could not be calculated. However, required samples for detecting deterioration have been calculated. Power analysis results for the Nu score have been used. The recommended sample size of 50 sites will allow detection of 20% deterioration to MG6.

Comparison with CS2000 data is recommended at the CVS aggregate class level because LDAG does not correspond exactly to particular CVS classes.

Lowland Meadows (LM)

AE schemes listed include those known to have existing LM, even if none is represented in the current monitoring sample.

RCA

RCA methods for LM on which the recommendations are based have been published by Robertson & Jefferson (2000), SNH (2001), Burch *et al.* (1999), Mitchley *et al.* (2000) and CCW (2002).

Quantitative

Provisional targets used for estimating sample sizes were from pristine MG5 on SSSIs provided by English Nature (Critchley *et al*. 1999a).

For LM, required sample sizes refer to power analysis results for the Nu score. The recommendation of 200 sites allows detection of 20% progression to the provisional target and 20% deterioration to MG6. AE schemes known to contain LM but with no current sample will need to be included in the new sample. LM was found in some of the existing AE samples that were targeted at specific grassland types. Because LM can occur over a wide range of environmental conditions, the extent to which the current samples are representative of the whole LM resource in these schemes is uncertain. The schemes in question are the Blackdown Hills, Cotswold Hills, Pennine Dales, Shropshire Hills, South Wessex Downs and Test Valley ESAs.

Sites with potential for re-establishment of LM will be mainly MG6 semi-improved grasslands. These are covered under the improved/semi-improved grassland schedule because it is unlikely that LM (as distinct from other neutral grassland Priority Habitats) can be explicitly identified as a target for these sites.

Comparison with CS2000 data is recommended at the CVS aggregate class level because LM does not correspond exactly to particular CVS classes.

Purple Moor-grass and Rush Pastures (PMRP)

AE schemes listed include those known to have existing PMRP, even if none is represented in the current monitoring sample. A slightly later fieldwork period (June – August) is recommended than for other grasslands.

RCA

RCA methods for PMRP on which the recommendations are based have been published by Robertson & Jefferson (2000) and SNH (2001).

Quantitative

Current sample sizes tabulated exclude M25. This community was not included in the classification exercise in Chapter 3 because much of the current sample is from unenclosed upland, and potentially on deep peat (in which case it would be blanket bog Priority Habitat).

No suitable data were available for use as a provisional target. In addition, the PMRP NVC communities differed substantially from one another in their community variable values. Therefore, it was not possible to calculate sample sizes for specified percentages of progression or deterioration. Instead, the magnitudes of change detectable for given sample sizes are presented. The suggested sample size of 50 sites will enable a change of 3.33 species m^{-2}, and of 0.05 and 0.08 in G and Nu score respectively to be detected. The extent to which the existing samples are representative of PMRP in the following ESAs will need to be checked: Broads, Blackdown Hills, Lake District, Test Valley and West Penwith.

Comparison with CS2000 data is recommended at the CVS aggregate class level because PMRP does not correspond exactly to particular CVS classes. It might be possible to identify a subset of the CVS aggregate class that corresponds to PMRP.

Upland Hay Meadows (UHM)

RCA

RCA methods for UHM on which the recommendations are based have been published by Robertson & Jefferson (2000), SNH (2001) and CCW 2002.

Quantitative

Three separate monitoring programmes had been set up previously in the PD ESA, namely the Indicative, Validation and Extension surveys. The samples included potential UHM (MG3a/MG7c), degraded UHM (MG3a) and existing UHM (MG3/MG5). The Indicative survey was designed to be a broad-level survey and to monitor change at a field level, whilst the Validation survey was initiated to target selected grassland communities. Finally, the Extension survey was set-up to investigate the new areas introduced into the ESA in 1992. Methods used were:

<u>Indicative Survey:</u>

Baseline survey in 1987.
Semi-fixed (by bearings only) 1m x 1m quadrats
Five quadrats in a 'W' pattern in a field.
Species recorded using the DAFOR scale

<u>Validation Survey:</u>

Baseline survey in 1987.
Standard ESA quadrat method

<u>Extension Survey:</u>

Baseline survey in 1992.
Fixed 1m x 1m quadrats.
Five quadrats in a transect across a field.
Species recorded using the DAFOR scale

A re-survey of potential, degraded and existing UHM in the PD ESA is being carried out by ADAS in 2002. For this, a separate power analysis had been carried out (Fowbert *et al*. 2002), the results of which have been used here. That analysis used an 80% power level (as opposed to 85% used in the current study). Current sample sizes presented in the table are from the original NVC classification as presented in ADAS (1996d) and used by Fowbert *et al*. (2002). The detectable change for given sample sizes are presented.

To ensure cross-compatibility between the programmes in future, % cover estimates are now being used in quadrats. Attempts had been made in 1995 to permanently fix the location of Indicative quadrats, but feedback from the 2002 survey suggests that this has not been successful. Recommendations will be made in the 2002 survey report on re-recording quadrat locations for future surveys.

Recommendations made here for Year 1 refer to the next survey after 2002. Additional samples from CSS and the LD ESA will probably be required then, using proportionate random sampling as also recommended for other grasslands, and using information on the stock of UHM. The extent to which the existing samples in the Pennine Dales ESA represents its UHM and potential UHM resource will need to be checked.

Semi-improved Grassland

There is a substantial resource of semi-improved grasslands within AE schemes with potential for re-establishment of unimproved grassland, but for which no specific targets can be set in terms of Priority Habitats. This is because the potential trajectory of semi-improved grassland cannot always be predicted accurately. In addition, individual site-specific targets are not always set in AE schemes. Therefore, a separate schedule has been produced for semi-improved grasslands for which no specific habitat has been identified as an end target.

The BAP objectives and targets are from the 'conservation direction' for the Neutral Grassland Broad Habitat (previously called the Unimproved Neutral Grassland Broad Habitat). Priority Habitats that are potential endpoints also have objectives and targets for re-establishment, but these refer specifically to ‘carefully targeted sites’ with only modest area targets, and are more relevant to arable reversion or improved grassland being subjected to interventionist management.

AE schemes listed are those that already contain the Priority Habitats that are the potential endpoints, as listed in the other schedules.

From the current samples, sites will need to be identified that have potential for re-establishment. This should be based on their species composition and NVC classification, and on the current tier of agreement (i.e. including sites under tiers likely to result in enhancement). Soil properties, where data are available, will also be a good indicator. Ultimately, EN’s restorability indicators could be developed and utilised to select appropriate sites. The extent to which these samples are likely to be representative of the potential Priority Habitat resource will need to be reviewed for each scheme. New samples will need to be drawn from schemes if the current sample was targeted at only one existing or potential Priority Habitat. For example, the Suffolk River Valleys ESA sample was targeted at existing and potential LDAG, but there might be potential LM and CFGM in other areas. Also, the Broads ESA was targeted at a small number of holdings and was not considered to be fully representative of CFGM in the scheme.

RCA

RCA methods applicable to semi-improved grassland on which the recommendations are based have been published by Robertson *et al.* (2002), SNH (2001), Burch *et al*. (1999), Mitchley *et al*. (2000) and CCW (2002). These methods do not always deal specifically with semi-improved grasslands and this is a habitat type that requires further work to define appropriate methods.

Quantitative

Sample sizes have been calculated for progression to Priority Habitats for which data were available to use as potential endpoints. For LCG and LM, these were the same as the provisional targets used in the respective schedules. For UHM, data for potential endpoints were from pristine MG3 on SSSIs provided by English Nature (Critchley *et al*. 1999a). No targets were available for LDAG, PMRP or CFGM. Required sample sizes are from power analysis of the Nu score. The recommended sample of 100 sites will enable progression to be detected of <10% towards LCG, 20% towards LM and 20-50% towards UHM.

4.2 GRASSLAND HABITAT MONITORING SCHEDULES

4.2.1 Monitoring Schedule: Coastal & Floodplain Grazing Marsh

1. BAP Habitats

Broad	Neutral grassland
Priority	Coastal & floodplain grazing marsh (CFGM)
NVC Communities	MG9-13

2. Relevant BAP Objectives and Targets

1. Maintain existing habitat extent and quality

2. Rehabilitate 10,000ha of grazing marsh habitat that has become too dry, or is intensively managed, by the year 2000

3. AE Schemes

Scheme	Code	Estimated stock
Countryside Stewardship	CSS	517 ha
Avon Valley ESA	AV	n/k
The Broads ESA	BD	n/k
Essex Coast ESA	EC	n/k
North Kent Marshes ESA	KM	n/k
Somerset Levels & Moors ESA	SL	n/k
Suffolk River Valleys ESA	SR	n/k
Test Valley ESA	TV	n/k
Upper Thames Tributaries ESA	UT	n/k

4. Proposed Scheme Objectives and Performance Indicators

1. Maintain the condition of coastal and floodplain grazing marsh under AE agreement where condition is currently favourable.

Coastal and floodplain grazing marsh sites in favourable condition in Year 1 do not show subsequent deterioration to a lower condition category as measured by RCA. No deterioration is detected after Year 1 in floristics or plant community variables on land under AE agreement or, if there is deterioration, it is within the range of variation of the favourable condition category.

2. Where the condition of coastal and floodplain grazing marsh under AE agreement is not currently favourable, achieve demonstrable improvements in condition by 2010.

Coastal and floodplain grazing marsh sites not currently in favourable condition improve by at least one condition category as measured by RCA between Year 1 and

2010. Improvement equivalent to at least one higher condition category is detected in floristics and plant community variables between Year 1 and 2010.

5. 2003: RCA Method Development

The recommended method is Mitchley *et al*. (2000). However there is scope for further methodological development:

1. Selection and agreement of appropriate attributes.
2. Selection and trialling of appropriate targets for agreed attributes.
3. Determining condition category thresholds for these targets.

6. Year 1: Sampling

RCA

Large sample (proportionate random according to stock) of existing CFGM, including sites selected for quantitative monitoring.

Quantitative

	Scheme	Method	*n* (plots or quadrats)	
Current sample	CSS	CS	53	
	AV	ADAS plot	36	
	BD	ESA quadrat	231	
	KM	ADAS plot	3	
	SL	ESA quadrat/ ADAS plot	233	
	SR	ESA quadrat	2	
	TV	ESA quadrat	99	
	UT	ADAS plot	19	
	all	various	676	
			% deterioration	***n (sites)***
Required sample	all	various	100	100
	all	various	50	>200
	all	various	20	>200
	all	various	10	>200

Recommended national minimum sample = 200 sites

7. Year 1: Field methods

RCA

Structured of the site, noting the existence and condition of the given attributes. With large extensive areas of little botanical interest there is no need for individual sampling positions. Recommended visiting period - before May / June, to assess standing water.

Key attributes
Low hedges - no more than 2m (unless e.g. pollarded willows)
Standing surface water maintained until May / June
Patches of soft mud
Vegetation mosaic of different heights – including frequent tussock forming species
Low infestation of pernicious weed species

Quantitative

Scheme	**Quantitative**
CSS	CS plots plus record species p/a in additional 1m x 1m central nest
BD, SL, SR, TV	ESA quadrats with % cover estimate plus record species p/a in surrounding 2m x 2m quadrat
all other ESAs	ADAS plots but reduce to 16 nests

8. Year 1: Environmental Data

To be collected from quantitative monitoring sample:

1. Management data: organic & inorganic fertiliser & lime application; stock type, density and timing; weed control; rolling/harrowing; water level manipulations.
2. Meteorological data.

9. Year 1: Analysis and Interpretation

1. Calibrate community variables (from quantitative data) against condition categories.
2. Analyse change in floristics and community variables for each scheme separately up to and including Year 1.
3. Community (indicator) variables: Ellenberg N & F; G suited species scores; species richness, individual species.
4. Analyse relationships between vegetation and management.
5. Compare trends with CVS Aggregate Class IV (infertile grassland) in CS2000.
6. Compare trends with ECN site (North Wyke).

10. Year 2 *et seq.*: Sampling & Field Methods.

Repeat Year 1 methods.

11. Year 2 *et seq*.: Environmental Data

To be collected from quantitative monitoring sample:

1. Management data as in Year 1.
2. Meteorological data.

12. Year 2 *et seq*.: Analysis and Interpretation

1. Analyse change in floristics and community variables for all schemes collectively from Year 1 to Year 2 *et seq.*
2. Analyse change in floristics and community variables for each scheme separately from original baselines up to and including Year 2 *et seq*.
3. Community (indicator) variables: as Year 1.
4. Analyse relationship between vegetation change and management.
5. Compare trends with CVS Aggregate Class IV (infertile grassland) in Countryside Survey if CS is repeated at appropriate interval.
6. Compare trends with ECN site (North Wyke).

4.2.2 Monitoring Schedule: Lowland Calcareous Grassland

1. BAP Habitats

Broad	Calcareous grassland
Priority	Lowland calcareous grassland (LCG)
NVC Communities	CG1-8, lowland CG9

2. Relevant BAP Objectives and Targets

1. Arrest depletion of unimproved lowland calcareous grassland

2. Within SSSIs, initiate rehabilitation management for all significant stands of unimproved lowland calcareous grassland in unfavourable condition by 2005, with the aim of achieving favourable status wherever feasible by 2010.

3. Secure favourable condition over 30% of the (non-SSSI) resource by 2005 and as near 100% as practicable by 2015

3. AE Schemes

Scheme	Code	Estimated stock
Countryside Stewardship	CSS	3716 ha
Breckland ESA	BK	n/k
Cotswold Hills ESA	CH	n/k
Lake District ESA	LD	n/k
Pennine Dales ESA	PD	n/k
South Downs ESA	SD	n/k
South Wessex Downs ESA	SX	n/k

4. Proposed Scheme Objectives and Performance Indicators

1. Maintain the condition of lowland calcareous grassland under AE agreement where condition is currently favourable.

Lowland calcareous grassland sites in favourable condition in Year 1 do not show subsequent deterioration to a lower condition category as measured by RCA. No deterioration is detected after Year 1 in floristics or plant community variables on land under AE agreement or, if there is deterioration, it is within the range of variation of the favourable condition category.

2. Where the condition of lowland calcareous grassland in SSSIs under AE agreement is not currently favourable, achieve favourable condition by 2010.

Lowland calcareous grassland sites not currently in favourable condition that are SSSIs achieve favourable condition as measured by RCA by 2010. Improvement in floristics and plant community variables equivalent to favourable condition is detected by 2010.

3. Where the condition of lowland calcareous grassland outside SSSIs under AE agreement is not currently favourable, achieve demonstrable improvements in condition by 2010 and favourable condition by 2015.

Lowland calcareous grassland sites not currently in favourable condition that are outside SSSIs improve by at least one condition category as measured by RCA between Year 1 and 2010, and achieve favourable condition by 2015. Improvement equivalent to at least one higher condition category is detected in floristics and plant community variables between Year 1 and 2010, and equivalent to favourable condition by 2015.

4. Semi-improved grassland that has potential for re-establishment to lowland calcareous grassland achieves demonstrable improvements by 2010.

Potential calcareous grassland sites improve by at least one condition category as measured by RCA between Year 1 and 2010. Improvement equivalent to at least one higher condition category is detected in floristics and plant community variables between Year 1 and 2010.

5. 2003: RCA Method Development

The recommended method is Robertson & Jefferson (2000). This method is appropriate for designated LCG sites and other LCG in or close to favourable condition. For other LCG sites and for restoration and re-establishment sites, method development is required:

Checking and agreeing attributes.

1. Selecting appropriate positive indicators.
2. Identifying species typical of early stages of successful LCG restoration and re-creation for use as potential "restorability indicators".
3. Selecting and trialling appropriate targets for agreed attributes.
4. Determining condition category thresholds for these targets.

6. Year 1: Sampling

RCA

Large sample (proportionate random according to stock) of existing LCG and potential LCG, including sites selected for quantitative monitoring.

Quantitative

<u>Existing LCG</u>

	Scheme	**Method**	***n* (plots or quadrats)**			
Current sample	CSS	CS	26			
	CH	ADAS plot*	13			
	PD	ESA quadrat	6			
	SD	ESA quadrat	49			
	SX	ADAS plot	39			
	TV	ESA quadrat	3			
	all	various	136			
			% progression	***n* (sites)**	**% deterioration**	***n* (sites)**
Required sample	all	various	100	<10	100	<10
	all	various	50	20	50	<10
	all	various	20	100	20	20
	all	various	10	200	10	50

*4m × 2m

Recommended national minimum sample = 50 sites

<u>Potential LCG</u>

	% progression	**MG1 (under-grazed)**	**MG6 (semi-improved)**	**MG7 (improved)**
Required sample	100	<10	<10	<10
	50	20	20	20
	20	100	100	100
	10	>200	>200	>200

Recommended national minimum sample = 50 each of MG1, MG6 or MG7.

7. Year 1: Field methods

RCA

Structured walk with 20 sampling positions

Grassland	Key attributes
Existing LCG	grass:herb ratio positive indicator species (presence & frequency) negative indicator species (presence & frequency): pernicious weeds, scrub & coarse grass species *e.g. Brachypodium pinnatum*, *Bromus erectus* sward structure: height, bare ground, litter cover lichens: % cover (CG1, CG7c)
Potential LCG	positive indicator species (presence) in margin (e.g. 20m closest to adjacent colonising source) & core of site

Quantitative

Scheme	Quantitative
CSS	CS plots plus record species p/a in additional 1m x 1m central nest
SD, PD	ESA quadrats with % cover estimate plus record species p/a in surrounding 2m x 2m quadrat
all other ESAs	ADAS plots but reduce to 16 nests

8. Year 1: Environmental Data

To be collected from quantitative monitoring sample.

1. Management data: organic & inorganic fertiliser application; stock type, density and timing; weed control; rolling/harrowing.
2. Meteorological data.

9. Year 1: Analysis and Interpretation

1. Calibrate community variables (from quantitative data) against condition categories.
2. Analyse change in floristics and community variables for each scheme separately up to and including Year 1.
3. Community (indicator) variables: Ellenberg N & R; C & G suited species scores; species richness, individual species.
4. Analyse relationships between vegetation and management.
5. Compare trends with CVS Class 44 (calcareous grassland) in CS2000.
6. Compare condition with EN BAP lowland calcareous grassland samples surveyed in 2002-3.
7. Compare trends with ECN site (Porton Down).

10. Year 2 *et seq.*: Sampling & Field Methods.

Repeat Year 1 methods.

11. Year 2 *et seq*.: Environmental Data

To be collected from quantitative monitoring sample:

1. Management data as in Year 1.
2. Meteorological data.

12. Year 2 *et seq*.: Analysis and Interpretation

1. Analyse change in floristics and community variables for all schemes collectively from Year 1 to Year 2 *et seq.*
2. Analyse change in floristics and community variables for each scheme separately from original baselines up to and including Year 2 *et seq*.
3. Community (indicator) variables: as Year 1.
4. Analyse relationship between vegetation change and management.
5. Compare trends with CVS class 44 (calcareous grassland) in Countryside Survey if CS is repeated at appropriate interval.
6. Compare condition with EN BAP lowland calcareous grassland samples surveyed in 2002-3 (or later surveys if repeated).
7. Compare trends with ECN site (Porton Down).

4.2.3 Monitoring Schedule: Lowland Dry Acid Grassland

1. BAP Habitats

Broad	Acid grassland
Priority	Lowland dry acid grassland (LDAG)
NVC Communities	lowland U1-4, SD10, 11 (inland sub-communities)

2. Relevant BAP Objectives and Targets

1. Arrest depletion of unimproved lowland acid grassland

2. Within SSSIs, initiate rehabilitation management for all significant stands of unimproved lowland acid grassland in unfavourable condition by 2005, with the aim of achieving favourable status wherever feasible by 2010.

3. Secure favourable condition over 30% of the (non-SSSI) resource by 2005 and as near 100% as practicable by 2015

3. AE Schemes

Scheme	Code	Estimated stock
Countryside Stewardship	CSS	2030 ha
Breckland ESA	BK	n/k
Clun ESA	CN	n/k
Dartmoor ESA	DM	n/k
Exmoor ESA	EX	n/k
Shropshire Hills ESA	SH	n/k
Suffolk River Valleys ESA	SR	n/k
West Penwith ESA	WP	n/k

4. Proposed Scheme Objectives and Performance Indicators

1. Maintain the condition of lowland dry acid grassland under AE agreement where condition is currently favourable.

Lowland dry acid grassland sites in favourable condition in Year 1 do not show subsequent deterioration to a lower condition category as measured by RCA. No deterioration is detected after Year 1 in floristics or plant community variables on land under AE agreement or, if there is deterioration, it is within the range of variation of the favourable condition category.

2. Where the condition of lowland dry acid grassland in SSSIs under AE agreement is not currently favourable, achieve favourable condition by 2010.

Lowland dry acid grassland sites not currently in favourable condition that are SSSIs achieve favourable condition as measured by RCA by 2010. Improvement in floristics and plant community variables equivalent to favourable condition is detected by 2010.

3. Where the condition of lowland dry acid grassland outside SSSIs under AE agreement is not currently favourable, achieve demonstrable improvements in condition by 2010 and favourable condition by 2015.

Lowland dry acid grassland sites not currently in favourable condition that are outside SSSIs improve by at least one condition category as measured by RCA between Year 1 and 2010, and achieve favourable condition by 2015. Improvement equivalent to at least one higher condition category is detected in floristics and plant community variables between Year 1 and 2010, and equivalent to favourable condition by 2015.

5. 2003: RCA Method Development

The recommended method is Robertson & Jefferson (2000). This method is appropriate for designated LDAG sites and other LDAG in or close to favourable condition. For other LDAG sites and for restoration and re-establishment sites further method development is required:

1. Checking and agreeing attributes.
2. Selecting appropriate positive indicators.
3. Selecting and trialling appropriate targets for agreed attributes.
4. Determining condition category thresholds for these targets.

6. Year 1: Sampling

RCA

Large sample (proportionate random according to stock) of existing LDAG, including sites selected for quantitative monitoring.

Quantitative

	Scheme	Method	*n* (plots or quadrats)	
Current sample	CSS	CS	11	
	BH	ADAS plot	1	
	CN	ADAS plot	4	
	DM	ADAS plot	17	
	EX	ADAS plot	14	
	PD	ESA quadrat	5	
	SH	ADAS plot	10	
	SP	ADAS plot	11	
	SR	ESA quadrat	10	
	WP	ADAS plot	4	
	all	various	87	
			% deterioration	***n* (sites)**
Required sample	all	various	100	<10
	all	various	50	<10
	all	various	20	50
	all	various	10	200

Recommended national minimum sample = 50 sites

7. Year 1: Field methods

RCA

Structured walk with 20 sampling positions.

Key attributes
Positive indicator species (presence and frequency) Frequency and % cover of *Agrostis curtisii* (U3 only) Negative indicator species (presence and frequency) - e.g. pernicious weeds, scrub (including *Ulex* spp. - U3 only, and *Rhododendron* spp.) and coarse grass species, e.g. *Holcus lanatus*, *Dactylis glomerata* Sward structure - sward height, bare ground, litter cover

Quantitative

Scheme	Quantitative
CSS	CS plots plus record species p/a in additional 1m x 1m central nest
PD, SR	ESA quadrats with % cover estimate plus record species p/a in surrounding 2m x 2m quadrat
all other ESAs	ADAS plots but reduce to 16 nests

8. Year 1: Environmental Data

To be collected from quantitative monitoring sample:

1. Management data: organic & inorganic fertiliser & lime application; stock type, density and timing; weed control; rolling/harrowing.
2. Meteorological data.

9. Year 1: Analysis and Interpretation

1. Calibrate community variables (from quantitative data) against condition categories.
2. Analyse change in floristics and community variables for each scheme separately up to and including Year 1.
3. Community (indicator) variables: Ellenberg N, F & R; A & G suited species scores; species richness, individual species.
4. Analyse relationships between vegetation and management.
5. Compare trends with CVS Aggregate Class IV (infertile grassland) in CS2000.
6. Compare condition with EN BAP lowland dry acid grassland samples surveyed in 2002-3.

10. Year 2 *et seq.*: Sampling & Field Methods.

Repeat Year 1 methods.

11. Year 2 *et seq.*: Environmental Data

To be collected from quantitative monitoring sample:

1. Management data as in Year 1.
2. Meteorological data.

12. Year 2 *et seq.*: Analysis and Interpretation

1. Analyse change in floristics and community variables for all schemes collectively from Year 1 to Year 2 *et seq.*
2. Analyse change in floristics and community variables for each scheme separately from original baselines up to and including Year 2 *et seq*.
3. Community (indicator) variables: as Year 1.
4. Analyse relationship between vegetation change and management.
5. Compare trends with CVS Aggregate Class IV (infertile grassland) in Countryside Survey if CS is repeated at appropriate interval.
6. Compare condition with EN BAP lowland dry acid grassland samples surveyed in 2002-3 (or later surveys if repeated).

4.2.4 Monitoring Schedule: Lowland Meadows

1. BAP Habitats

Broad	Neutral grassland
Priority	Lowland meadows (LM)
NVC Communities	MG4, MG5, MG8

2. Relevant BAP Objectives and Targets

1. Arrest depletion of unimproved lowland meadow

2. Within SSSIs, initiate rehabilitation management for all significant stands of unimproved lowland meadow in unfavourable condition by 2005, with the aim of achieving favourable status wherever feasible by 2010.

3. Secure favourable condition over 30% of the (non-SSSI) resource by 2005 and as near 100% as practicable by 2015

3. Principle AE Schemes

Scheme	Code	Estimated stock
Countryside Stewardship	CSS	682 ha
Breckland ESA	BK	n/k
Cotswold Hills ESA	CH	n/k
Lake District ESA	LD	n/k
Pennine Dales ESA	PD	n/k
Shropshire Hills ESA	SH	n/k
Somerset Levels & Moors ESA	SL	n/k
South Downs ESA	SD	n/k
South Wessex Downs ESA	SD	n/k
Upper Thames Tributaries ESA	UT	n/k

4. Proposed Scheme Objectives and Performance Indicators

1. Maintain the condition of lowland meadow under AE agreement where condition is currently favourable.

Lowland meadow sites in favourable condition in Year 1 do not show subsequent deterioration to a lower condition category as measured by RCA. No deterioration is detected after Year 1 in floristics or plant community variables on land under AE agreement or, if there is deterioration, it is within the range of variation of the favourable condition category.

2. Where the condition of lowland meadow in SSSIs under AE agreement is not currently favourable, achieve favourable condition by 2010.

Lowland meadow sites not currently in favourable condition that are SSSIs achieve favourable condition as measured by RCA by 2010. Improvement in floristics and plant community variables equivalent to favourable condition is detected by 2010.

3. Where the condition of lowland meadow outside SSSIs under AE agreement is not currently favourable, achieve demonstrable improvements in condition by 2010 and favourable condition by 2015.

Lowland meadow sites not currently in favourable condition that are outside SSSIs improve by at least one condition category as measured by RCA between Year 1 and 2010, and achieve favourable condition by 2015. Improvement equivalent to at least one higher condition category is detected in floristics and plant community variables between Year 1 and 2010, and equivalent to favourable condition by 2015.

5. 2003: RCA Method Development

The recommended method is Robertson & Jefferson (2000). This method is appropriate for designated LM sites and other LM in or close to favourable condition. For other LM sites and for restoration and re-establishment sites, method development is required:

1. Checking and agreeing attributes.
2. Selecting appropriate positive indicators.
3. Selecting and trialling appropriate targets for agreed attributes.
4. Determining condition category thresholds for these targets.

6. Year 1: Sampling

RCA

Large sample (proportionate random according to stock) of existing LM, including sites selected for quantitative monitoring.

Quantitative

	Scheme	**Method**	***n* (plots or quadrats)**			
Current sample	CSS	CS	76			
	AV	ADAS plot	3			
	BH	ADAS plot	10			
	CH	ADAS plot*	9			
	CN	ADAS plot	6			
	DM	ADAS plot	12			
	EX	ADAS plot	2			
	PD	ESA quadrat	4			
	SH	ADAS plot	3			
	SL	ESA quadrat/ ADAS plot	25			
	SP	ADAS plot	4			
	SX	ADAS plot	6			
	TV	ESA quadrat	12			
	UT	ADAS plot	3			
	all	various	175			
			% progression	***n* (sites)**	**% deterioration**	***n* (sites)**
Required sample	all	various	100	20	100	20
	all	various	50	50	50	50
	all	various	20	200	20	200
	all	various	10	>200	10	>200

*4m × 2m

Recommended national minimum sample = 200 sites

7. Year 1: Field methods

RCA

Structured walk with 20 sampling positions. Recommended visiting period: May – July, prior to cutting

Key attributes
Grass:herb ratio
Positive indicator species
Negative indicator species
Sward structure - sward height, bare ground, litter cover

Quantitative

Scheme	Quantitative
CSS	CS plots plus record species p/a in additional 1m x 1m central nest
PD, SL, TV	ESA quadrats with % cover estimate plus record species p/a in surrounding 2m x 2m quadrat
all other ESAs	ADAS plots but reduce to 16 nests

8. Year 1: Environmental Data

To be collected from quantitative monitoring sample:

1. Management data: organic & inorganic fertiliser & lime application; stock type, density and timing; weed control; rolling/harrowing; closing & cutting date.
2. Meteorological data.

9. Year 1: Analysis and Interpretation

1. Calibrate community variables (from quantitative data) against condition categories.
2. Analyse change in floristics and community variables for each scheme separately up to and including Year 1.
3. Community (indicator) variables: Ellenberg N & F; G suited species scores; species richness, individual species.
4. Analyse relationships between vegetation and management.
5. Compare trends with CVS Aggregate Class IV (infertile grassland) in CS2000.
6. Compare condition with EN BAP lowland meadow samples surveyed in 2002-3.
7. Compare trends with ECN sites (Drayton, Wytham, North Wyke).

10. Year 2 *et seq.*: Sampling & Field Methods.

Repeat Year 1 methods.

11. Year 2 *et seq.*: Environmental Data

To be collected from quantitative monitoring sample:

1. Management data as in Year 1.
2. Meteorological data.

12. Year 2 *et seq.*: Analysis and Interpretation

1. Analyse change in floristics and community variables for all schemes collectively from Year 1 to Year 2 *et seq*.
2. Analyse change in floristics and community variables for each scheme separately from original baselines up to and including Year 2 *et seq*.
3. Community (indicator) variables: as Year 1.
4. Analyse relationship between vegetation change and management.
5. Compare trends with CVS Aggregate Class IV (infertile grassland) in Countryside Survey if CS is repeated at appropriate interval.

6. Compare condition with EN BAP lowland meadow samples surveyed in 2002-3 (or later surveys if repeated).
7. Compare trends with ECN sites (Drayton, Wytham, North Wyke).

4.2.5 Monitoring Schedule: Purple Moor Grass & Rush Pastures

1. BAP Habitats

Broad	Fen, Marsh and Swamp
Priority	Purple moor grass & rush pastures
NVC Communities	M22-26 (except on deep peat or unenclosed uplands)

2. Relevant BAP Objectives and Targets

1. Secure sympathetic management of at least 5,000 ha (in England) of purple moor grass and rush pasture by 2000

3. AE Schemes

Scheme	Code	Estimated stock
Countryside Stewardship	CSS	n/k
Blackdown Hills ESA	BH	n/k
Broads ESA	BD	n/k
Dartmoor ESA	DM	n/k
Exmoor ESA	EX	n/k
Somerset Levels & Moors ESA	SL	n/k
Suffolk River Valleys ESA	SR	n/k

4. Proposed Scheme Objectives and Performance Indicators

1. Maintain the condition of purple moor grass and rush pasture under AE agreement where condition is currently favourable.

Purple moor grass and rush pasture sites in favourable condition in Year 1 do not show subsequent deterioration to a lower condition category as measured by RCA. No deterioration is detected after Year 1 in floristics or plant community variables on land under AE agreement or, if there is deterioration, it is within the range of variation of the favourable condition category.

2. Where the condition of purple moor grass and rush pasture under AE agreement is not currently favourable, achieve demonstrable improvements in condition by 2010.

Purple moor grass and rush pasture sites not currently in favourable condition improve by at least one condition category as measured by RCA between Year 1 and 2010. Improvement equivalent to at least one higher condition category is detected in floristics and plant community variables between Year 1 and 2010.

5. 2003: RCA Method Development

The recommended method is Robertson & Jefferson (2000). This method is appropriate for designated PMRP sites and other PMRP in or close to favourable condition. For other PMRP sites and for restoration and re-establishment sites, further method development is required:

1. Checking and agreeing attributes.
2. Selecting appropriate positive indicators.
3. Selecting and trialling appropriate targets for agreed attributes.
4. Determining condition category thresholds for these targets.

6. Year 1: Sampling

RCA

Large sample (proportionate random according to stock) of existing PMRP, including sites selected for quantitative monitoring.

Quantitative

	Scheme	Method	*n* (plots or quadrats)
Current sample	CSS	CS	21
	BD	ESA quadrat	2
	BH	ADAS plot	1
	CN	ADAS plot	3
	EX	ADAS plot	9
	LD	ADAS plot	2
	SL	ESA quadrat	11
	SP	ADAS plot	5
	TV	ESA quadrat	1
	WP	ADAS plot	2
	all	various	57

Detectable change in community variables for given sample sizes:

n (sites)	10	20	50	100	200
Species richness	8.21	5.44	3.33	2.33	1.64
G score	0.14	0.09	0.05	0.04	0.03
Nu score	0.21	0.14	0.08	0.06	0.03

Recommended national minimum sample = 50 sites

7. Year 1: Field methods

RCA

Structured walk with 20 sampling positions. Recommended visiting period: June – August.

Key attributes
Positive indicator species (presence and frequency)
Frequency and cover of *Molinia caerulea*
Negative indicator species (presence and frequency) - e.g. pernicious weeds, scrub and trees
Percentage cover of *Juncus* species
Percentage cover *Cirsium palustre* (M24 and M25 only)
Percentage cover *Deschampsia cespitosa*
Percentage cover *Phragmites australis*
Percentage cover *Myrica gale* (M24 and M25 only)
Sward structure - sward height, bare ground, litter cover

Quantitative

Scheme	**Quantitative**
CSS	CS plots plus record species p/a in additional 1m x 1m central nest
BD, SL, TV	ESA quadrats with % cover estimate plus record species p/a in surrounding 2m x 2m quadrat
all other ESAs	ADAS plots but reduce to 16 nests

8. Year 1: Environmental Data

To be collected from quantitative monitoring sample:

1. Management data: organic & inorganic fertiliser & lime application; stock type, density and timing; weed control; rolling/harrowing.
2. Meteorological data.

9. Year 1: Analysis and Interpretation

1. Calibrate community variables (from quantitative data) against condition categories.
2. Analyse change in floristics and community variables for each scheme separately up to and including Year 1.
3. Community (indicator) variables: Ellenberg N & F; G suited species scores; species richness, individual species.
4. Analyse relationships between vegetation and management.
5. Compare trends with a subset of CVS Aggregate Class IV (infertile grassland) in CS2000.
6. Compare condition with EN BAP purple moor grass & rush pasture samples surveyed in 2002-3.
7. Compare trends with ECN site (North Wyke).

10. Year 2 *et seq.*: Sampling & Field Methods.

Repeat Year 1 methods.

11. Year 2 *et seq*.: Environmental Data

To be collected from quantitative monitoring sample:

1. Management data as in Year 1.
2. Meteorological data.

12. Year 2 *et seq*.: Analysis and Interpretation

1. Analyse change in floristics and community variables for all schemes collectively from Year 1 to Year 2 *et seq.*
2. Analyse change in floristics and community variables for each scheme separately from original baselines up to and including Year 2 *et seq.*
3. Community (indicator) variables: as Year 1.
4. Analyse relationship between vegetation change and management.
5. Compare trends with a subset CVS Aggregate Class IV (infertile grassland) in Countryside Survey if CS is repeated at appropriate interval.
6. Compare condition with EN BAP purple moor grass & rush pasture samples surveyed in 2002-3 (or later surveys if repeated).
7. Compare trends with ECN site (North Wyke).

4.2.6 Monitoring Schedule: Upland Hay Meadows

1. BAP Habitats

Broad	Neutral grassland
Priority	Upland hay meadows (UHM)
NVC Communities	MG3

2. Relevant BAP Objectives and Targets

1. Arrest depletion of unimproved upland hay meadow

2. Within SSSIs, initiate rehabilitation management for all significant stands of unimproved upland hay meadow in unfavourable condition by 2005, with the aim of achieving favourable status wherever feasible by 2010.

3. Secure favourable condition over 30% of the (non-SSSI) resource by 2005 and as near 100% as practicable by 2015

3. AE Schemes

Scheme	Code	Estimated stock
Countryside Stewardship	CSS	n/k
Lake District ESA	LD	n/k
Pennine Dales ESA	PD	n/k

4. Proposed Scheme Objectives and Performance Indicators

1. Maintain the condition of upland hay meadow under AE agreement where condition is currently favourable.

Upland hay meadow sites in favourable condition in Year 1 do not show subsequent deterioration to a lower condition category as measured by RCA. No deterioration is detected after Year 1 in floristics or plant community variables on land under AE agreement or, if there is deterioration, it is within the range of variation of the favourable condition category.

2. Where the condition of upland hay meadow in SSSIs under AE agreement is not currently favourable, achieve favourable condition by 2010.

Upland hay meadow sites not currently in favourable condition that are SSSIs achieve favourable condition as measured by RCA by 2010. Improvement in floristics and plant community variables equivalent to favourable condition is detected by 2010.

3. Where the condition of upland hay meadow outside SSSIs under AE agreement is not currently favourable, achieve demonstrable improvements in condition by 2010 and favourable condition by 2015.

Upland hay meadow sites not currently in favourable condition that are outside SSSIs improve by at least one condition category as measured by RCA between Year 1 and 2010, and achieve favourable condition by 2015. Improvement equivalent to at least one higher condition category is detected in floristics and plant community variables between Year 1 and 2010, and equivalent to favourable condition by 2015.

5. 2003: RCA Method Development

The recommended method is Robertson & Jefferson (2000). This method is appropriate for designated UMH sites and other UHM in or close to favourable condition. For other UHM sites and for restoration and re-establishment sites, method development is required:

1. Checking and agreeing attributes.
2. Selecting appropriate positive indicators.
3. Selecting and trialling appropriate targets for agreed attributes.
4. Determining condition category thresholds for these targets.

6. Year 1: Sampling

RCA

Large sample (proportionate random according to stock) of existing UHM, including sites selected for quantitative monitoring.

Quantitative

Current sample: data for Pennine Dales ESA are number of sites (fields) that are predominantly of that grassland type.

Scheme **Method**	***PD*** **ESA quadrat**	***PD*** **'Indicative'**	***PD*** **'Extension'**	**CSS** **CS plot**
Grassland				
Potential UHM	7	28	44	0
Degraded UHM	37	45	50	0
Existing UHM	6	0	1	2

Detectable change in community variables for given sample sizes:

Sample size (sites)	50		100		200	
	Potential UHM	**Degraded UHM**	**Potential UHM**	**Degraded UHM**	**Potential UHM**	**Degraded UHM**
Species richness	≈ 5.5	≈ 5.1	≈ 4.2	≈ 3.7	≈ 2.7	< 2.8
G score	< 0.034	< 0.037	< 0.034	< 0.037	< 0.034	< 0.037
Nu score	> 0.012	≈ 0.039	> 0.012	≈ 0.027	> 0.012	≈ 0.020

Recommended national minimum sample = 100 sites each for potential and degraded UHM. The stock of UHM appears to be low, and it is recommended that as many as possible are sampled, using local grassland inventories to identify suitable sites.

7. Year 1: Field methods

RCA

Structured walk with 20 sampling positions. Recommended visiting period: May - July prior to cutting.

Key attributes
Grass herb ratio
Positive indicator species (presence and frequency)
Negative indicator species (presence and frequency) - e.g. pernicious weeds, trees and scrub
Sward structure - sward height, bare ground, litter cover

Quantitative

Scheme	Quantitative
CSS	CSS plots plus record species p/a in additional 1m x 1m central nest
PD	ESA quadrats with % cover estimate plus record species p/a in surrounding 2m x 2m quadrat
LD	ADAS plots but reduce to 16 nests

8. Year 1: Environmental Data

To be collected from quantitative monitoring sample:

1. Management data: organic & inorganic fertiliser & lime application; stock type, density and timing; weed control; rolling/harrowing; closing & cutting date.
2. Meteorological data.

9. Year 1: Analysis and Interpretation

1. Calibrate community variables (from quantitative data) against condition categories.
2. Analyse change in floristics and community variables for each scheme separately up to and including Year 1.
3. Community (indicator) variables: Ellenberg N & R; C & G suited species scores; species richness, individual species.
4. Analyse relationships between vegetation and management.
5. Compare trends with CVS Aggregate Class IV (infertile grassland) in CS2000.
6. Compare condition with EN BAP upland hay meadow samples surveyed in 2002-3.
7. Compare trends with ECN site (Moor House-Upper Teesdale).

10. Year 2 *et seq.*: Sampling & Field Methods.

Repeat Year 1 methods.

11. Year 2 *et seq*.: Environmental Data

To be collected from quantitative monitoring sample:

1. Management data as in Year 1.
2. Meteorological data.

12. Year 2 *et seq*.: Analysis and Interpretation

1. Analyse change in floristics and community variables for all schemes collectively from Year 1 to Year 2 *et seq.*
2. Analyse change in floristics and community variables for each scheme separately from original baselines up to and including Year 2 *et seq.*
3. Community (indicator) variables: as Year 1.
4. Analyse relationship between vegetation change and management.
5. Compare trends with CVS Aggregate Class IV (infertile grassland) in Countryside Survey if CS is repeated at appropriate interval.
6. Compare condition with EN BAP upland hay meadow samples surveyed in 2002-3 (or later surveys if repeated).
7. Compare trends with ECN site (Moor House-Upper Teesdale).

4.2.7 Monitoring Schedule: Semi-Improved Grassland

1. BAP Habitats

Broad Neutral grassland

NVC Communities MG6

2. Relevant BAP Objectives and Targets

1. Restore degraded neutral grasslands to buffer sites and restore the range of neutral grasslands

3. Principle AE Schemes

Scheme	Code	Estimated stock
Countryside Stewardship	CSS	682 ha
Avon Valley ESA	AV	n/k
Blackdown Hills ESA	BH	n/k
Breckland ESA	BK	n/k
Broads ESA	BD	n/k
Clun ESA	CN	n/k
Cotswold Hills ESA	CH	n/k
Dartmoor ESA	DM	n/k
Essex Coast ESA	EC	n/k
Exmoor ESA	EX	n/k
Lake District ESA	LD	n/k
North Kent Marshes ESA	KM	n/k
Pennine Dales ESA	PD	n/k
Shropshire Hills ESA	SH	n/k
Somerset Levels & Moors ESA	SL	n/k
South Downs ESA	SD	n/k
South Wessex Downs ESA	SD	n/k
Suffolk River Valleys ESA	SR	n/k
Upper Thames Tributaries ESA	UT	n/k
Test Valley ESA	TV	n/k
West Penwith ESA	WP	n/k

4. Proposed Scheme Objectives and Performance Indicators

1. Semi-improved grassland that has potential for re-establishment to a grassland Priority Habitat or other grassland of wildlife value achieves demonstrable improvements by 2010.

Semi-improved grassland sites with potential for re-establishment improve by at least one condition category as measured by RCA between Year 1 and 2010. Improvement equivalent to at least one higher condition category is detected in floristics and plant community variables between Year 1 and 2010.

5. 2003: RCA Method Development

The recommended method is Mitchley *et al*. (2000). This is a habitat type that requires considerable further work to define appropriate methods:

1. Checking and agreeing appropriate attributes.
2. Selecting appropriate positive indicators including restorability indicators of potential grassland trajectory.
3. Selecting and trialling appropriate targets for the agreed attributes.
4. Determining appropriate condition category thresholds for these targets.

6. Year 1: Sampling

RCA

Large sample (proportionate random according to stock) of MG6 that has potential to progress to one of the lowland grassland Priority Habitats, including sites selected for quantitative monitoring.

Quantitative

	Scheme	Method	*n* (plots or quadrats)			
Current sample	CSS	CS	106			
	AV	ADAS plot	1			
	BD	ESA quadrat	10			
	BH	ADAS plot	9			
	CH	ADAS plot*	18			
	CN	ADAS plot	33			
	DM	ADAS plot	7			
	EX	ADAS plot	7			
	KM	ADAS plot	20			
	PD	ESA quadrat	159			
	SD	ESA quadrat	1			
	SH	ADAS plot	14			
	SL	ESA quadrat/ ADAS plot	51			
	SP	ADAS plot	23			
	SR	ESA quadrat	2			
	SX	ADAS plot	6			
	TV	ESA quadrat	7			
	UT	ADAS plot	4			
	WP	ADAS plot	2			
	all	various	480			
			% progression	**LCG**	**LM**	**UHM**
Required sample (sites)	all	various	100	<10	<10	20
	all	various	50	<10	20	50
	all	various	20	20	100	200
	all	various	10	50	200	>200

*4m × 2m

Recommended national minimum sample = 100 sites

7. Year 1: Field methods

RCA

Structured walk with 20 sampling positions. Recommended visiting period: May – July.

Key attributes
Grass:herb ratio Positive indicator species (presence and frequency) - typically NVC based but could include “restorability indicators” Negative indicator species (presence and frequency) - e.g. pernicious weeds Sward structure - sward height, bare ground, litter cover

Quantitative

Scheme	Quantitative
CSS	CSS plots plus record species p/a in additional 1m x 1m central nest
BD, PD, SD, SL, SR, TV	ESA quadrats with % cover estimate plus record species p/a in surrounding 2m x 2m quadrat
all other ESAs	ADAS plots but reduce to 16 nests

8. Year 1: Environmental Data

To be collected from quantitative monitoring sample:

1. Management data: organic & inorganic fertiliser & lime application; stock type, density and timing; weed control; rolling/harrowing; closing & cutting date.
2. Meteorological data.

9. Year 1: Analysis and Interpretation

1. Calibrate community variables (from quantitative data) against condition categories.
2. Analyse change in floristics and community variables for each scheme separately up to and including Year 1.
3. Community (indicator) variables: Ellenberg N, F & R; G, A & C suited species scores; species richness, individual species.
4. Analyse relationships between vegetation and management.
5. Compare trends with CVS Aggregate Class IV (infertile grassland) in CS2000.
6. Compare trends with ECN sites (Drayton, Wytham, North Wyke, Porton Down).

10. Year 2 *et seq.*: Sampling & Field Methods.

Repeat Year 1 methods.

11. Year 2 *et seq.*: Environmental Data

To be collected from quantitative monitoring sample:

1. Management data as in Year 1.
2. Meteorological data.

12. Year 2 *et seq.*: Analysis and Interpretation

1. Analyse change in floristics and community variables for all schemes collectively from Year 1 to Year 2 *et seq.*
2. Analyse change in floristics and community variables for each scheme separately from original baselines up to and including Year 2 *et seq.*
3. Community (indicator) variables: as Year 1.
4. Analyse relationship between vegetation change and management.
5. Compare trends with CVS Aggregate Class IV (infertile grassland) in Countryside Survey if CS is repeated at appropriate interval.
6. Compare trends with ECN sites (Drayton, Wytham, North Wyke, Porton Down).

4.3 UPLAND MONITORING EXPLANATORY NOTES

One of the main causes of deterioration of upland heath and blanket bog is overgrazing by livestock. It is also the key factor controlled by AE schemes, so it is important to monitor the effects of varying grazing intensity. Other practices, such as burning management, also have an impact. The overall approach recommended will address these at three different levels: RCA, measurement of changes in plant species composition, and estimation of heather performance and vegetation condition in relation to grazing.

1. BAP Habitats

A single schedule has been produced for the following upland habitats:

BAP Priority Habitats

Upland heathland (UH)
Blanket bog (BB)

Potential Priority Habitats

Potential upland heathland (acid grassland with dwarf shrubs present but <25% cover)

2. Relevant BAP Objectives

BAP objectives for UH and BB are listed. Area targets refer to the whole of the UK.

Re-establishment of heathland (i.e. on land where upland heathland is unlikely to develop without interventionist management) is not included in the upland schedules, being recommended as a separate, targeted study.

3. AE schemes

AE schemes are listed that include moorland agreements and in which monitoring should be targeted. Estimated stock of moorland under agreement is at 1998, from Cooke (1999). This can be revised as more recent data become available.

4. Proposed Scheme Objectives and Performance Indicators

These are derived from the relevant BAP objectives and targets. Objectives for AE schemes should refer to the majority of sites under agreement even if the national BAP target is only for a percentage of that habitat. This is because AE schemes are one of the main vehicles for achieving national targets, so the majority of agreement sites are expected to be maintained in favourable condition, or to show improvements.

The first part of each performance indicator refers to RCA, which provides assessments at the Management Unit (MU) or sampling unit level. The second part refers to the plant species composition and heather performance, which assesses vegetation condition and change at a national level, and across individual schemes. The performance indicators refer explicitly to the variables that can be successfully calibrated for the habitat. The utility of these variables will be dependent on successful and meaningful calibration against condition categories or attributes.

The objectives and performance indicators should be viewed as suggestions only, but are an attempt to link AE schemes and their monitoring programme more closely to the national BAP.

5. 2003: Method Development

Development work on upland assessment and monitoring methods is currently being carried out by the country agencies and by DEFRA. In particular, a range of RCA methods have been recommended for upland habitats (Jerram *et al.* 2001; CCW 2002; Glaves *et al.* 2001; MacDonald 2002), but a consensus between the country agencies has not yet been obtained. A range of attributes indicative of overgrazing is currently also being tested (Glaves *et al.* 2001). The results of these studies need to be reviewed and evaluated in the context of AE monitoring. There is an opportunity to do this in 2003, if results are available by then.

6. Year 1: Sampling

Year 1 refers to the first year of survey in the new monitoring programme. Year 2 *et seq.* refers to the second and subsequent surveys. Recommendations for timing of surveys are given in Section 5.1.

A Management Unit (MU) is equivalent to a grazing unit, as defined in the current ESA monitoring programmes. The extent of individual MUs will need to be defined clearly for each agreement. The number of MUs sampled in each scheme can be amended as stock data are updated. The sample can include current CSS sites with plots, and sites used for Grazing Index/Biomass Utilisation (GI/BU) assessment in ESAs. This will ensure some continuity with previous assessments or monitoring. In some ESAs, ADAS plots were also set up at rough grazing sites. If these management units contain UH, potential upland heathland or BB, then they can also be included in the sample. Existing plots can be used if they are located in the required vegetation type. Moorland Scheme (MS) sites that subsequently enter CSS (from 2003) can also be included. The current samples of heather moorland and rough grazing sites are representative of the resource in each scheme, although this is not certain for the North Peak ESA and needs to be confirmed. Existing sites or plots for monitoring bracken control, heather restoration or heather burning will not be included in the new sample, as it is more appropriate to include these in separate, targeted studies.

The UH and BB habitats targeted for monitoring are as defined in the UK BAP. Potential upland heathland is defined in the BAP as having potential for restoration to UH, having up to 25% heather cover. However, the spatial scale at which heather cover is measured is not specified in the BAP. Therefore, it is assumed that this applies at all spatial scales at which cover will be measured in the monitoring programme.

In the current sample, relatively few plots were located in UH because the monitoring was focussed mainly on GI/BU assessments. Therefore, power analysis results presented are those from plots classified as Dwarf Shrub Heath Broad Habitat (excluding CSS plots because of their larger size). Although this includes some lowland heathland samples, these were considered to be the best available data. The recommended sample of 100 MUs would allow changes of approximately 0.5 species m^{-2}, and 0.05 in G and Nu scores to be detected in UH, if a there is UH available for establishment of a plot in every MU.

Sampling recommendations are made for BAP habitats at the national (England) scale. If the same questions need to be addressed at smaller scales (e.g. RDR regions, individual AE schemes) then the same sample size as that for the national sample would be required for each region, scheme, etc. If designated sites (e.g. SSSIs) are to be assessed specifically, then the sample would need to be targeted at them. Objectives for individual sites in the sample will be assessed by the RCA. No stratification by tier is recommended because tier structure and management prescriptions evolve over time. Sites not currently under AE agreement should not be included because the overall aim is to monitor the target habitats under AE agreement.

Only MUs that contain at least one of the three target vegetation types will be included in the sample, so that up to three habitats will be sampled in each MU. MUs that do not contain any readily identifiable dwarf shrub cover will be rejected. Habitat maps of MUs are not routinely produced as part of the agreement process. However, there are other maps that can be used to help to focus site selection and to increase the probability of locating plots and RCA sampling locations in the targeted habitats. These include:

1. Land Cover Map 2000 can distinguish between bog, dwarf shrub heath and several categories of grassland. There is a good agreement with ground data from CS2000 (in the order of about 85 %) once differences of scale and timing are taken into account. The 25 m grid underlying the data makes the map less useful for small parcels of land.
2. Soil maps to identify areas of deep peat, and therefore potentially blanket bog.
3. ESA land cover maps, that identify heathland with >25% dwarf shrub cover.

The current agreement tier will also help to screen the suitability of sites. For example, those in a heather restoration tier can be assumed to contain at least some heather cover. Sampling locations within MUs will need to be checked in the field to ensure that they are positioned within the target habitat.

If selected MUs contain other habitats at which targeted studies are aimed (upland calcareous grassland Priority Habitat and other upland features such as flushes and valley mires) then these should be included in the targeted study sample. Logistically, these targeted studies can therefore be combined with the upland monitoring, although strategically they will be part of a separate study.

7. Year 1: Field methods

RCA, species plots and heather performance will be monitored in all MUs in the sample. This will provide an overall assessment of condition with good representation, along with a sensitive method for detecting & exploring change, and links to short-term changes in grazing intensity.

RCA

There are a number of major outstanding issues that need to be resolved before RCA methods are agreed for upland habitats and these are outlined below and elaborated in Section 3.

<u>Area monitored</u>

The uplands often comprise extensive areas typically incorporating a range of habitat types. It is not yet agreed how RCA can be adapted to cope with this, e.g. by monitoring the whole site or MU or by monitoring representative samples of each major habitat.

<u>Sampling method and the number and size of samples</u>

Several contrasting sampling methods have been proposed for the uplands, for example:

Jerram *et al*. (2001): Structured walk covering at least 20% of the site unit - both core and margin. 10 random sampling points selected + 5 for subsidiary habitats (10 if of equivalent area).

MacDonald (2002): Random samples are assessed for condition of attributes; if 6 samples fail the site is recorded as in unfavourable condition, if 28 samples pass the site is recorded as in favourable condition. This approach provides answers at a 90% confidence level and this statistical rigour is important for optimising sampling intensity of condition assessments in common standards reporting. However this approach may be less appropriate for AE scheme monitoring which has rather different objectives.

In addition to the issue of number of samples, different scales of sampling may be required for different attributes, e.g. vegetation composition 4 m^2; ground disturbance 1 ha; disturbance indicators – visual estimate from sample location or while travelling between sample locations (MacDonald 2002).

<u>Mosaics, transitions and multiple interest features</u>

Where the site incorporates a range of different habitat types or interest features, RCA needs to be adapted to cope with this. The structured walk with 20 sampling positions may not provide sufficient coverage for extensive upland mosaics, although the assessment of larger areas at each sampling position would help here. The MAP project deals with mosaics by using a sample grid and classifying each sample point by habitat type and then applying the appropriate attributes. However this is a potentially time-consuming approach and scarce habitats can be missed or under recorded. A further approach is to identify the range of habitats from a map and to sample these individually. However, this approach can also be very time-consuming and result in excessive multiplication of work, although some of this can be reduced by monitoring some habitats/attributes from suitable vantage points. This is one case where it may be helpful to plot the position of key habitats/features using GPS for subsequent relocation.

<u>Setting appropriate attributes and targets, especially for restoration and re-establishment</u>.

The available methodologies for upland RCA include often long lists of attributes, e.g. MacDonald (2002). Not all of these attributes will be appropriate for RCA of upland AE schemes. For the uplands, much more than for the lowlands, selective use of published attributes may need to be considered.

For restoration sites, work is needed to select, for example, the most appropriate indicators of overgrazing. The results of the MAPP work currently in progress, as well as some analysis of appropriate existing AE data, will help here.

Many areas of high mountain heath may be dominated by acid grassland and targets over a 10 year management agreement may do little more than ensuring that frequency and cover of grass species does not increase. PIs and RCA targets for improvement of condition may need to be modest for such sites.

For RCA to work effectively in the uplands (as in the lowlands) site objectives will need to be clear and unambiguous. Objectives will need to deal with issues such as mosaics and transitions. Further, modified wet bogs may support important "secondary" vegetation communities such as marshy grassland and wet woodland which have developed following disturbance and in some cases the maintenance of these habitats may be an acceptable alternative to bog restoration, although currently this is not the case.

Species composition

In earlier reviews of moorland monitoring, recommendations were made for more emphasis to be made on species composition, and for frequency or cover estimates, preferably at different scales, to be used (Gardner *et al*. 1998; 1999). ADAS plots satisfy these requirements, and so appear to be the most appropriate method. Any existing plots in ESAs (and MS) that meet the sampling criteria specified above can be retained for continuity. In CSS, existing CS plots should also be used, again for continuity. The addition of % cover estimates in ADAS plots will ensure better compatibility between the two field methods (presence and % cover within 2m × 2m). It is recommended the existing grid size of ADAS plots (32 nests) is retained (in contrast to the recommendation for grassland of a reduction to 16 nests). This is because in relatively species-poor upland habitats, changes in individual species are often more informative than changes in community variables. Reduction of the grid in ADAS plots would compromise the ability to detect change in individual species (Burke & Critchley 1999).

Plots in UH will be located on the interface with grassland because it is here that temporal responses to grazing in UH are most likely to occur. The intention is to detect changes in species composition within the plant community, not to trace movement of the dwarf shrub/grass interface, which would require a mapping approach. If the MU contains only continuous dwarf shrub cover, then the plot should be located randomly within the UH.

Fixed plots will not be used in BB because of its sensitivity to physical damage and the instability of deep peat. Monitoring of BB will need to be done by RCA alone; it is assumed that the assessments of dwarf shrubs, bog mosses and bare peat cover will provide adequate information.

Heather performance

Previously, heather suppression has been estimated in ESAs using the GI/BU method. However, problems have been identified with this method, which are mainly due to uncertainties and lack of reliable data on the relationship between grazing pressure and heather performance. In a comprehensive review of heather moorland monitoring, Gardner *et al*. (1998) recommended that the BU method should be discontinued. However, the GI component (i.e. the proportion of shoots in a sample that are grazed) is considered to be relatively robust. DEFRA has also continued to use GI for assessing overgrazing in relation to environmental cross-compliance for HLCA/HFA payments (Glaves 2001). The significance of GI for heather performance is dependent on other factors including heather age and condition, but nevertheless is considered to be a useful indicator. This would complement the RCA and species composition monitoring, as it should also be more sensitive to short-term changes in grazing intensity. A protocol for estimating GI and for integrating this information with RCA can be developed in 2003.

8. Year 1: Environmental data

From the results of the review (Chapter 2), recommendations can be made on the use of environmental data.

The quality of management data is dependent on the availability of accurate records from farmers. Although this is usually variable, the information is key to explaining how AE schemes might be influencing vegetation change and condition. Grazing (stock type, intensity, timing), burning and control of weeds such as rushes and bracken, are the most important elements. Ideally, an estimate of the area of different vegetation types within the MU would also be obtained, since this will influence stock grazing behaviour and consequently localised grazing intensity. This would require a vegetation map to be produced by field survey, and would be dependent on a large resource being made available.

Meteorological data provide contextual background information for interpreting trends that might be attributable to short-term weather effects.

The relationships between vegetation and other environmental factors would be best explored in a discrete project (or projects) that is complementary to the core monitoring programme. Environmental data that can be examined in this way are physical, atmospheric deposition and climate change data.

9. Year 1: Analysis and interpretation

Progression towards the BAP targets can be measured by a combination of RCA, heather performance and botanical monitoring. To do this, the relationships between RCA attributes and botanical and heather performance data will need to be explored. This will indicate the extent to which the different variables can be used to measure progression or deterioration against target values. The power test results for the relevant community variables can be used to declare the magnitude of progression or deterioration that is detectable.

Community variables (from plot data) that are most relevant to the objectives for upland habitats have been selected from the list identified in the review (Chapter 2), and from upland assessment methods under development. It is recommended that the Ellenberg N (nitrogen) score is used in future in place of the Nu suited species score. The latter was developed for the last round of reporting for ESA monitoring because at that time Ellenberg N values were not available for the full British flora. Although Nu scores are based partly on functional traits of species, which have a more objective theoretical base than Ellenberg values, this had to be supplemented with data on species' habitat preferences due to incomplete functional trait databases. On balance, it is considered that Ellenberg N values have the advantage of simplicity, and can be usefully applied until functional data are more fully expanded.

10. Year 2 *et seq.*

Recommendations are made for sampling, data collection and analysis in subsequent years.

Trends in AE schemes can be put in the context of the wider countryside by comparison with results from Countryside Survey. However, a quantitative comparison is only possible if at least two survey years coincide with those of Countryside Survey. There is an opportunity for AE scheme monitoring and Countryside Survey fieldwork to be synchronised in the future. Currently, however, trends will have to be compared on a qualitative basis. Comparisons will be dependent on an adequate sample being available in CS for each Priority Habitat. The CS samples also include AE agreement sites, which would have to be excluded (e.g. in 1999, 19% of CS upland Broad Habitat plots were under ESA agreement). The CVS aggregate classes that most closely correspond with the UH and BB Priority Habitats have been identified.

Suggestions are made as to which ECN sites are likely to provide information relevant to upland habitats. ECN data will be useful for interpreting long-term trends in vegetation that might be attributable to external environmental factors.

4.4 UPLAND HABITATS MONITORING SCHEDULE

4.4.1 Monitoring Schedule: Upland Heathland And Blanket Bog

1. BAP Habitats

Broad	Dwarf shrub heath (DSH)
Priority	Upland heathland (UH) Blanket bog (BB)

2. Relevant BAP objectives and targets

UH 1 Maintain the current extent and overall distribution of the upland heathland that is currently in favourable condition

2 Achieve favourable condition on all upland heathland SSSIs by 2010 and demonstrable improvements in the condition of at least 50% of semi-natural upland heath outside SSSIs by 2010 (compared with their condition in 2000)

3 Seek to increase dwarf shrubs to at least 25% cover where they have been reduced or eliminated due to inappropriate management. A target for such restoration of between 50,000 and 100,000 ha by 2010 is proposed.

4 Initiate management to re-create 5,000 ha of upland heath by 2005 where heathland has been lost due to agricultural improvement [or afforestation], with a particular emphasis on reducing fragmentation of existing heathland.

BB 1 Maintain the current extent and overall distribution of blanket mire currently in favourable condition

2 Improve the condition of those areas of blanket mire that are degraded but readily restored, so that the total area in, or approaching, favourable condition by 2005 is 340,000 ha (i.e. around 30% of the total extent of restorable blanket mire).

3 Introduce management regimes to improve to, and subsequently maintain in, favourable condition a further 280,000 ha of degraded blanket mire by 2010

4 Introduce management regimes to improve the condition of a further 225,000 ha of degraded blanket mire by 2015, resulting in a total of 845,000 ha (i.e. around 75% of the total extent of restorable blanket mire) in, or approaching, favourable condition

3. AE Schemes

Scheme	Code	Estimated stock of moorland (ha)
Countryside Stewardship	CSS	15,500
Moorland Scheme	MS	10,300
Exmoor ESA	EX	8,500
Dartmoor ESA	DM	4,900
Lake District ESA	LD	54,200
North Peak ESA	NP	35,600
Shropshire Hills ESA	SH	750
South West Peak ESA	SP	3,700
	Total	133,450

4. Proposed Scheme Objectives and Performance Indicators

UH

1. Maintain the condition of upland heathland under AE agreement where condition is currently favourable.

Upland heathland sites in favourable condition in Year 1 do not show subsequent deterioration to a lower condition category as measured by RCA. No deterioration is detected after Year 1 in heather performance, floristics or plant community variables on land under AE agreement or, if there is deterioration, it is within the range of variation of the favourable condition category.

2. Where the condition of upland heathland SSSIs under AE agreement is not currently favourable, achieve favourable condition by 2010.

Upland heathland sites not currently in favourable condition that are SSSIs achieve favourable condition as measured by RCA by 2010. Improvement in heather performance, floristics and plant community variables equivalent to favourable condition is detected by 2010.

3. Where the condition of upland heathland outside SSSIs under AE agreement is not currently favourable, achieve demonstrable improvements in condition by 2010.

Upland heathland sites not currently in favourable condition that are outside SSSIs improve by at least one condition category as measured by RCA between Year 1 and 2010. Improvement equivalent to at least one higher condition category is detected in heather performance, floristics and plant community variables between Year 1 and 2010.

4. On potential upland heathland (less than 25% dwarf shrub cover due to inappropriate management) under AE agreement, achieve 25% dwarf shrub cover by 2010.

Potential upland heathland sites achieve at least 25% heather cover at the management unit (or RCA sampling unit) scale by 2010, and their condition improves to at least one higher category as measured by RCA. Improvement equivalent to at *least one higher condition category is detected in heather performance, floristics and plant community variables between Year 1 and 2010.*

BB

1. Maintain the condition of blanket bog under AE agreement where condition is currently favourable.

Blanket bog sites in favourable condition in Year 1 do not show subsequent deterioration to a lower condition category as measured by RCA. No deterioration is detected after Year 1 in heather performance on land under AE agreement or, if there is deterioration, it is within the range of variation of the favourable condition category.

2. Where the condition of blanket bog under AE agreement is not currently favourable, achieve demonstrable improvements in condition by 2010 and favourable condition by 2015.

Blanket bog sites not currently in favourable condition improve by at least one condition category as measured by RCA between Year 1 and 2010, and achieve favourable condition by 2015. Improvement equivalent to at least one higher condition category is detected in heather performance between Year 1 and 2010, and equivalent to favourable condition by 2015.

5. 2003: Method Development

Confirm the most appropriate field method for RCA of AE Schemes in the uplands.

Select appropriate indicators of overgrazing from results of MAP project currently in progress.

6. Year 1: Sampling

Proportionate random sample of Management Units (MUs) according to stock of moorland in each scheme to be drawn. Habitats to be sampled are UH, potential upland heathland (acid grassland with dwarf shrubs present but <25% cover) and BB. MUs with existing CSS or ADAS plots on heathland to be included in sample, along with plots from other habitats that are potential upland heathland.

Distribution of sample between AE schemes for given total sample sizes:

Scheme	**% of total stock**			
CSS	11.6	6	12	23
MS	7.7	4	8	15
EX	6.4	3	6	13
DM	3.7	2	4	7
LD	40.6	20	40	81
NP	26.7	13	26	53
SH	0.6	0	1	2
SP	2.8	2	3	6
	Total *n*	50	100	200

Detectable change in community variables for given sample sizes:

	10	*20*	*50*	*100*	*200*
Species richness	1.91	1.27	0.78	0.54	0.39
G score	0.17	0.11	0.07	0.05	0.03
Nu score	0.16	0.11	0.06	0.05	0.02

Recommended minimum sample size = 100 MUs.

7. Year 1: Field Methods

RCA

Field methods for upland habitats are subject to agreement during 2003 (see explanatory notes).

Habitat	Key attributes
UH & BB	Positive indicator species (frequency/cover) Frequency / cover of dwarf shrubs Frequency/cover of graminoids Negative indicator species (frequency/cover) e.g. pernicious weeds, bracken, scrub, trees Grazing impact/index (overgrazing indicators) Dead foliage
UH	Dwarf shrub age structure Bryophyte and lichen abundance Bare ground Indicators of disturbed/undisturbed heath
BB	Position of water table Frequency / cover of *Sphagna* (+ other bryophytes) Extent of bare peat Disturbance indicators (e.g. *Sphagnum* trampling) Indicators of increased drying out of pools, e.g. reduced area of pools and /or *Sphagnum* filled hollows

Species composition

Scheme	Plot type
CSS	CSS plots
ESAs & ex-MS	ADAS plots plus record % cover of species in 2m x 2m nest or group of nests if smaller

Habitat	Plot location
UH	one CS or ADAS plot per MU randomly located within RCA sampling areas on the interface with grassland
potential UH	one CS or ADAS plot per MU randomly located within RCA sampling areas within potential UH
BB	no fixed plots

Heather performance

Grazing Index (GI) and other attributes to be recorded according to protocol developed in 2003.

8. Year 1: Environmental Data

1. Management data: stocking density and timing, burning, bracken or rush control.
2. Meteorological data

9. Year 1: Analysis and Interpretation

1. Analyse relationships between RCA attributes, heather performance, floristics and plant community variables for all schemes collectively and for individual schemes with adequate sample sizes.
2. Community (indicator) variables from species plots: Ellenberg N; A & G suited species scores; species richness, dwarf shrubs, dwarf shrub:graminoid ratio, bryophytes as a group.
3. Analyse relationship between vegetation and management.

10. Year 2 *et seq.*: Sampling & Field Methods.

Repeat Year 1 methods.

11. Year 2 *et seq.*: Environmental Data

1. Management data as in Year 1.
2. Meteorological data.

12. Year 2 *et seq.*: Analysis and Interpretation

1. Analyse change in heather performance, floristics and community variables for all schemes collectively from Year 1 onwards, and for individual schemes with adequate sample sizes. Relate changes to site variables from RCA and environmental variables.
2. Community (indicator) variables: as Year 1.
3. Analyse relationship between vegetation change and management.
4. Compare trends with CVS aggregate classes VII (moorland grass/mosaic) and VIII (heath/bog) in Countryside Survey if CS is repeated at appropriate intervals.
5. Compare trends with ECN sites (Moor House-Upper Teesdale, Y Wyddfa/Snowdon, Sourhope).

4.5 TARGETED STUDIES

Habitats are listed below ([1]Broad Habitats, [2]Priority Habitats) for which targeted studies are recommended. In most cases, some monitoring of these habitats has been carried out previously, and existing sites or plots could potentially be used in the future programme. It is recommended that the objectives for each habitat are reviewed separately, and the relative merits assessed of continuing with existing samples or establishing new projects. In some cases, it might be appropriate to use RCA, either alone or in combination with quantitative methods.

Arable[1] (including Cereal Field Margins[2])

A range of habitats to benefit biodiversity can be created on arable land. Examples include overwinter stubble, spring fallow, undersown cereals, grass margins and conservation headlands. Methods for their establishment and management have been relatively well researched. In most cases, these were successfully established under the ASPS. Some of these management methods have now been introduced at a national level under CSS. These arable habitats are expected to be most beneficial at higher trophic levels, for example to invertebrates and farmland birds. Therefore, it would be more appropriate for monitoring to be focussed on habitat structure rather than detailed botanical composition. RCA could be used to check that the desired habitat structure is being achieved.

More detailed botanical monitoring might be justified in those arable habitats that remain in the same location for more than one season. Where perennial vegetation is established (e.g. grass margins) the establishment and spread of grassland or woodland species might be of interest. In uncropped wildlife strips, the maintenance of annual dicotyledonous plant communities is the main aim. Sites surveyed in the ASPS assessment might provide a suitable sample for longer-term monitoring.

Also in the ASPS, populations of rare annual arable plants were identified, particularly in the East Anglia Pilot Area. It would be important to establish whether these are being maintained under AE scheme agreements. This might also apply to populations elsewhere that are the target of CSS agreements.

Arable Reversion

Arable reversion to grassland has been monitored or assessed in a sample of sites in the South Downs ESAs. Similarly, arable reversion to lowland heathland has been assessed in Breckland ESA, both as part of the botanical monitoring programme, and within a separate research project (Fowbert *et al.* 2000). Given that individual arable reversion sites would normally be expected to have clear objectives, RCA might be a suitable method for monitoring their progress towards targets. RCA methods for arable reversion are relatively well developed.

Ditches

Ditch monitoring has been carried out in the Broads and North Kent Marshes ESAs, and on more limited samples in the Somerset Levels and Moors ESA and South Downs ESA. The value of ditches is influenced primarily by water quality and by ditch management. In areas where ditches are of high biodiversity value, a monitoring or assessment programme might be justified. However, it might be preferable to focus on aspects such as the relationships between ditch management, vegetation structure and invertebrate communities as well as botanical composition.

Fen, Marsh & Swamp[1]

This Broad Habitat includes the Reedbeds and Fens Priority Habitats that are of local importance and can be incorporated in AE scheme agreements. Because of the relatively small area of these habitats, any botanical monitoring would probably be best focussed on objectives for individual sites. Purple moor-grass and rush pastures is also included in this Broad Habitat, but has its own monitoring schedule.

Saltmarsh[2]

A number of saltmarsh sites, formerly under the Habitat Scheme, have been the focus of specific studies. These could be continued using the same methods as previously. Alternatively, it might be worth developing an RCA method for this habitat.

Former Set-aside

Sites previously managed as non-rotational set-aside were included in the Habitat Scheme monitoring programme. Some sites from this sample are now in the CSS. This presents a good opportunity to monitor the development of set-aside in the longer term, with sites now being up to fourteen years old. This also has relevance for arable reversion to habitats such as grassland, heathland or scrub. Botanical monitoring could be continued at the remaining sites in the sample.

Water Fringe

Sites formerly in the Habitat Scheme were monitored between 1995 and 1997. These included land withdrawn from agricultural production, and sites formerly under arable cropping. Along with the Former Set-aside sample, continued monitoring of these sites would provide an opportunity to assess habitat development over the longer-term.

Lowland Heathland[2]

Lowland heathland samples have been monitored in the Breckland, West Penwith and Blackdown Hills ESAs and in CSS. Lowland heathland is an important habitat in AE schemes, and is expected to benefit from management agreements, especially where grazing and burning regimes are controlled. It is recommended that high priority is given to monitoring this habitat in future. However, the objectives of the current monitoring programmes have varied, for example being focussed on the effects of grazing in Breckland and West Penwith, and recovery after burning in a second West Penwith sample. Monitoring methods have also varied between the schemes. It is suggested that the objectives of lowland heathland monitoring should be reviewed, and consideration given as to whether studies should focus in future on specific aspects of management (as in Breckland and West Penwith) or more generally on heathland condition and change (as in the Blackdown Hills and CSS). Lowland dry acid grassland often occurs as part of the habitat mosaic of lowland heathland sites, although it also exists elsewhere as a discrete grassland type. At sites where they coincide, the monitoring programmes for lowland dry acid grassland and lowland heathland could be linked.

Upland Calcareous Grassland[2]

Upland calcareous grassland is an important habitat in CSS and the Pennine Dales and Lake District ESAs. However, it has not been included in the upland monitoring schedule because its relative scarcity means that it is unlikely to be well represented in the main upland sample that is aimed at upland heathland and blanket bog. Instead, it is suggested that a targeted sample of upland calcareous grassland is selected. As noted in the upland schedule, calcareous grassland could be surveyed at the same time as the main upland sites, where it is present. For logistical reasons, the targeted study of this habitat could be timed to coincide with the main upland surveys.

Upland Flushes and Valley Mires

Upland management units often contain flushes and valley mires that are important components in the overall mosaic of habitats. They are vulnerable to inappropriate levels of grazing, and are sensitive to damage by burning, and merit consideration for inclusion in the monitoring programme. However, flushes occupy a relatively small area in comparison with the main upland heath and blanket bog habitats, while valley mires are also relatively scarce. Small examples can also be more difficult to identify without detailed searching in the field. As with upland calcareous grassland, a targeted study of flushes and valley mires would be appropriate, with fieldwork timed to coincide with the main upland surveys.

Upland Management (Bracken Control, Heather Burning, Heather Restoration)

A number of studies have been carried in ESAs focussing on specific components of the management prescriptions. It might be of value to continue some of these studies in the longer term. It is recommended that they should be reviewed collectively with a view to integrating them within a small programme of upland management studies.

Broadleaved Woodland[1]

The only woodland assessments carried out to date in English AE schemes is of a limited sample within the FWS/FWPS. Consideration could be given to extending this study to national sample, with repeated surveys to monitor development of new woodland. RCA methods for woodland are well developed and could be readily applied here.

Ancient and/or Species-Rich Hedges[2]

Hedge monitoring has not been addressed specifically in this study, being the subject of another project (AE05: ‘Study of hedgerow maintenance and restoration under the Environmentally Sensitive Areas and Countryside Stewardship Schemes in England’).

However, this is clearly a major habitat within AE schemes that merits consideration for a monitoring programme.

5 LOGISTICS

5.1 TIMETABLE

It is anticipated that the new monitoring programme will not start until after 2003. This provides an opportunity to carry out methodological development work that is still needed before the recommended programme can be fully implemented. Outstanding requirements are specified for each habitat. Site selection can also be started in 2003.

To spread the resource evenly between years, fieldwork could be carried out on only a selection of habitats in each year. A suggested roster is shown below. It is important to allow sufficient time between field data collection and reporting, so that a thorough analysis can be carried out. A period of 12 months between the end of fieldwork and reporting is suggested. Resurvey intervals will be determined mainly by the perceived need to detect any early signs of deterioration in Priority Habitats, and by resource availability. An interval of 5-9 years between quantitative surveys is suggested. This will provide a long-term monitoring programme that can feed into policy reviews as they arise. RCA should be done at the same time at each site, with the option also of RCA surveys being done at more frequent intervals.

Suggested roster for field data collection:

1st year	Lowland calcareous grassland	High botanical value
	Lowland dry acid grassland	High botanical value
	Lowland meadows	High botanical value
	Purple moor grass & rush pasture	High botanical value
2nd year	Upland heathland & blanket bog	Allows additional time for method development
	Semi-improved grassland	Deterioration less important; re-establishment probably slow
3rd year	Upland hay meadows	Last surveyed in 2002
	Coastal & floodplain grazing marsh	Botanical value less important

5.2 FIXED UNIT RELOCATION

Existing quadrats and plots are fixed and potentially relocatable. Many of these have already been relocated (some more than once) since their first establishment. However, buried plot/quadrat markers can deteriorate over time, and some landmarks used as reference points for bearings and measurements can change over the longer term. Recent experience in the Pennine Dales ESA has shown that the accuracy of instructions and measurements for relocating fixed positions sometimes varies depending on the quality of supervision of the original field teams. It is recommended that in 2003, the opportunity is taken to evaluate a sample of plots or quadrats from each scheme for ease relocation. Where there are shortcomings, the continued usefulness of a sample might need to be re-assessed. In all future surveys, GPS readings should be taken for all fixed units to assist their subsequent relocation.

5.3 LINKS WITH OTHER PROGRAMMES

The main purpose of the AE scheme botanical monitoring programme will be to assess the contribution of AE schemes to achieving BAP targets for specific habitats. The monitoring results should also provide feedback, by helping to identify strengths and weaknesses in the way that the schemes operate. At the whole-scheme level, this would allow improvements to be made to help the schemes to meet their objectives. It would also be advantageous if the resource allocated to monitoring could be used to improve the effectiveness of the day to day running of schemes. This could be achieved by using, for example, results of RCA at individual sites to influence the way that each site is managed. However, unless RCA was carried out at all agreement sites, this could bias the monitoring sample in the longer term, and the monitoring programme would no longer be fit for its main purpose. Nevertheless, RCA could be a useful tool for Project Officers to use themselves, as it could help them to make judgements about the condition of particular sites/features in a standardised way. This would need to be done independently of the monitoring programme.

There are also opportunities to link the AE botanical monitoring more closely to other monitoring programmes. These include CS, and EN’s programme of BAP grassland condition assessment on designated and non-designated sites. In addition, there will be opportunities to make links with the validation network being developed by EN, for which quantitative data will be collected from a series of designated sites. If the timetables for these national monitoring schemes coincided, then trends in AE schemes and elsewhere could be compared more readily. It would be of great benefit if DEFRA could ensure that, as far as possible, these programmes are co-ordinated and data exchange is facilitated.

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APPENDIX 1

DATA TABLES

Appendices 1.1-1.2: Datasets used and excluded from classification exercise.

Appendices 1.3-1.7: Summary data for classification of Countryside Stewardship Scheme (CSS), ESA plots (ESAP) and ESA quadrats (ESAQ).

Appendices 1.8-1.13: Summary data from power analysis of Countryside Stewardship Scheme (CSS), ESA plots and ESA quadrats.

Appendix 1.1. Main grassland and upland data sets utilised in data classification.

N = no. of quadrats or plots

ESA	Type	Baseline Year	**Re-survey Years**			***N*[1]**	***N*[2]**
Avon	P	1993				44	
Blackdown Hills	P	1994, 1995				37	
Broads	Q	1987	1990	1994		330	330
Clun	P	1993, 1994	1996			60	29
Cotswold Hills	P	1995				44	
Dartmoor	P	1994, 1995	1997			70	33
Exmoor	P	1993	1996			49	24
Lake District	P	1993	1994	1996		9	9
North Kent Marshes	P	1993				33	
Pennine Dales (Validation)	Q	1987	1990	1995		310	302
Shropshire Hills	P	1995				32	
Somerset Levels	Q	1988	1990	1995		497	497
Somerset Levels	P	1995	1995	1998		25	25
South Downs	Q	1987	1990	1994		134	134
South Wessex Downs	P	1993	1996			52	50
South West Peak	P	1993, 1994	1996			67	28
Suffolk River Valleys	Q	1988	1991	1993	1996	95	95
Test Valley	Q	1988	1991	1995		145	144
Upper Thames Tributaries	P	1995	1995			40	
West Penwith	P	1993	1996			29	29

[1] Baseline year, [2]Baseline and re-survey years

Appendix 1.2. AE scheme datasets excluded from classification.

ESA/Scheme	Type
Breckland	Conservation Headlands
	Uncropped Wildlife Strips*
	Lowland Heath*
Broads	Ditches
Dartmoor	Heather Biomass
Exmoor	Heather Biomass
Habitat Scheme	Salt-marsh Transects
	Set-aside
	Water-fringe
Lake District	Heather Biomass
North Kent Marshes	Ditches
North Peak	Heather regeneration
	Heather Biomass
Pennine Dales	Indicative (includes Extension)*
Shropshire Hills	Heather Biomass
Somerset Levels	Ditches
South Downs	Arable Reversion
South West Peak	Heather Biomass
West Penwith	Lowland Heath Burning
	Lowland Heath Grazing*

* = data not available on AEMA database at time of analysis.

Appendix 1.3. Number of quadrats/plots in each scheme by main NVC type.

Community type		CSS	ESAP	ESAQ	Total	% of total
A	Aquatic	1	0	0	1	<0.1
CG	Calicolous grassland	29	52	59	140	5
H	Heaths	20	27	0	47	2
M	Mires	42	60	44	146	5
MC	Maritime cliff	5	0	0	5	<0.5
MG	Mesotrophic grassland	310	365	1,414	2,089	76
OV	Other vegetation	69	0	47	116	4
S	Swamps	7	0	29	36	1
SD	Sand dune	8	0	1	9	<0.5
SM	Salt-marsh	7	1	0	8	<0.5
U	Calcifugous & montane	22	84	17	123	4
W	Woodland & scrub	13	2	3	18	<1
Total		533	591	1614	2738	100

Appendix 1.4. Number of quadrats/plots in each scheme by NVC.

	Community	CSS	ESAP	ESAQ	Total
A1	*Lemna gibba* community	1	0	0	1
CG1	*Festuca ovina – Carlina vulgaris* grassland	1	0	0	1
CG2	*Festuca ovina – Avenula pratensis* grassland	17	36	0	53
CG3	*Bromus erectus* grassland	7	5	39	51
CG4	*Brachypodium pinnatum* grassland	0	2	16	18
CG5	*Bromus erectus – Brachypodium pinnatum* grassland	0	6	0	6
CG6	*Avenula pubescens* grassland	1	3	3	7
CG9	*Sesleria albicans – Galium sterneri* grassland	0	0	1	1
CG10	*Festuca ovina – Agrostis capillaris – Thymus praecox* grassland	3	0	0	3
H1	*Calluna vulgaris – Festuca ovina* heath	2	0	0	2
H2	*Calluna vulgaris – Ulex minor* heath	6	0	0	6
H3	*Ulex minor – Agrostis curtisii* heath	1	0	0	1
H4	*Ulex gallii – Agrostis curtisii* heath	1	20	0	21
H7	*Calluna vulgaris – Scilla verna* heath	2	0	0	2
H8	*Calluna vulgaris – Ulex gallii* heath	2	0	0	2
H9	*Calluna vulgaris – Deschampsia flexuosa* heath	6	0	0	6
H10	*Calluna vulgaris – Erica cinerea* heath	0	1	0	1
H12	*Calluna vulgaris – Vaccinium myrtillus* heath	0	6	0	6
M6	*Carex echinata – Sphagnum recurvum/auriculatum* mire	2	1	1	4
M10	*Carex dioica – Pinguicula vulgaris* mire	1	1	0	2
M13	*Schoenus nigricans – Juncus subnodulosus* mire	0	0	3	3
M15	*Scirpus cespitosus – Erica tetralix* wet heath	3	14	0	17
M16	*Erica tetralix – Sphagnum compactum* wet heath	2	1	0	3
M17	*Scirpus cespitosus – Eriophorum vaginatum* blanket mire	0	5	0	5
M19	*Calluna vulgaris – Eriophorum vaginatum* blanket mire	2	0	0	2
M21	*Narthecium ossifragum – Sphagnum papillosum* valley mire	1	0	0	1
M22	*Juncus subnodulosus – Cirsium palustre* fen-meadow	10	0	2	12
M23	*Juncus effusus/acutiflorus – Galium palustre* rush-pasture	11	22	10	43
M24	*Molinia caerulea – Cirsium dissectum* fen-meadow	0	0	2	2
M25	*Molinia caerulea – Potentilla erecta* mire	6	16	9	31
M27	*Filipendula ulmaria – Angelica sylvestris* mire	0	0	17	17
M28	*Iris pseudacorus – Filipendula ulmaria* mire	4	0	0	4
MC9	*Festuca rubra – Holcus lanatus* maritime grassland	4	0	0	4
MC11	*Festuca rubra – Daucus carota* spp. *gummifer* maritime grassland	1	0	0	1
MG1	*Arrhenatherum elatius* grassland	22	4	34	60
MG3	*Anthoxanthum odoratum – Geranium sylvaticum* grassland	2	0	2	4
MG4	*Alopecurus pratensis – Sanguisorba officinalis* grassland	7	3	0	10
MG5	*Cynosurus cristatus – Centaurea nigra* grassland	68	52	0	120
MG6	*Lolium perenne – Cynosurus cristatus* grassland	106	144	230	480
MG7	*Lolium perenne* leys an related grassland	48	63	549	660
MG8	*Cynosurus cristatus – Caltha palustris* grassland	1	12	32	45
MG9	*Holcus lanatus – Deschampsia cespitosa* grassland	10	35	94	139
MG10	*Holcus lanatus – Juncus effusus* grassland	26	39	312	377
MG11	*Festuca rubra – Agrostis stolonifera – Potentilla anserina* grassland	17	3	99	119
MG12	*Festuca arundinacea* grassland	3	0	12	15
MG13	*Agrostis stolonifera – Alopecurus geniculatus* grassland	0	10	50	60

OV8	*Veronica persica – Alopecurus myosuroides* community	1	0	0	1
OV9	*Matricaria perforata – Stellaria media* community	1	0	0	1
OV10	*Poa annua – Senecio vulgaris* community	3	0	0	3
OV13	*Stellaria media – Capsella bursa-pastoris* community	1	0	0	1
OV15	*Anagallis arvensis – Veronica persica* community	1	0	0	1
OV18	*Polygonum aviculare – Chamomilla suaveolens* community	1	0	0	1
OV19	*Poa annua – Matricaria perforata* community	3	0	5	8
OV20	*Poa annua – Sagina procumbens* community	2	0	0	2
OV21	*Poa annua – Plantago major* community	9	0	0	9
OV22	*Poa annua – Taraxacum officinale* community	2	0	0	2
OV23	*Lolium perenne – Dactylis glomerata* community	21	0	1	22
OV24	*Urtica dioica – Galium aparine* community	7	0	2	9
OV25	*Urtica dioica – Cirsium arvense* community	6	0	6	12
OV26	*Epilobium hirsutum* community	4	0	24	28
OV27	*Epilobium angustifolium* community	1	0	9	10
OV28	*Agrostis stolonifera – Ranunculus repens* community	4	0	0	4
OV37	*Festuca ovina – Minuartia verna* community	2	0	0	2
S4	*Phragmites australis* swamp and reed-beds	1	0	0	1
S5	*Glyceria maxima* swamp	1	0	3	4
S7	*Carex acutiformis* swamp	0	0	1	1
S12	*Typha latifolia* swamp	1	0	0	1
S18	*Carex otrubae* swamp	0	0	1	1
S19	*Eleocharis palustris* swamp	0	0	12	12
S22	*Glyceria fluitans* water-margin vegetation	0	0	2	2
S26	*Phragmites australis – Urtica dioica* tell-herb fen	4	0	0	4
S28	*Phalaris arundinacea* tall-herb fen	0	0	10	10
SD6	*Ammophila arenaria* mobile dune community	1	0	1	2
SD7	*Ammophila arenaria – Festuca rubra* semi-fixed dune community	1	0	0	1
SD8	*Festuca rubra – Galium Verum* fixed dune grassland	3	0	0	3
SD12	*Carex arenaria – Festuca ovina – Agrostis capillaris* dune	1	0	0	1
SD17	*Potentilla anserina – Carex nigra* dune-slack	2	0	0	2
SM10	Transitional low-marsh vegetation	2	0	0	2
SM14	*Halimione portulacoides* salt-marsh community	1	0	0	1
SM16	*Festuca rubra* salt-marsh community	2	0	0	2
SM23	*Spergularia marina – Puccinellia distans* salt-marsh community	1	0	0	1
SM28	*Elytrigia repens* salt-marsh community	1	1	0	2
U1	*Festuca ovina – Agrostis capillaris – Rumex acetosella* grassland	3	3	11	17
U2	*Deschampsia flexuosa* grassland	1	5	0	6
U3	*Agrostis curtisii* grassland	0	6	0	6
U4	*Festuca ovina – Agrostis capillaris – Galium saxatile* grassland	7	47	4	58
U5	*Nardus stricta – Galium saxatile* grassland	7	17	0	24
U6	*Juncus squarrosus – Festuca ovina* grassland	0	0	2	2
U20	*Pteridium aquilinum – Galium saxatile* community	4	6		10
W6	*Alnus glutinosa – Urtica dioica* woodland	2	0	0	2
W8	*Fraxinus excelsior – Acer campestre – Mercurialis perennis* woodland	1	0	0	1
W23	*Ulex europaeus – Rubus fruticosus* scrub	6	0	3	9
W24	*Rubus fruticosus – Holcus lanatus* underscrub	1	0	0	1
W25	*Pteridium aquilinum – Rubus fruticosus* underscrub	3	2	0	5

Appendix 1.5. Number of quadrats/plots in each scheme by CVS Aggregate Class. Unclassified records are bare ground/water etc.

CVS Aggregate Class		CSS	ESAP	ESAQ	Total
I	Crops/Weeds	8	0	1	9
II	Tall Grassland/Herb	40	1	66	107
III	Fertile Grassland	115	99	601	815
IV	Infertile Grassland	280	344	928	1552
V	Lowland Wooded	8	0	0	8
VI	Upland Wooded	23	20	1	44
VII	Moorland Grass/Mosaic	34	64	17	115
VIII	Heath/Bog	21	63	0	84
	Unclassified	4	0	0	4
	Total	533	591	1614	2738

Appendix 1.6. Number of quadrats/plots in each scheme by CVS Vegetation Class.

Aggregate Class	CVS	Vegetation Class	CSS	ESAP	ESAQ	Total
	0		4	0	0	4
I	3	Cereal crops with scattered grass weeds	4	0	0	4
I	4	Mixed crops with broad-leaved weeds	1	0	0	1
I	5	Cereal crops with mixed weeds	0	0	1	1
I	6	Weedy leys/undersown cereal crops	3	0	0	3
V	7	Fertile open hedges/crop boundaries	2	0	0	2
V	8	Fertile hedges/boundaries	1	0	0	1
II	9	Fertile tall grassland/open crop hedges	5	0	14	19
II	10	Tall grassland/herb boundaries	3	0	24	27
II	11	Stream-sides within crops	3	0	3	6
II	12	Fertile roadsides	0	0	1	1
II	13	Lowland neutral roadsides	0	1	0	1
II	14	Low roadsides/crop boundaries	16	0	4	20
II	15	Lowland stream-sides	0	0	2	2
II	17	Lowland wetland/stream-sides	0	0	2	2
II	18	Fertile shaded stream-sides	1	0	0	1
II	19	Fertile stream-sides/wetland tall herb	0	0	2	2
V	21	Species-rich lowland hedges	1	0	0	1
II	22	Fertile wood edges/stream-sides	1	0	0	1
III	23	Fertile grassland	12	5	6	23
V	24	Dry base-rich woodland	1	0	0	1
II	25	Shaded grassland/hedges	1	0	2	3
III	27	Rye-grass roadsides	6	0	3	9
II	28	Fertile tall herb/grassland	10	0	12	22
III	29	Rye-grass grassland	2	2	66	70
III	30	Fertile mixed grassland	80	69	484	633
III	31	Rye-grass/clover grassland	15	23	42	80
IV	32	Gravel reed-beds by stream-sides	6	0	5	11
IV	33	Wet neutral grassland	2	0	5	7
IV	34	Mixed grassland/scrub/hedges	8	0	1	9
V	35	Diverse base-rich woodland/hedges	1	0	0	1
IV	37	Neutral grassland/scrub	2	1	0	3
IV	38	Fertile/neutral grassland on roadsides	16	4	6	26
IV	40	Rye-grass/Yorkshire-fog grassland	113	164	411	688
IV	41	Species-rich stream-sides/wet grassland	8	4	20	32
V	42	Woodland on heavy soils	2	0	0	2
IV	43	Rye-grass/bent grass grassland	34	18	141	193
IV	44	Calcareous grassland	38	67	76	181
VI	45	Shaded rushy stream-sides	3	0	1	4
VI	46	Species-rich wooded stream-sides	1	0	0	1
IV	47	Species-rich neutral grassland	5	0	0	5
IV	48	Marsh/stream-sides	1	6	15	22
VI	49	Neutral/acidic woodland patches	4	0	0	4
IV	51	Wet rushy grassland	24	51	219	294
IV	52	Neutral grassland	11	13	2	26

IV	53	Species-rich neutral/acid grassland/scrub	2	2	4	8
IV	54	Marsh/fen	7	2	10	19
IV	55	Wet neutral/acid rush grassland	0	2	6	8
IV	56	Species-rich neutral/acid grassland	3	10	7	20
VII	57	Enriched acid grassland/moorland grass flushes	7	5	9	21
VII	58	Species-rich moorland grass stream-sides/flushes	1	6	0	7
VII	60	Acid grassland/stream-sides/flushes	3	3	2	8
VII	61	Species-rich acid grassland	3	5	1	9
VI	62	Woodland on podzolic soils	6	0	0	6
VII	63	Herb-rich stream-sides/acid grassland	0	4	0	4
VI	64	Bracken/acid grassland	9	20	0	29
VII	65	Herb-rich acid grassland/heath	3	1	0	4
VII	67	Moorland grass	5	8	3	16
VII	71	Herb-rich moorland grass/heath	0	1	0	1
VII	72	Herb-rich moorland grass/heath	2	0	0	2
VII	73	Rushy moorland grass/stream-sides on peat soils	5	13	0	18
VII	74	Inundated stream-sides/flushes	2	4	0	6
VII	80	Moorland grass/heath on podzolic soils	3	14	2	19
VIII	82	Wet heath/bog	0	4	0	4
VIII	84	Rush heath/moorland grass	2	0	0	2
VIII	87	Moorland grass/bog on peaty gley/peat soils	3	9	0	12
VIII	88	Moorland grass/heath/bog	3	11	0	14
VIII	89	Dry heath on podzolic soils	3	2	0	5
VIII	90	Wet heath/moorland grass on variable soils	3	25	0	28
VIII	93	Montane heath on podzolic soils	0	2	0	2
VIII	94	Sphagnum bog	0	1	0	1
VIII	95	Crowberry blanket bog	4	0	0	4
VIII	98	Cotton grass bog	3	5	0	8
VIII	99	Saturated bog	0	3	0	3
VIII	100	Inundated bog/wetland	0	1	0	1

Appendix 1.7.

Comparison of CSS data classified by BAP habitat at time of field survey (rows) and by NVC in this project (columns). AcG = Acid grassland, BMW = Broad-leaved, mixed and yew woodland, CalG = calcareous grassland, CFGM = coastal and floodplain grazing marsh, Coastal VS = coastal vegetated shingle, DSH = dwarf shrub heath, FMS = fen, marsh and swamp, ILRock = inland rock, ImG = improved grassland, LCalG = lowland calcareous grassland, LDAG = lowland dry acid grassland, Lsed = littoral sediment, NeG = neutral grassland, PMGRP = purple moor grass and rush pasture, SLRock = supra littoral rock, SLSed = supra littoral sediment, UCalG = upland calcareous grassland, X = unclassified.

by NVC	AcG	BMW	Bogs	Bracken	CalG	DSH	FMS	ILRck	ImG	Lsed	NeG	SLRock	SLSed	Water	X	Total
by field survey																
AcG/Bracken/DSH	1															1
AcG/FMS													1			1
Ac/Upland heath	1															1
AcG	9					2	3		1		2	1			2	20
AcG/Bracken	1															1
Arable&Hort									4		7			1	7	19
Blanket Bog							1									1
BMW		1			1		1				1				2	6
BMW/AcG																
BMW/Bracken						2										2
BMW/CalG											2					2
BMW/DSH				1												1
BMW/LDAG/DSH						1										1
BMW/LCalG					1						1					2
BMW/NeG									1		1					2
Bogs							1									1
Bracken	1					1										2
Bracken/Lowland heath															1	1
CalG					2						7					9
CalG/AcG											1					1
Cereal field margins							7		5	1	10	1	1		11	36
CFGM							2				3					5
Coastal VS										1						1
DSH	1					2						1				4
FMS							3				2					5
Fens							5				2					7
Fens/Reedbeds													1			1
ImG	2	1		1	1		4		33		69		1		27	139
ImG/Arable&Hort											1					1
ImG/BMW									1		2	1			2	6
ImG/BMW/Bracken				1												1
ImG/Bracken																
ImG/Fens											1					1
ImG/NeG											1					1
ILRock					1											1
LCalG					20		1				18				1	40
LDAG	4					3							1		1	9
LDAG/DSH	1															1

contd.

	AcG	BMW	Bogs	Bracken	CalG	DSH	FMS	ILRck	ImG	Lsed	NeG	SLRock	SLSed	Water	X	Total
LDAG/Lowland heath						1										1
LDAG/Upland heath			1			2									1	4
Lowland hay meadows									1		10					11
Lowland heath						5						1			1	7
Lsed										3						3
NeG									1		5		1		2	9
PMGRP							1				1					2
Reedbeds							5				1					6
SLSed										1			2			3
Spring & Flush	1						7	1			4					13
UCalG					2			1								3
UCalG/AcG																
UCalG/FMS											1					1
Upland heath			1			1					1					3
Wet Wood		1					2									3
X					1		4		1	1	2				1	10
Grand Total	22	3	2	3	29	20	47	2	48	7	156	5	8	1	59	412

Appendix 1.8.

Mean and standard deviation of species richness, Ellenberg N value, Nu and G scores for each of the NVC classes. Data are derived from four sources: CSS data, ESA quadrat data (scores calculated on presence/absence and Domin basis) and ESA plot data (32 nest and 16 nest data at optimal scale).

Species richness

	CSS		ESA quadrat		ESA plot32		ESA plot16	
NVC	mean	sd	mean	sd	mean	sd	mean	sd
CG2					29.38	4.15	29.86	4.30
CG3			31.38	6.39				
H4					6.55	1.49	6.42	1.34
M23					11.85	3.92	11.78	3.76
MG1	21.45	10.35	19.18	9.44				
MG5	32.85	9.77			19.61	4.38	19.71	4.34
MG6	19.84	5.75	19.30	4.91	12.87	3.46	13.05	3.57
MG7	15.13	6.30	12.64	5.58	9.17	2.76	9.20	2.82
MG8			26.19	4.62				
MG9			19.45	7.60	12.95	4.12	12.88	4.22
MG10	15.88	5.39	13.94	5.88	10.34	3.57	10.37	3.63
MG11			11.09	4.61				
MG13			10.40	3.23				
OV23	20.00	7.19						
OV26			8.38	4.85				
U4					10.45	3.63	10.63	3.68

British Ellenberg N

	CSS		ESA quadrat		ESA plot32		ESA plot16	
NVC	mean	sd	mean	sd	mean	sd	mean	sd
CG2					3.42	0.37	3.41	0.37
CG3			3.75	0.32				
H4					1.87	0.24	1.86	0.25
M23					3.83	0.67	3.84	0.65
MG1	5.76	0.79	5.16	0.97				
MG5	4.50	0.40			4.38	0.39	4.41	0.40
MG6	5.14	0.32	4.66	0.31	5.03	0.38	5.03	0.39
MG7	5.72	0.36	5.36	0.52	5.68	0.38	5.68	0.39
MG8			4.20	0.21				
MG9			4.76	0.51	5.05	0.51	5.04	0.51
MG10	5.42	0.56	5.18	0.47	5.44	0.51	5.44	0.51
MG11			5.53	0.39				
MG13			5.43	0.51				
OV23	5.71	0.34						
OV26			6.24	0.74				
U4					3.10	0.78	3.11	0.80

Nu score

	CSS		ESA quadrat				ESA plot32		ESA plot16	
			p/a		Domin					
NVC	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd
CG2							-0.531	0.105	-0.509	0.096
CG3			-0.438	0.116	-0.435	0.136				
H4							-0.911	0.105	-0.906	0.100
M23							-0.218	0.219	-0.222	0.197
MG1	0.290	0.283	0.058	0.319	0.031	0.291				
MG5	-0.133	0.150					-0.206	0.131	-0.206	0.123
MG6	0.124	0.115	-0.090	0.144	-0.102	0.135	0.027	0.112	0.014	0.109
MG7	0.223	0.143	0.100	0.152	-0.007	0.163	0.132	0.099	0.125	0.095
MG8			-0.217	0.103	-0.230	0.112				
MG9			-0.076	0.178	-0.092	0.178	-0.026	0.113	-0.030	0.115
MG10	0.228	0.186	0.126	0.161	0.005	0.193	0.127	0.097	0.120	0.086
MG11			0.244	0.154	-0.036	0.203				
MG13			0.234	0.165	0.136	0.235				
OV23	0.256	0.094								
OV26			0.531	0.344	0.583	0.330				
U4							-0.437	0.218	-0.412	0.208

G score	CSS		ESA quadrat				ESA plot32		ESA plot16	
			p/a		Domin					
NVC	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd
CG2							0.382	0.052	0.370	0.045
CG3			0.261	0.099	0.226	0.100				
H4							-0.183	0.112	-0.194	0.157
M23							0.124	0.121	0.119	0.111
MG1	-0.144	0.176	-0.018	0.279	-0.006	0.306				
MG5	0.212	0.120					0.332	0.126	0.327	0.125
MG6	0.213	0.135	0.337	0.102	0.306	0.142	0.295	0.119	0.281	0.114
MG7	0.114	0.141	0.250	0.130	0.180	0.163	0.216	0.137	0.206	0.135
MG8			0.228	0.100	0.231	0.106				
MG9			0.095	0.151	0.080	0.174	0.067	0.112	0.073	0.121
MG10	0.008	0.174	0.167	0.160	0.124	0.180	0.100	0.139	0.082	0.137
MG11			0.158	0.146	0.151	0.185				
MG13			0.123	0.168	0.169	0.198				
OV23	0.161	0.117								
OV26			-0.484	0.205	-0.550	0.279				
U4							0.206	0.111	0.185	0.105

Appendix 1.9.

Mean and standard deviation of species richness, Ellenberg N value, Nu and G scores for each of the CVS classes. Data are derived from four sources: CSS data, ESA quadrat data (scores calculated on presence/absence and Domin basis) and ESA plot data (32 nest and 16 nest data).

Species richness

	CSS		ESA quadrat		ESA plot32		ESA plot16	
CVS	mean	sd	mean	sd	mean	sd	mean	sd
10			4.50	1.93				
29			6.83	2.24				
30	15.18	6.74	10.14	3.57	8.86	2.78	8.89	2.83
31			10.81	3.78	8.78	2.30	8.91	2.35
40	23.45	6.73	19.42	4.74	14.40	4.19	14.51	4.29
41			15.20	5.05				
43	15.62	4.79	13.27	3.15				
44	40.03	10.98	31.01	5.93	25.70	6.41	26.05	6.50
51	26.88	10.02	20.68	6.43	15.69	5.12	15.79	5.24
64					8.65	2.19	8.78	2.14
90					6.70	1.38	6.69	1.38

British Ellenberg N

	CSS		ESA quadrat		ESA plot32		ESA plot16	
CVS	mean	sd	mean	sd	mean	sd	mean	sd
10			6.78	0.56				
29			5.98	0.41				
30	5.75	0.34	5.60	0.32	5.67	0.29	5.67	0.29
31			5.40	0.42	5.68	0.45	5.66	0.46
40	5.03	0.36	4.79	0.30	4.99	0.37	5.00	0.37
41			5.26	0.31				
43	5.07	0.46	4.96	0.35				
44	4.17	0.33	3.85	0.41	3.59	0.48	3.58	0.49
51	4.58	0.42	4.48	0.36	4.65	0.42	4.65	0.42
64					2.87	0.45	2.88	0.49
90					1.82	0.20	1.83	0.23

Nu score

	CSS		ESA quadrat				ESA plot32		ESA plot16	
			p/a		Domin					
CVS	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd
10			0.702	0.317	0.690	0.359				
29			0.169	0.149	-0.037	0.212				
30	0.300	0.147	0.215	0.137	0.000	0.215	0.161	0.113	0.146	0.103
31			0.110	0.133	-0.011	0.188	0.113	0.101	0.111	0.117
40	0.078	0.136	-0.030	0.136	-0.045	0.127	-0.001	0.116	-0.012	0.117
41			0.176	0.134	0.197	0.144				
43	0.076	0.175	0.011	0.157	-0.024	0.164				
44	-0.275	0.126	-0.393	0.172	-0.400	0.187	-0.483	0.143	-0.465	0.135
51	-0.039	0.134	-0.110	0.163	-0.110	0.171	-0.063	0.122	-0.068	0.117
64							-0.506	0.140	-0.465	0.167
90							-0.911	0.097	-0.912	0.076

G score

	CSS		ESA quadrat				ESA plot32		ESA plot16	
			p/a		Domin					
CVS	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd
10			-0.462	0.266	-0.506	0.343				
29			0.256	0.118	0.120	0.217				
30	0.100	0.150	0.181	0.153	0.138	0.180	0.133	0.121	0.120	0.113
31			0.329	0.127	0.227	0.171	0.313	0.100	0.276	0.094
40	0.226	0.113	0.292	0.122	0.250	0.155	0.290	0.139	0.284	0.130
41			-0.031	0.182	0.111	0.269				
43	0.121	0.120	0.263	0.118	0.220	0.140				
44	0.188	0.147	0.263	0.110	0.233	0.122	0.352	0.089	0.345	0.085
51	0.079	0.133	0.135	0.156	0.126	0.175	0.143	0.109	0.133	0.107
64							0.157	0.168	0.112	0.169
90							-0.110	0.160	-0.122	0.185

Appendix 1.10.

Mean and standard deviation of species richness, Ellenberg N value, Nu and G scores for each of the Broad habitats. Data are derived from four sources: CSS data, ESA quadrat data (scores calculated on presence/absence and Domin basis) and ESA plot data (32 nest and 16 nest data at optimum scale). AG = Acid Grassland, CG = Calcareous Grassland, DSH = Dwarf Shrub Heath, FMS = Fen, Marsh and Swamp, IG = Improved Grassland, NG = Neutral Grassland.

Species richness

	CSS		ESA quadrat		ESA plot32		ESA plot16	
Broad Habitat	mean	sd	mean	sd	mean	sd	mean	sd
AG	17.91	6.77			9.46	3.20	9.56	3.25
CG	39.45	10.68	32.02	6.22	26.92	5.97	27.36	6.06
DSH	10.70	6.67			7.19	1.77	7.14	1.79
FMS	21.51	11.63	15.05	8.42	12.21	4.08	12.17	3.97
IG	15.13	6.30	12.64	5.58	9.17	2.76	9.20	2.82
NG	23.76	11.87	15.06	7.15	15.06	6.22	15.13	6.30

British Ellenberg N

	CSS		ESA quadrat		ESA plot32		ESA plot16	
Broad Habitat	mean	sd	mean	sd	mean	sd	mean	sd
AG	3.30	0.61			2.92	0.79	2.92	0.80
CG	3.93	0.42	3.73	0.34	3.44	0.39	3.43	0.39
DSH	2.71	0.62			1.98	0.31	1.97	0.31
FMS	4.94	1.24	5.24	1.17	3.69	0.81	3.69	0.80
IG	5.72	0.36	5.36	0.52	5.68	0.38	5.68	0.39
NG	5.08	0.73	5.12	0.60	4.91	0.63	4.92	0.63

Nu score

	CSS		ESA quadrat				ESA plot32		ESA plot16	
			p/a		Domin					
Broad Habitat	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd
AG	-0.489	0.226					-0.492	0.220	-0.484	0.221
CG	-0.360	0.143	-0.440	0.135	-0.445	0.155	-0.526	0.119	-0.505	0.114
DSH	-0.587	0.218					-0.857	0.135	-0.852	0.133
FMS	0.071	0.412	0.147	0.444	0.191	0.461	-0.271	0.276	-0.274	0.256
IG	0.223	0.143	0.100	0.152	-0.007	0.163	0.132	0.099	0.125	0.095
NG	0.071	0.262	0.096	0.213	-0.018	0.211	-0.039	0.182	-0.045	0.174

G score

	CSS		ESA quadrat				ESA plot32		ESA plot16	
			p/a		Domin					
Broad Habitat	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd
AG	0.134	0.183					0.184	0.123	0.171	0.121
CG	0.211	0.157	0.280	0.097	0.250	0.099	0.367	0.070	0.358	0.067
DSH	-0.128	0.224					-0.113	0.157	-0.139	0.175
FMS	-0.118	0.219	-0.260	0.299	-0.221	0.409	0.134	0.122	0.129	0.112
IG	0.114	0.141	0.250	0.130	0.180	0.163	0.216	0.137	0.206	0.135
NG	0.088	0.191	0.143	0.170	0.123	0.192	0.175	0.163	0.167	0.164

Appendix 1.11.

Mean and standard deviation of species richness, Ellenberg N value, Nu and G scores for each of the Priority habitats. Data are derived from four sources: CSS data, ESA quadrat data (scores calculated on presence/absence and Domin basis) and ESA plot data (32 nest and 16 nest data at optimum scale). LCG = Lowland Calcareous Grassland, LDAG = Lowland Dry Acid Grassland, LM = Lowland Meadows.

Species richness

	CSS		ESA quadrat		ESA plot32		ESA plot16	
Priority Habitat	mean	sd	mean	sd	mean	sd	mean	sd
LCG	40.77	10.23	32.12	6.22	26.92	5.97	27.36	6.06
LDAG					9.87	3.50	10.00	3.54
LM	31.75	9.94	26.19	4.62	20.26	4.67	20.41	4.62

British Ellenberg N

	CSS		ESA quadrat		ESA plot32		ESA plot16	
Priority Habitat	mean	sd	mean	sd	mean	sd	mean	sd
LCG	3.99	0.38	3.75	0.32	3.44	0.39	3.43	0.39
LDAG					3.00	0.87	3.01	0.88
LM	4.55	0.42	4.20	0.21	4.42	0.37	4.44	0.38

Nu score

	CSS		ESA quadrat				ESA plot32		ESA plot16	
			p/a		Domin					
Priority Habitat	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd
LCG	-0.341	0.135	-0.434	0.129	-0.439	0.149	-0.526	0.119	-0.505	0.114
LDAG							-0.471	0.239	-0.451	0.234
LM	-0.114	0.160	-0.217	0.103	-0.230	0.112	-0.182	0.131	-0.181	0.125

G score

	CSS		ESA quadrat				ESA plot32		ESA plot16	
			p/a		Domin					
Priority Habitat	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd
LCG	0.195	0.154	0.277	0.096	0.248	0.098	0.367	0.070	0.358	0.067
LDAG							0.188	0.132	0.172	0.123
LM	0.200	0.123	0.228	0.100	0.231	0.106	0.288	0.143	0.282	0.143

Appendix 1.12. Summary from repeat ESA quadrat data.

		Richness		Ellenberg N		G p/a		Nu p/a		G Domin		Nu Domin	
n	**NVC**	corr	sd-diff	corr	sd-diff	corr	sd-diff	corr	sd-diff	corr	sd-diff	corr	sd-diff
117	CG3	0.66	5.74	0.74	0.236	0.77	0.064	0.70	0.084	0.83	0.060	0.71	0.111
48	CG4	0.59	5.46	0.82	0.205	0.75	0.053	0.92	0.059	0.54	0.063	0.86	0.084
30	M23	0.38	4.26	0.58	0.259	0.63	0.101	0.60	0.104	0.75	0.091	0.50	0.176
46	M27	0.77	4.02	0.70	0.404	0.26	0.218	0.13	0.190	0.12	0.393	-0.13	0.194
96	MG1	0.94	3.80	0.94	0.327	0.68	0.193	0.90	0.136	0.69	0.223	0.88	0.136
680	MG6	0.80	3.40	0.75	0.277	0.57	0.101	0.78	0.115	0.48	0.122	0.60	0.146
1499	MG7	0.79	3.86	0.82	0.317	0.53	0.137	0.71	0.138	0.48	0.144	0.49	0.194
96	MG8	0.66	4.33	0.57	0.240	0.47	0.105	0.66	0.091	0.38	0.120	0.74	0.112
257	MG9	0.90	3.63	0.92	0.256	0.64	0.123	0.85	0.114	0.42	0.158	0.78	0.134
768	MG10	0.78	4.16	0.81	0.316	0.62	0.135	0.72	0.136	0.31	0.190	0.27	0.243
267	MG11	0.76	3.29	0.76	0.295	0.37	0.174	0.67	0.138	0.03	0.230	0.14	0.277
29	MG12	0.69	4.11	0.42	0.329	0.53	0.093	0.30	0.119	0.74	0.105	0.60	0.112
141	MG13	0.66	3.71	0.87	0.299	0.52	0.133	0.71	0.155	0.08	0.210	0.39	0.316
36	OV25	0.01	3.45	0.54	0.486	0.13	0.201	0.34	0.193	0.12	0.149	0.35	0.223
108	OV26	0.80	2.70	0.49	0.559	0.34	0.284	0.39	0.255	0.47	0.271	0.49	0.264
54	OV27	0.55	6.93	0.88	0.552	0.74	0.215	0.83	0.220	0.75	0.198	0.81	0.247
27	S19	0.51	3.62	0.84	0.243	0.86	0.096	0.66	0.129	0.76	0.182	0.75	0.124
28	S28	0.70	2.53	0.52	0.492	0.52	0.291	0.26	0.220	0.62	0.356	0.21	0.322
63	U1	0.36	4.71	0.53	0.593	0.34	0.161	0.50	0.212	0.47	0.208	0.54	0.243
	mean	**0.65**	**4.09**	**0.71**	**0.352**	**0.54**	**0.151**	**0.61**	**0.148**	**0.48**	**0.183**	**0.53**	**0.193**

n	**CVS**												
72	9	0.46	3.38	0.56	0.537	0.55	0.173	0.40	0.216	0.53	0.170	0.51	0.217
126	10	0.43	3.33	0.43	0.536	0.17	0.311	0.42	0.280	0.35	0.312	0.45	0.292
24	14	0.35	2.43	-0.05	0.307	0.16	0.192	0.12	0.167	0.01	0.134	-0.20	0.175
39	28	0.33	5.29	0.69	0.592	0.76	0.245	0.66	0.188	0.76	0.265	0.56	0.202
123	29	0.47	3.51	0.60	0.375	0.23	0.160	0.42	0.170	0.39	0.178	0.20	0.256
1248	30	0.67	3.37	0.65	0.330	0.49	0.150	0.53	0.150	0.17	0.200	0.24	0.270
136	31	0.52	4.53	0.73	0.413	0.38	0.180	0.42	0.207	0.43	0.184	0.20	0.252
24	32	0.75	2.26	0.39	0.480	0.30	0.185	0.75	0.132	0.24	0.256	0.74	0.124
1192	40	0.71	4.15	0.76	0.250	0.65	0.110	0.79	0.100	0.54	0.130	0.68	0.130
46	41	0.56	4.73	0.59	0.339	0.42	0.166	0.53	0.155	-0.01	0.272	0.21	0.224
426	43	0.67	3.27	0.78	0.296	0.58	0.121	0.78	0.119	0.57	0.130	0.74	0.145
228	44	0.67	5.43	0.86	0.216	0.80	0.065	0.89	0.077	0.76	0.077	0.85	0.101
25	48	0.86	2.68	0.79	0.272	0.79	0.103	0.18	0.122	0.40	0.222	0.36	0.150
599	51	0.81	4.12	0.81	0.256	0.77	0.102	0.80	0.106	0.65	0.135	0.67	0.145
24	53	-0.01	5.64	0.57	0.623	0.51	0.156	0.32	0.205	0.37	0.242	0.24	0.255
21	54	0.06	7.68	0.60	0.482	0.70	0.167	0.63	0.179	0.83	0.160	0.38	0.320
21	56	0.72	3.93	0.19	0.920	0.72	0.086	0.28	0.346	0.59	0.147	0.36	0.366
	mean	**0.53**	**4.10**	**0.58**	**0.425**	**0.53**	**0.157**	**0.53**	**0.172**	**0.44**	**0.189**	**0.42**	**0.213**

		Richness		Ellenberg N		G p/a		Nu p/a		G Domin		Nu Domin	
n	**Broad Habitat**	corr	sd-diff	corr	sd-diff	corr	sd-diff	corr	sd-diff	corr	sd-diff	corr	sd-diff
78	AciGra	0.65	4.96	0.42	0.733	0.39	0.153	0.54	0.254	0.47	0.197	0.55	0.271
177	CalGra	0.63	5.72	0.80	0.223	0.77	0.063	0.81	0.079	0.76	0.067	0.78	0.103
203	FenMarSwa	0.90	3.66	0.88	0.534	0.59	0.252	0.81	0.245	0.57	0.303	0.74	0.273
1499	ImpGra	0.79	3.86	0.82	0.320	0.53	0.140	0.71	0.140	0.48	0.140	0.49	0.190
1660	NeuGra	0.87	3.95	0.88	0.300	0.58	0.140	0.82	0.130	0.33	0.190	0.49	0.240
	mean	**0.78**	**4.26**	**0.76**	**0.398**	**0.58**	**0.142**	**0.75**	**0.161**	**0.52**	**0.170**	**0.62**	**0.204**
n	**Priority Habitat**												
174	LCG	0.62	5.76	0.78	0.224	0.77	0.063	0.79	0.080	0.76	0.068	0.76	0.104
72	LDAG	0.65	5.05	0.62	0.594	0.37	0.157	0.70	0.207	0.46	0.199	0.67	0.233
96	LM	0.66	4.33	0.57	0.240	0.47	0.105	0.66	0.091	0.38	0.120	0.74	0.112
	mean	**0.64**	**5.05**	**0.66**	**0.352**	**0.53**	**0.108**	**0.71**	**0.126**	**0.54**	**0.129**	**0.72**	**0.150**

Appendix 1.13. Summary from repeat ESA plots.

		Species richness 32		Species richness 16		Ellenberg N 32		Ellenberg N 16		G score 32		G score 16		Nu score 32		Nu score 16	
n	**NVC**	corr	SD-diff	corr	SD-diff	corr	SD-diff	corr	SD-diff	corr	SD-diff	corr	SD-diff	corr	SD-diff	corr	SD-diff
36	CG2	0.72	3.15	0.64	3.54	0.97	0.09	0.97	0.09	0.78	0.03	0.53	0.05	0.93	0.04	0.90	0.04
22	MG6	0.91	1.66	0.87	2.03	0.91	0.18	0.90	0.21	0.84	0.06	0.77	0.07	0.88	0.06	0.83	0.07
31	U4	0.90	1.41	0.86	1.52	0.98	0.16	0.98	0.15	0.76	0.08	0.77	0.07	0.94	0.07	0.91	0.09

n	**CVS**	corr	SD-diff	corr	SD-diff	corr	SD-diff	corr	SD-diff	corr	SD-diff	corr	SD-diff	corr	SD-diff	corr	SD-diff
27	40	0.47	4.24	0.57	4.01	0.85	0.22	0.86	0.21	0.78	0.12	0.82	0.10	0.87	0.07	0.86	0.07
47	44	0.87	3.01	0.81	3.55	0.98	0.10	0.98	0.10	0.86	0.04	0.79	0.05	0.92	0.05	0.90	0.05
25	51	0.60	5.09	0.55	5.31	0.90	0.15	0.88	0.17	0.71	0.10	0.55	0.12	0.74	0.09	0.84	0.07

n	**Broad Habitat**	corr	SD-diff	corr	SD-diff	corr	SD-diff	corr	SD-diff	corr	SD-diff	corr	SD-diff	corr	SD-diff	corr	SD-diff
57	AG	0.91	1.20	0.90	1.27	0.97	0.15	0.97	0.16	0.81	0.07	0.71	0.09	0.93	0.07	0.90	0.09
39	CG	0.80	3.20	0.73	3.72	0.97	0.08	0.97	0.09	0.85	0.03	0.72	0.05	0.92	0.04	0.88	0.04
23	DSH	0.72	1.57	0.74	1.58	0.98	0.07	0.98	0.06	0.90	0.07	0.94	0.06	0.94	0.05	0.94	0.05
57	NG	0.79	4.41	0.78	4.46	0.95	0.19	0.94	0.21	0.72	0.11	0.75	0.11	0.90	0.09	0.88	0.09

n	**Priority Habitat**	corr	SD-diff	corr	SD-diff	corr	SD-diff	corr	SD-diff	corr	SD-diff	corr	SD-diff	corr	SD-diff	corr	SD-diff
39	LCG	0.80	3.20	0.73	3.72	0.97	0.08	0.97	0.09	0.85	0.03	0.72	0.05	0.92	0.04	0.88	0.04
39	LDAG	0.92	1.31	0.89	1.42	0.97	0.17	0.98	0.17	0.83	0.07	0.76	0.08	0.94	0.07	0.92	0.09
30	LM	0.53	5.73	0.49	5.80	0.94	0.14	0.93	0.15	0.80	0.12	0.74	0.13	0.90	0.08	0.90	0.08

APPENDIX 2

POLICY BACKGROUND

The objectives of any AE scheme agreement should fit into the objectives of a hierarchy of bureaucracy from the European Union level through national targets, to the scheme, local targets within schemes and down to the objectives of the individual agreement.

European Policy

Agri-environment schemes began in Europe voluntarily following Regulation 797/85 and compulsorily after Regulation 2078/92.

More recently rural development in the European Union has been defined legally by the following directives: 1257/1999; 1750/1999; 2603/1999; 445/2002

These directives link rural development to the funding of agriculture in a fundamental way.

Agenda 2000 are the reforms of the Common agricultural policy of the EU. The new rural development policy, now the “second pillar” of the Common Agricultural Policy, meets these needs. As an essential part of the European agricultural model, it aims to put in place a consistent and lasting framework for guaranteeing the future of rural areas and promoting the maintenance and creation of employment.

The principles are as follows:

- The **multifunctionality of agriculture**, i.e. its varied role over and above the production of foodstuffs. This implies the recognition and encouragement of the range of services provided by farmers.
- A **multisectoral and integrated** approach to the rural economy in order to diversify activities, create new sources of income and employment and protect the rural heritage.
- **Flexible** aids for rural development, based on subsidiarity and promoting decentralisation, consultation at regional, local and partnership level.
- **Transparency** in drawing up and managing programmes, based on simplified and more accessible legislation.

One of the main innovations in this policy is the method used to improve integration between the different types of intervention, to help ensure smooth and balanced development in all European rural areas. The main features of this development can be defined as follows:

- strengthening the agricultural and forestry sector
- improving the competitiveness of rural areas
- preserving the environment and rural heritage

A consequence of the EU directives is that each nation has had to produce its own rural development plan. Agri-environment schemes in England now fall within the LEADER + programme of the European Union that has the following objectives:

- The Commission has approved on 14 August 2001 the programme for the Community Initiative Leader+ in England. During the period 2001-2006, the total expenditure under the programme is EUR 119.2 million. This includes a contribution from EAGGF Guidance Section of EUR 54.3 million and a contribution of EUR 10.6 million from the private sector.

- The programme covers all the rural areas of England. The Leader+ programme aims to pilot with new ideas to contribute to a more sustainable society, economy and environment for rural England. These will be developed under the following themes; the use of know how and new technology to make the products and services of rural areas more competitive, improving the quality of life in rural communities, adding value to local products and, making the best use of natural and cultural resources. The programme identifies five target groups; women, young people, the older population, unemployed and underemployed and rural businesses and workers affected by rural restructuring. The English LAGs will complement their own activities by developing co-operation with other LAGs both within the UK and with transnational partnerships.

- It is expected that the programme will support around 23 Local Action Groups (LAGs) selected in England and these LAGs will be supported by the UK national network The Leader+ programme for England provides the legal and financial framework for the LAGs. However, in order to ensure a bottom-up approach, each LAG will define their own measures and specific goals based on the particular characteristics of their area. These will be set out in development plans drawn up by the LAGs themselves. The selection of the LAGs by the Department for Environment, Food and Rural Affairs (DEFRA) will be based on the merits of these development plans.

Making the best uses of natural and cultural resources is intimately linked to the agri-environment schemes.

Further to their place in rural development plans the agri-environment schemes are seen as a way of delivering the targets of the Rio convention.

The EU has provided a list of common evaluation criteria for rural development with questions and indicators as outlined in Regulation 1750/1997. For agri-environment schemes section I.6 is relevant:

I.6. To what extent have supported investments facilitated environmentally friendly farming?

I.6-1. Integration of environmental concerns into farm investments

I.6-1.1. Share of beneficiary holdings introducing environmental improvements thanks to the co-financing (%)

(a) of which with the environmental improvement as the direct aim of
the investment (%)

(b) of which as a collateral effect (e.g., due to new equipment acquired mainly for economic purposes) (%)
(c) of which relating to waste and excess manure (%)
(d) of which relating to on-farm water management (%)
(e) of which relating to (other) benign farming practices/systems (%)

The evaluations carried out in most countries have been based on uptake figures alone and although they answer the criteria, they do not give an understanding of the impact of the schemes on wildlife. Only the monitoring of schemes by nations such as the UK has addressed the processes that are at work within the uptake figures.

England

In 2000 the government published the England Rural Development Plan. Biodiversity goals are to be achieved through the Environmentally Sensitive Areas Scheme (ESAs) and the Countryside Stewardship Scheme (CSS). The following text outlining one departmental position comes from the “Guidance on UK Priority Habitats” (Ovenden & Turner 2001):

- Agri-environment scheme agreements need to take account of Government commitments to the UK Biodiversity Action Plan (BAP). A large number of the published BAPs contain explicit actions for DEFRA and other agriculture departments to consider and address though the agri-environment schemes that they operate.

- DEFRA's policy position on how Biodiversity Action Plan (BAP) habitats and species should be handled in CSS is set out in general terms in the public policy document "MAFF's role in implementing the Biodiversity Action Plans". This highlights the role that quinquennial policy reviews and county targeting will have in modifying the scheme to take account of biodiversity (and other) objectives. These two processes will have a significant effect on the achievement of biodiversity objectives by the scheme, but this does not reduce the primary importance of evaluating the wildlife value of each application on its own merit.

- The major contribution of the ESA and Countryside Stewardship schemes to biodiversity will be through measures to address the priority habitats, with benefits for priority species being largely indirect through the habitat measures. However, individual agreements may be tailored to address species requirements where appropriate.

Regions

The CSS has overall scheme objectives and different landscape types and counties have their own target objectives relating to local biodiversity. The degree to which these are tied to local Agenda 2000 BAP targets is unclear (to the authors of this report). Each ESA has its own objectives that are related to local landscape and biodiversity objectives. Both the objectives for CSS and ESAs were originally written before the national and local BAP targets were developed and therefore are not linked directly.

Agreements

Each CSS agreement should include objectives tailored to the land under that agreement. These individual objectives usually come from a generic stock of phrases but some individual agreements have objectives for individual species or features. The quality of the objectives is variable but has been improving (Carey *et al* 2001b) as the collective knowledge of project officers has increased.

Only the most recent ESA agreements have similar objectives and these are for agreements with management plans.

Future Developments

It is likely that following the review currently being undertaken by DEFRA that the agri-environment schemes will be modified or new schemes will be created. There is debate as to whether these schemes will be “narrow and deep” or “broad and shallow”. Narrow and deep schemes would highlight priority habitats and species with detailed and expensive management on a few sites whereas broad and shallow schemes would have basic management to improve the countryside as a whole.

APPENDIX 3

WORKSHOP REPORT

This appendix contains documents relating to the workshop held on 13 May 2002. These are:

1. Workshop Briefing Document supplied to attendees in advance of the workshop.

2. Workshop Programme

3. Report on Workshop Discussion Groups

4. List of Attendees

1 WORKSHOP BRIEFING DOCUMENT

This workshop is being carried out as part of a project funded by DEFRA, in a contract to ADAS, CEH and Imperial College at Wye.

1.1 BACKGROUND TO THE PROJECT

1.1.1 Aims & scope

Agri-environment (AE) schemes in England have been run by DEFRA (previously MAFF) since 1987, when the first Environmentally Sensitive Areas (ESAs) were introduced under the 1986 Agriculture Act. Since then, further ESAs have been introduced along with other schemes such as the Habitat Scheme and Moorland Scheme. Agri-environment schemes now come under the England Rural Development Programme (RDP), along with the Countryside Stewardship Scheme (CSS), the Arable Stewardship Pilot Scheme (ASPS), Organic Farming Scheme, Farm Woodland Premium Scheme and Hill Farming Allowance Scheme.

Since their first introduction, DEFRA has been committed to monitoring the performance of agri-environment schemes in relation to objectives. As part of this monitoring programme, botanical data have been collected from a number of schemes. The methods for sampling, field data collection and data interpretation have varied. However, in addition to reporting of scheme performance per se, there is now a requirement for DEFRA to report within a wider policy context.

The aim of this project is to make recommendations for the future botanical monitoring programme of AE schemes, scheduled to run from 2002-2005, for reporting of scheme performance in 2005-2006. Future monitoring will need to be scientifically valid, but also economical. There is a requirement to optimise the use of existing botanical samples and time series data, whilst also taking account of recent developments in botanical monitoring methods.

In the first stage of the project, a review was carried out. This covered current AE botanical monitoring methods, methods for analysing and interpreting change in the context of policy objectives, and recent developments in approaches to botanical monitoring. Statistical power testing has been applied to existing data to help to determine the relative benefits and costs of different sampling, data collection and interpretative methods.

1.1.2 Summary of review

Key findings were:

- In England, grassland botanical monitoring programmes have been established in CSS, the Habitat Scheme and 19 ESAs. Field methods used for grasslands were mostly based on fixed quadrats or plots. Heathland monitoring in ESAs and the Moorland Scheme have focussed on heather grazing, abundance and burning, and change in species composition. Arable habitats, including field margins, have been monitored in the ASPS, Habitat Scheme and Breckland ESA. Other more limited studies have also been done for ditches, banksides, saltmarsh and woodland.

- Comparison of monitoring methods between the four UK countries showed that strategies for site selection varied widely, being dictated by the specific objectives of each monitoring programme. There was some consistency between countries in the field methods used for grasslands. On heather moorland, a range of methods has been used to measure grazing intensity, species composition and vegetation structure. Field methods used for other habitats varied according to the monitoring objectives.
- Literature searches revealed relatively few examples of research specifically directed at botanical monitoring methods. However, there are clear advantages of using nested systems compared to cover or frequency estimation at single scales. Currently, there does not appear to be a single ideal method for direct measurement of grazing intensity on plants such as heather. Different methods for measuring sward height and structure will be appropriate depending on the objectives of the monitoring. Few novel techniques were identified in the review, and although some show promise, they need further development.
- In England, a range of indicators and methods were used to detect and interpret change, depending on objectives of the monitoring programmes. Quantitative floristic data were reduced to community variables that indicate different attributes (e.g. suited species scores, Ellenberg values, diversity indices, functional groups), and indicators such as individual species and measures of vegetation structure were used. Indices of grazing and biomass utilisation were also applied to heather moorland. Most samples were classified by National Vegetation Classification or the Countryside Vegetation System. In other UK countries, similar interpretation methods to these were used in many cases.
- Suited species scores and Ellenberg values can be related to scheme objectives and management, and indicate the underlying environmental conditions. The FIBS approach is potentially powerful but requires expert interpretation and data are lacking for some species. Species richness is widely used but requires careful interpretation. Community variables can potentially be compared with control data, and calibrated into JNCC condition categories. Current methods for measuring heather condition require further research.
- ‘Control’ datasets can be used to compare vegetation condition against external standards, and trends with those in the wider countryside. Sources that have been used for AE scheme botanical data include Countryside Survey, survey datasets from EN, CCW and SNH, non-agreement land within ESAs, and results from other independent research.
- Environmental data have been collected to assist in interpreting monitoring results. These include data on soil properties, management, meteorology and physical parameters. Quantitative analyses were not always possible and environmental data were often used as background information. Climate change and atmospheric deposition are also potentially important external drivers of vegetation change.
- Rapid methods of condition assessment are currently being developed, mainly by the statutory conservation agencies. These are working towards common standards of assessment, within the existing JNCC framework. Ten studies were identified in various stages of development, covering a wide range of habitats. A common model has been adopted, using generic attributes and site specific targets. The methods have been evaluated and an initial exploration done of their applicability to AE schemes.

1.1.3 Objectives of workshop

There is a considerable pool of expertise and experience on botanical monitoring within a range of organisations in the UK. This includes specialist knowledge from different perspectives such as policy, ecology, conservation and field survey. In the workshop we hope to draw on some of this experience to ensure that issues relating to botanical monitoring strategies in AE schemes are fully explored. It will also be an opportunity for any new issues to be raised.

1.2 DISCUSSION GROUPS

1.2.1 Policy background

The UK Biodiversity Action Plan (BAP) sets out objectives and targets for Priority Habitats. These include

- the *re-establishment* of priority habitat where it has been severely degraded or destroyed, such that the current vegetation is not recognisable as a priority habitat type (e.g. re-establishment of a priority habitat grassland type on arable land or agriculturally improved or semi-improved grassland)
- the *rehabilitation*[1] of vegetation that is recognisable as a priority habitat, but where its condition is currently unfavourable
- the *maintenance* of the condition and extent of a priority habitat that is in favourable condition.

The BAP also specifies a ‘conservation direction’ for Broad Habitats, which acts as a framework within which targets for Priority Habitats and Species are set. The aims for Broad Habitats refer to their protection, maintenance of extent and quality, and improvement. These objectives therefore apply to vegetation that is of conservation value, even if it does not fit the definition of any priority habitat.

In 2000 the government published the England Rural Development Plan. Biodiversity goals are to be achieved through the Environmentally Sensitive Areas Scheme (ESAs) and the Countryside Stewardship Scheme (CSS). A large number of the published BAPs contain explicit actions for DEFRA and other agriculture departments to consider and address through the agri-environment schemes that they operate. The major contribution of the ESA and Countryside Stewardship schemes to biodiversity will be through measures to address the priority habitats, with benefits for priority species being largely indirect through the habitat measures. However, individual agreements might be tailored to address species requirements where appropriate. In CSS, quinquennial policy reviews and county targeting will have a significant effect on the achievement of BAP habitat and species objectives, but this does not reduce the primary importance of evaluating the wildlife value of each application on its own merit.

The CSS has overall scheme objectives, plus more targeted objectives relating to local biodiversity in different landscape types and counties. Each ESA has its own objectives that are related to local landscape and biodiversity objectives. The objectives for both CSS and ESAs were originally written before the national and local BAP targets were developed and therefore are not linked directly.

[1] equivalent to ‘restoration’ as used elsewhere in this report (see Table 4.1).

Individual CSS agreements should include objectives tailored to the land under that agreement. These individual objectives usually come from a generic stock of phrases but some agreements have objectives for particular species or features. Only the most recent ESA agreements have individual objectives, which are encompassed within management plans.

DEFRA is currently reviewing AE schemes. It is likely that the current schemes will be modified or new schemes will be created. There is debate as to whether these schemes will be “narrow and deep” or “broad and shallow”. Narrow and deep schemes would highlight priority habitats and species with detailed and expensive management on a few sites, whereas broad and shallow schemes would have basic management to improve the countryside as a whole. Potentially, future AE schemes could be of one or other type, or a combination of both.

1.2.2 Scenarios for discussion[2]

In future, it will be necessary to measure the contribution being made by AE schemes to meeting BAP objectives and targets. The strategy for botanical monitoring will need to be designed with this as the primary aim. Different strategies might need to be adopted for broad & shallow and narrow & deep schemes. There is a range of issues that need to be addressed across a range of habitats. During the workshop, these will be considered under four different scenarios. It won’t be possible to consider all possible combinations, but discussion groups will focus on a particular scenario, using one or more habitat types as examples. The four scenarios are:

1. Rehabilitation of Priority Habitat or improvement of Broad Habitat in a broad & shallow scheme
2. Maintenance of Priority or Broad Habitat in a broad & shallow scheme
3. Re-establishment or rehabilitation of Priority (or Broad) Habitat in a narrow & deep scheme
4. Maintenance of Priority Habitat in a narrow & deep scheme.

Issues

For each of the four scenarios, the following general issues need to be considered:

a) How might the stock and condition (with respect to JNCC categories) of a habitat be measured
b) How might change in its condition over time be measured
c) How might the drivers of change be assessed

[2] scenarios were altered after production of the briefing document. Three discussion groups were held (see Report on Workshop Discussion Groups).

Habitats

There is a wide range of Priority and Broad Habitats subjected to AE scheme management. However, the above scenarios need to be considered for three generic vegetation types:

(i) lowland grasslands (includes 'upland hay meadows')
(ii) upland heaths, mires and rough grazing
(iii) arable land and linear habitats

2 WORKSHOP PROGRAMME

DEFRA, Nobel House (Conference Room B), Smith Square, London
Monday 13 May, 2002

10.00h coffee

10.30h	Introduction	Alan Hooper, DEFRA RDS

Part 1: The project so far

10.35h	Scope of project & objectives of workshop	Nigel Critchley, ADAS
10.45h	Overview of existing data	John Fowbert, ADAS
11.00h	Rapid condition assessment	Jonathan Mitchley, IC
11.15h	Summary of review	Les Firbank, CEH
11.30h	Clarification of points	Andy Parkin (chair)

Part 2: Issues for a monitoring strategy

11.45h	Objectives for discussion groups	Nigel Critchley
	Discussion groups	
13.00h	lunch	
13.45h	Report back from discussion groups	Nigel Critchley (lead)
14.45h	General discussion	Andy Parkin (chair)
15.15h	Concluding remarks	Alan Hooper, DEFRA RDS
15.30h	tea & finish	
[15.45h – 17.00h		consortium meeting]

3 REPORT ON WORKSHOP DISCUSSION GROUPS

3.1 PRELIMINARY COMMENTS FROM GEOFF RADLEY (DEFRA)

There have been concerns about the current schemes, particularly with reference to their administrative complexity and their effectiveness. The Curry report recommended that existing schemes be maintained and broad and shallow schemes introduced.

It is likely that a narrow and deep approach will continue to run, though ESA and CSS might not continue to run as such, but might be combined – particularly to build in a framework for rewarding existing good stewardship.

It is also likely that a broad and shallow scheme will be developed. This should be simpler to set up and simpler to ensure compliance.

Monitoring will be required to ensure that the schemes are effective.

The Biodiversity Action Plan (BAP) is likely to play a key role in the new monitoring program; because BAP wasn't in existence when the previous monitoring program was set up, it is difficult to assess how current schemes contribute to BAP targets.

The new monitoring programme should be carefully designed to answer the pertinent questions. Also, it should fit in around timescales and reports and should feedback into existing management. Ideally monitoring methods should be simple enough to be used to provide site by site feedback and inform decisions by project officers.

3.2 DISCUSSION GROUPS

Because of the uncertainty about the type of AE schemes that might exist in the future, the four discussion topics in the Workshop Briefing Document were amended. Instead, each of three discussion groups was given one of the following topics:

- Re-establishment of Priority or Broad Habitat
- Rehabilitation (= restoration) of Priority Habitat or improvement of Broad Habitat
- Maintenance of Priority or Broad Habitat

It was suggested that each group discussed some or all of the following points:

- How should stock and condition be measured?
- How should change over time be measured?
- How can the drivers of change be determined?

Discussion groups were also asked to consider one or all of the following general habitat types:

- Lowland grasslands
- Upland habitats
- Arable and linear habitats

3.3 RE-ESTABLISHMENT OF PRIORITY OR BROAD HABITAT

chair: *Jonathan Mitchley (IC).*
rapporteur: *Sarah Gardner (ADAS)*

It was considered that re-establishment of Priority or Broad Habitat would be a relatively small part of the agri-environment scheme and that to obtain random, representative samples would be difficult. It would be sufficient for monitoring to take place on a case study basis.

How should stock and condition be measured?

Since the habitat would inevitably be in poor condition, it was felt that there was no need to monitor stock and condition.

How should change over time be measured?

The outcomes of the restoration are likely to be variable. A monitoring tool that would determine whether a site is suitable for restoration prior to treatment being applied, would be valuable. It would also be useful to have a decision tree/tool to assist analysis of the outcome, not just in terms of BAP targets, but also in terms of other elements of biodiversity.

Because restoration work would probably involve a considerable amount of intervention, and change is likely to be rapid, it was felt that the Rapid Condition Assessment (RCA) approach might be all that is necessary. JNCC categories, however, are currently too crude; categories should be added so that, for instance, 'unfavourable but improving' sites might be recognised. As time progresses, the rate of change might slow down. It was suggested that, at this point, collection of data at a quadrat scale might be required in order to detect smaller scale changes. The data should be disaggregated so that progress against different objectives can be assessed.

How can the drivers of change be determined?

The attributes that determine whether a site is favourable or unfavourable should be linked with drivers of change e.g. grazing pressure, nutrient levels.

Discussion

- The restoration sites might, in fact, be the most appropriate sites at which to carry out detailed quadrat scale monitoring. The results might help to understand processes and the link with environmental data and so assist in future site selection.

Alternatively, this sort of detailed monitoring might be better suited to specific experiments.

- Each site should have an individual, specific target.

3.4 REHABILITATION (= RESTORATION) OF PRIORITY HABITAT OR IMPROVEMENT OF BROAD HABITAT

chair: *Nigel Critchley (ADAS).*
rapporteur: *Lisa Norton (CEH)*

How should stock and condition be measured?

There appears to be difficulty in measuring stock, as a random sample would inevitably miss many BAP habitats, and it would be useful to know how many BAP sites there are. Also, there is a need to identify the type of habitat that has the potential to become a BAP habitat. An inventory of all sites is possibly required, though this would be time consuming.

RCA methods might be appropriate to get an initial handle on condition, though RCA should be validated using quadrat data.

How should change over time be measured?

RCA and quadrat data could both be used; quadrat data are more useful for long term monitoring. The data should be disaggregated. RCA needs to be developed to include more habitats as most of the habitats currently in the scheme are not Priority habitats.

Along with BAP targets it would be good to have some more general conservation oriented targets.

RCA data could be linked with compliance data e.g. spring sowing of arable crops.

Results from the monitoring should be fed back into the scheme if possible, to influence future management.

How can the drivers of change be determined?

Methods of collecting management information from farmers should be carefully considered in order to ensure the data are usable, standardised and relatively easy to collect.

Soil data should also be collected.

Discussion

- Results should not be fed back into the scheme as then there is a danger of the monitoring driving the scheme rather than assessing it. The results could become biased.
- Currently farmers receive about two visits in ten years. Some sort of training which would help farmers understand conservation processes and aims could be

incorporated into the scheme. This might make them feel more actively involved and interested in the outcome.

- It would be useful to get at least a small amount of information from every site.

3.5 MAINTENANCE OF PRIORITY OR BROAD HABITAT

chair: *Les Firbank (CEH).*
rapporteur: *Francis Kirkham (ADAS)*

How should stock and condition be measured?

Extent and quality of the habitat need to be measured. Site management data should be collected and judgements made as to whether the land is in an appropriate agreement tier.

How should change over time be measured?

It is hoped that, on these sites, changes would not take place, or if they did, they would be improvements and probably minor. Monitoring is required to ensure that sites are not degrading, although by the time changes are detected, it might be too late to reverse the process. Indicator species (not necessarily botanical) need to be identified which will help detect early signs of degradation. Farmers could become more involved with assessing the condition, recognising these indicator species and then have more input into management decisions. Management should be tailored to individual sites and this could be based on outcome (e.g. sward height) rather than stocking rate

Change could also be monitored on a more formal basis. The data should be disaggregated so that they remain useful if the aims of the scheme change. RCA methods could be used in order to collect a lot of data quickly, though it is argued that the collection of data at a quadrat level takes no longer than RCA and that it is difficult to collect disaggregated RCA data. If RCA is used, the thresholds have to be very carefully considered. Although the existing monitoring programme using quadrat data has not detected much change, it has been useful in identifying vulnerable habitats.

How can the drivers of change be determined?

We do need to understand what the drivers of change are, and so we need to collect or obtain environmental data. In some cases we may have little or no control over the changes (e.g. atmospheric pollution), whilst in others (e.g. management data) we may be able to use the information to affect policy.

Discussion

- It might be useful to collect other quantitative data as well as species composition, (e.g. bare ground).

- Data should be collected at a wide range of scales.

3.6 OVERALL DISCUSSION

- RCA and quadrat data can take a similar length of time in the field; travel to a site is often the biggest cost. RCA takes a long time to develop to ensure indicators, thresholds and objectives are appropriate. Quadrat data can take a long time to analyse. It is not really known as yet whether a RCA method could be developed which is effective and cheap.

- Modelling tools could be developed using existing and future data, though this could be costly. Management data would be needed for this, although management data can of variable quality. Farmers could be compelled to keep standardised management data as part of the scheme requirements, but this is unlikely to be successful.

- We need to use existing data to confirm and improve our knowledge of indicator species e.g. *Prunella vulgaris* indicates a site might be suitable for restoration.

- The new monitoring scheme should fully exploit existing data.

4 ATTENDEES:

i) consortium

Andy Parkin, Nigel Critchley, Sarah Gardner, Francis Kirkham, John Fowbert & Helen Adamson (ADAS)

(Peter Carey – n/a), Les Firbank, Lisa Norton, Colin Barr & Roger Cummins (CEH)

Jonathan Mitchley & Frances Burch (Imperial College)

ii) DEFRA

Alan Hooper, Iain Diack, Andrea Turner, Andrew Cooke, David Glaves, (DEFRA Rural Development Service)

Geoff Radley, Paul Smith, Mark Baylis (DEFRA Conservation Management Division)

Deborah Jackson (DEFRA European Wildlife Division)

iii) others

Kevin Austin (WAGARAD)

Joanna Drewitt (SEERAD)

Heather Robertson (EN)

John Harvey (NT)