COUNTRYSIDE INFORMATION FOR POLICY

THE LESSONS FROM CS2000

CS2000 REVIEW REPORT

A report on behalf of DEFRA and CEH, NERC

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London

January 3rd 2003

EXECUTIVE SUMMARY

CS2000 outputs and achievements

Completion of Countryside Survey (CS2000) provides results for the fourth national survey of the countryside in Great Britain, and makes available an important new information source for policy support. In terms of methodology and data, it also represents an important advance on previous surveys.

- The field survey is based on an extended set of sample squares, with additional sampling in upland areas in England and Wales.
- For the first time, data for Northern Ireland have been integrated with data from Great Britain, based on a complementary survey.
- Detailed data are also provided for the first time on riverine and freshwater habitats (hydromorphology).
- A wide range of measures of habitat condition is reported, in addition to data on habitat extent.
- In order to facilitate use of the CS2000 data for policy, data are reported for Broad Habitats.
- A new land cover map has also been completed (LCM2000), using satellite imagery; classification methods have been improved since the survey in 1990, but as a result direct comparisons with the previous, Land Cover Map of Great Britain have not been carried out.
- Standard reporting is provided for seven Environmental Zones covering Great Britain and Northern Ireland, as well as by country.
- In order to allow analysis of changes in soil conditions, 258 sample squares, originally surveyed in 1978, were resampled for soil analysis.
- CS2000 data are being made available in summary form, via a published report and the CS2000 Web site, as data sets within the Countryside Information System, and on a service basis in a customised form from CEH.

Technical and scientific issues

In order to ensure consistency with previous surveys, CS2000 was based on a similar survey design and methodology. Several important enhancements were, however, made compared to earlier surveys. Experience from CS2000 also demonstrates that scope exists for further improvements if future Surveys are to meet changing policy priorities and needs.

- The adoption of Broad Habitats as basic reporting classes has helped to strengthen the link between CS2000 and national policy on biodiversity. Many other habitat and land cover classifications are, however, used for policy and management purposes in the countryside, and difficulties in translating CS2000 data into these may inhibit its use in some areas of policy.

- The sampling framework and stratification system used in the field survey determine to a large extent the spatial resolution and accuracy of the data available from CS2000. Though these are appropriate for reporting at the national scale, pressures are developing to produce data at more regional or local scales, and for their own zone systems. In most cases, the current survey design cannot produce reliable data at these scales. This acts to limit the range of active users.
- Timeliness is a major factor in determining the utility of Countryside Survey data for policy support. On the one hand, the cost of surveys and the slow rate of change of many features of the countryside mean that intervals between surveys need to be relatively long; on the other hand, many policy applications need up-to-date data (comparable to that available on other policy-related factors).
- The value of Countryside Survey has increased more than proportionately as the length of the time series of data has increased: with completion of CS2000 the Survey has now achieved a critical mass that ensures its utility for policy support.
- Consistency and continuity of the time series data are essential if they are to be used to detect changes and trends. This has been achieved with the field data, over the last three Surveys; the same degree of consistency has not yet been attained, however, in the land cover mapping.
- For many applications, there is the need to link CS data to a wide range of other data sets, including information on management, and habitat data based on different classification systems. GIS techniques make these types of analysis increasingly feasible, but many users would prefer to have a ready-made package of integrated data sets.
- For many applications there is also a need to be able to reanalyse the data from the sample field squares. Limitations on access to these data are likely to inhibit the use CS2000, especially for exploratory analysis.

CS2000 in support of policy

Biodiversity

CS2000 provides a valuable source of information on the extent and condition of Broad Habitats, that can be used to help inform the development of Broad Habitat Statements and provide context for Priority Habitat Action Plans

- In general, CS2000 works well as a source of information for the Biodiversity Action Plan (BAP) at the national level. In particular, it provides a useful baseline for characterisation and assessment of change in Broad Habitats. Its use to monitor priority habitat plans, however, is inevitably limited by its spatial scale. There is also preliminary evidence from the FOCUS study that these rare habitats are not well represented in the CS2000 data set. Further analysis and research is therefore needed to develop and explore methods for monitoring key habitats.
- The time interval between surveys is long compared to the target dates for many actions in the national habitat priority and species plans; additional, purpose-designed monitoring and survey will therefore be necessary.
- The sampling density of the field survey, and the spatial resolution of data derived from it, limits its use for informing and monitoring local action plans; CS2000 does,

however, provide important contextual information, showing for example the extent to which local conditions and trends are representative of the national picture.

- Opportunities also exist to link CS data to other relevant data sets (e.g. Environmental Change Network, SSSI condition, National Biodiversity Network, habitat inventories, breeding bird survey, mammal monitoring, Plant Atlas), as a basis for monitoring and assessment of the BAP.

Sustainable agriculture

Policies on sustainable agriculture represent an important force for change in the countryside; CS2000 represents a useful source of information on the effects of these policies at national and regional scale, but data from Countryside Survey need to be linked to other data, and supported by other, more targeted monitoring, to provide the information needed to support these policies.

- Agri-environment schemes represent some of the main instruments for implementation of policies on sustainable agriculture; CS2000 cannot provide reliable information on individual areas or schemes, but the impacts of such schemes will inevitably contribute to changes detected by CS at the national level.
- Adoption of 'broad-and-shallow' entry-level agri-environment schemes would greatly extend the area of agricultural land under positive environmental management and will increase the need for (and range of) monitoring. Countryside Survey will provide an important baseline against which to assess impacts of these schemes, and should also provide a framework within which to design monitoring programmes and interpret their results. Future Countryside Surveys should become recipients of, and provide a framework for integrating, data from these purpose-designed monitoring systems.
- Important changes in habitat extent and, particularly, condition are occurring in more intensively farmed areas, and these are likely to continue in the future. CS2000 can provide valuable information on some of these changes, especially in those micro-habitats (e.g. hedgerows and cereal field margins) that have been targeted for special attention.
- Some farmed areas (e.g. marginal uplands, wetlands) are important as sentinels of change in agricultural environments because they are especially vulnerable to economic effects. CS2000 does provide valuable baseline information on some of these sentinel areas, but the sampling density of the field data limit their ability to detect regional or local changes.
- Linkage of CS data to other data sets, including management information (e.g. from the agricultural census, pesticide data and agri-environment scheme data) and data from the Environmental Change Network, is vital to help interpret and explain changes in farmed landscapes under policies of sustainable agriculture. More detailed, purpose-designed monitoring should be undertaken in key areas and habitats to supplement the information available from Countryside Survey.

Water management

The Water Framework Directive will have important implications for management and monitoring of the countryside in the UK, and will focus attention on the catchment as a key *management and reporting unit.*

- The more detailed and extensive information on riverine and freshwater habitats included in CS2000 means that it will provide an important source of baseline data for implementation and monitoring of the Directive; adoption of the Directive also highlights the need to maintain (and if possible expand) this element of the Survey in future years.
- CS can also provide a valuable higher-level scale of analysis on the impacts of the Directive, though to do so there will be a need to ensure that data from catchment monitoring can be linked to, or fed into, the CS framework. One way of facilitating this would be to provide catchment boundaries as part of the Countryside Information System (CIS).
- Countryside Surveys should become clients for data from this catchment-level monitoring and be seen as a means by which to integrate the data with other information on the countryside.

Soil protection

Adoption of a national Soil Protection Strategy would increase the relevance of soil-related information in Countryside Survey and add an important new area of application.

- Soil data, and measures of vegetation condition, collected and reported by CS2000 already provide a valuable source of information to help develop and implement this Strategy.
- Although some extension of these elements of the Survey might be worthwhile in the future, to help support the Strategy, it is important not to stretch the scope of CS too far. The main contribution of Countryside Survey should thus be as a way of complementing purpose-designed monitoring carried out as part of the Strategy. To enable this, there is a need to improve access to, and linkage with, national soil survey data (e.g. within CIS).

Urban development

Urban development exerts important pressures on the countryside. CS2000 should be able to provide useful information on these impacts, but its ability to do so is limited to some extent by the spatial resolution of the data and the survey design.

- The ability of CS2000 to provide data on pressures from urban expansion and its impacts on the countryside is limited by the way in which core urban areas are excluded from the field survey and the limited discrimination of urban areas in the land cover map: understanding of changes in core urban areas are essential in order to understand developments and pressures both in the urban fringe and beyond.
- Greater discrimination of urban land classes as part of the land cover mapping would provide a cost-effective way of improving data on the urban environment. Closer linkage to the Use Change Statistics (LUCS) and National Land Use Database (NLUD) would also strengthen these data.
- More attention also needs to be given in analysing CS data to the peri-urban environment, since this represents an area of especially complex and rapid change.

Environmental pollution

Environmental pollution is a key driver for policy in the UK, and an important source of pressure on the countryside. CS2000 provides valuable data on some of these impacts, but many are local and subtle, so that the capability of CS2000 to quantify pollution effects is inevitably limited.

- Measures of habitat condition, and data from the survey of soils, are especially valuable in indicating broad-scale effects of pollution, and have already shown that eutrophication is a growing problem in some habitats.
- Countryside Survey also provides important inputs to modelling of the impacts of environmental pollution (e.g. acidification). Closer linkage is needed with other pollution-related data (e.g. on source activities, emissions and atmospheric concentrations) in order to enhance the utility of CS data for pollution monitoring and modelling. More intensive monitoring of pollutant loads in the countryside, stratified to match the CS habitats, would also be useful.

Climate change

The extensive and long-term nature of climate change means that it is especially suited to analysis using information from broad-scale, longitudinal surveys like Countryside Survey. Whilst CS2000 has only limited capability to detect change, or attribute changes specifically to climatic effects, it does provide important inputs to climate change modelling.

- Many of the effects of climate change are subtle and slow, and often dwarfed or diluted by other developments in the countryside. CS data alone, therefore, cannot define or quantify these effects. It does, however, provide an important means by which to scale up results from more detailed field studies (e.g. via ECN), and a valuable source of data for climate change effect modelling. This application of CS data is likely to increase as the spatial resolution of these models increases.

Policy analysis

Analysis of policy requires the ability both to identify and attribute changes resulting from existing (or past) policies, and predict future policy impacts.

- CS2000 provides a valuable (and in many cases unique) source of data as inputs to models and for analysis of policy and countryside change scenarios. To date, however, use of CS data in these ways has been limited and more effort is needed to develop these types of application.
- Data from Countryside Survey can help to calibrate and validate models by methods of now- and hind-casting. This is a potentially valuable area of application, for there is a widespread need to improve testing and assessment of environmental models. Again, however, only limited attempts have been made to use the data in these ways, and further encouragement needs to be given to developing the relevant data sets and research tools.
- Attribution of policy effects on the basis of aggregate data, such as that from CS2000, is difficult due to the complex and confounded nature of relationships between policy and the countryside. Interpreting national (or broad regional) changes in the countryside in terms of specific policies is therefore potentially

misleading. Scope does exist, however, to use CS data as a way of scaling up results from more detailed and controlled field studies, and then corroborating the results as far as possible by analysis of national trends.

Policy implementation and habitat management

Habitat management is a vital means of implementing policies and has direct effects on the state of the countryside. Good habitat management depends upon having reliable, up-to-date and detailed information on habitat condition and trends.

- The spatial scale and resolution, and reporting frequency of CS data mean that they will only rarely be appropriate for management support at the site or local level.
- They do, however, provide important contextual and strategic information, showing the extent to which the local situation is typical of the national picture. They may also help to identify problems and trends which, whilst operating at the local level, are not readily apparent to managers at that scale.
- In future, Countryside Survey could usefully draw more extensively upon local-scale management data, as a way of supplement information from the national-level survey.

Providing indicators for policy

Indicators are an increasingly important tool for policy support, but designing effective indicators is difficult. CS2000 is a potentially valuable source of data for the construction of indicators on the countryside, though relatively few countryside indicators based on CS data have yet been developed.

- Indicators are transient measures, that change in response to changes in policy priorities. CS2000 provides a wealth of policy-relevant data and can thus be used to help develop indicators, but should not become driven by this need, since this might lead to loss of continuity and consistency in Countryside Survey.
- Until recently, the ability of Countryside Survey to provide a basis for indicators was limited by the few available data points within the time series; with the completion of CS2000 this constraint has been relieved to some extent, for a relatively long time series of data is now available. Nevertheless, lack of direct comparability between the surveys to date, and the long time interval between successive surveys, still inhibit its use as a basis for developing trend indicators.
- Countryside Survey can provide reasonable robust estimates of change in the countryside, but the sensitivity of the data is limited by the spatial resolution and sampling intensity of the field data, and by the relatively long time intervals between surveys.

A basis for research

Countryside Survey already provides an important basis for research in the UK, and has made a significant contribution to research in a range of areas. The core research community is, however, small and efforts are needed to encourage – and gain benefit from – a wider body of advanced research.

- A growing body of CS-related research is being undertaken, and CS data are increasingly being used for many different applications, some of them far removed from the main focus of Countryside Survey.
- Researchers nevertheless cite a number of obstacles to developing such studies, amongst which problems of access to the detailed, sample square field data are one of the most intractable.
- More important in the long-term, however, is the limited scope to obtain funding for CS-related research, outside the core Countryside Survey programme.

Key issues and recommendations

Future Countryside Surveys

The great strength of Countryside Survey is that it is a rigorous, well-established, longitudinal survey which has achieved considerable coherence and consistency. Pressures to change come both from changing policy demands and from advances in survey methodology and science. Changes, however, should only be made if they improve the quality and relevance of the data provided by the Survey and maintain consistency with past data.

- Countryside Survey is recognised as a leader of its kind, and its value as a source of support to policy is increasing with each new survey. It should therefore be continued.
- A survey interval of ca. 8 years is appropriate given the rates and magnitude of change in the countryside and the logistical considerations of cost, staffing and training.
- More time needs to be available for each survey, in order to give greater capability to deal with short-term problems (e.g. weather) that might restrict fieldwork or the availability of satellite data.
- The next survey should thus start no later than summer 2005, and report no later than summer 2008.
- To plan for this extended survey period (and to avoid possibilities of bias or distortion of the results) a detailed timetable for the Survey needs to be developed in advanced, and adhered to.
- Key issues that require early reporting of 'headline' results need to be identified at the start of the Survey, so that data analysis can be prioritised accordingly.
- Analytical techniques need to be developed, tested and programmed well in advance of the Survey in order to ensure that data processing and analysis proceed efficiently.

The field survey

Regionalisation of policy, the development of new policies and growing concerns about threatened and sensitive habitats are all increasing the demand for more localised information on the countryside. The field Survey needs to be developed to respond to these.

- No major changes to the field survey should be envisaged, though a limited expansion of the sample size is possible, focused in areas of especial policy interest or where the current survey design provides inadequate coverage (e.g. peri-urban areas, coastal areas, sentinel habitats).

- Methods for making more localised estimates of habitat pattern and condition (e.g. using spatial modelling techniques) need to be investigated as a basis for providing more regionalised data.

The land cover map

The national land cover maps provide valuable sources of information, that are used not only to support countryside policy but also policy and research in many other areas.

- Data from LCM2000 need to be matched to data from the 1990 Land Cover Map of Great Britain, in order to allow analysis of change in land cover between the two surveys.
- Future land cover surveys will need to respond to changes in satellite technologies and techniques for image analysis, but must maintain continuity with the past. Any technological changes must therefore be assessed in terms of their effects not only on data quality, but also data comparability.
- Even if survey techniques are kept consistent, difficulties will inevitably occur in attempting to derive estimates of change by comparing pairs of land cover maps, each with their own inherent uncertainties. Further research is needed into the statistical techniques needed to make such comparisons, in the presence of complex, spatially structured error and uncertainty.
- Growing demands for land cover data are occurring, from many different areas of application. It is unlikely to be cost-effective to serve these varied needs by producing separate land cover maps, so attempts need to be made to develop a co-ordinated national programme of land cover mapping, meeting the needs of all these users. The National Land Use Database (NLUD) represents an important instrument in this contest. Close co-ordination with NLUD, and through that with the wider body of users, needs to be ensured in planning g the next Countryside Survey.

Data linkage and integration of monitoring activities

The value of CS data is greatly enhanced through their linkage with other data sets. The ability to use CS data in these ways is, however, still limited by the lack of common methods and data formats between different surveys and sources.

- The importance of data linkage is not only to increase the value of CS data, but also to encourage the use of CS as a template and framework for data co-ordination, and to allow CS to draw upon local and more site-specific monitoring.
- Important areas in which improved linkage and harmonisation of monitoring would be beneficial include: agricultural land use, soils, phase 1 survey, Plantlife common plants survey, designated areas, areas under agri-environment schemes, ESAs, surface and ground water quality, ECN sites, agricultural land capability/suitability, structural fund boundaries (objective 5b/2; LFAs etc), environmental pollution, population census, archaeological features.

- Improved data linkage and comparability can, in part, be achieved by improving metadata and development of better data standards by the various data holders.
- The most important need, however, is to improve co-operation between the various organisations responsible for these and other monitoring programmes in the UK. Steps should therefore be taken in advance of the next Survey to negotiate closer collaboration and procedures for data exchange with as wide a range of data providers as possible.
- Close links need to be established and maintained with other data collection and monitoring initiatives, both in the UK and the EU more widely. Close partnership with NLUD, especially, is essential to co-ordinate developments on land cover and land use data in the UK. In the EU, the Global Monitoring for Environment and Security (GMES) programme is likely to be an important force (and source of funding) for future monitoring activities.

Access to the sample field square data

Problems of access to relevant data sets remains a problem in some areas. For many users, difficulties of access to the raw data for the sample field squares are the main deterrent to use of CS2000.

- There is a need to review and attempt to address the issues and concerns that currently restrict access to the field data.
- CIS provides an important means of 'entry-level' access to CS data for many users. Further development of CIS would provide one means of enhancing data linkage (e.g. by providing an integrated CS 'data package'). Continued development and free dissemination of CIS is also essential to facilitate access to CS data.
- For more advanced users (e.g. those from a research background), however, it would be more useful to provide CS and other data in a GIS-compatible format, so that they can be analysed according to need.
- The most important functionality of CIS is its ability to provide regional estimates based on the field sample squares, without jeopardising their security. Consideration needs to be given to developing a 'GIS add-on' (e.g. in VBA and Avenue) with this capability, that could be run from within proprietary GIS.

Meeting users' needs

The core set of CS users remains small, and further expansion of the user base is necessary, both to achieve the full potential of Countryside Survey, and to ensure long-term support for the Survey. This implies that users are both made more aware of Countryside Survey and what it can do, and encouraged to be take part in planning the next Survey.

- CIS needs to be seen as an important means of winning new users to Countryside Survey, and its wider dissemination (and upkeep) needs to be seen as a priority.
- Training in the use of CIS specifically (and CS more generally) needs to be offered to prospective users.
- Roadshows and regional seminars should be set up early in the planning stage for the next Survey to raise awareness about Countryside Survey and to open up

debate about how future surveys can best meet user needs.

Survey management

No major changes in the funding or management of the Survey need to be seen, though devolution, new policy needs and the growing user base all mean that some changes will be required and a wider range of sponsorship needs to be prepared for. Early planning is also essential in order to ensure that the next Survey keeps pace with the changing needs of users and the available technologies.

- A user forum needs to be established as early as possible, in order to gain a fuller understanding of user needs, and feed these into plans for the next Survey. A wider range of users might also be represented on the Steering Group, and provide sponsorship, as a result.
- A simpler modular structure would be beneficial for the next Survey, in order to provide better integration of the key survey elements (field survey, land cover mapping, data analysis and reporting). Supporting projects should be identified where appropriate, but should be co-ordinated by the leader of the module that they are intended to serve.
- In order to ensure that future Surveys maintain a clear and consistent focus, whilst at the same time allowing wider sponsorship and user involvement, the aims and purpose of CS should be reviewed and restated by the current Joint Management Team.
- Scope to extend the Survey into Europe, and to attract European funding for future surveys need to be recognised. The Global Monitoring for Environment and Security (GMES) programme, currently being developed by the Research Directorate of the European Commission, has particular relevance to Countryside Survey, and liaison with the GMES Steering Group should be established as a priority

Research

CS data are increasingly being used to support research in the UK: for example, as inputs to broad-scale environmental models, as a source of data for model calibration and validation, and as a basis for geographical stratification. Countryside Survey also draws heavily upon research developments from a wide range of disciplines, including environmental science, ecology, geography, statistics and social sciences. Closer synergies need to be developed, however, between the CS and research communities in order to maximise the research benefits.

- Research is needed into survey and analytical methodologies (e.g. for assessing landscape quality, small-area spatial modelling of habitat extent, modelling uncertainty), to investigate patterns and trends in the countryside using CS data and to analyse policy and land use effects. There is also a need for research to assess the cost-benefit or cost-effectiveness of CS2000.
- A NERC-funded research programme needs to be established to help develop new ways of analysing CS2000 data, and to explore new applications. Joint research projects between academia and users should be encouraged to ensure the policy relevance of the research.
- In order to capture and bring together the results of research more effectively,

consideration should be given to establishing a CS data archive (like that run by ESRC), as a repository for research findings and derived data sets.

Contents

1. INTRODUCTION

Publication of the synthesis report, *Accounting for Nature* (Haines Young *et al* 2000), in November 2000 and of the Land Cover Map 2000 in October 2001, represented a further milestone in Countryside Survey in the UK. Following similar field studies in 1978, 1984 and 1990, Countryside Survey 2000 (CS2000) is the fourth national survey of the state of the countryside in Great Britain (and the first to incorporate data on Northern Ireland). It also provides the second satellite-derived land cover map of the country, in succession to that produced as part of the 1990 survey.

Against a background of changing policy on the countryside, and a range of both short-and long-term pressures on the rural environment, the data made available by CS2000 have enormous value in support of both policy and research. In recent years, however, there has been growing awareness that data sources such as these are not always used as effectively or as intensively as might be expected. Many different obstacles and deterrents appear to exist – some relating to the data themselves, others to the needs and limitations of potential users (Briggs *et al.* 1996, 2001, Tantram 2002). Together, however, they imply that policy and management might not always be as well informed as they could be, and that the public investment made in collecting data is not always achieving its full return[1]. In the light of this, questions clearly need to be posed about how best to make use of CS2000 information, how to interpret and follow-up the results, and how to develop future monitoring of the countryside. The need for a closer dialogue between data providers, those who analyse and process the data (the 'information makers') and the ultimate users of the information is also implied, if the various obstacles that limit effective use of CS2000 are to be removed.

This report presents an attempt to initiate this dialogue. It provides an assessment of CS2000 from the perspective of users, and describes and discusses:

- the background to CS2000;
- the characteristics and quality of data deriving from CS2000, that might affect their use for policy and research applications;
- potential applications of CS2000 in relation to policy and research;
- implications for future countryside survey in the UK.

The report draws on several lines of evidence and enquiry, including: final reports from CS2000 modules (subject to availability); a series of interviews with users, undertaken as part of the co-ordinating function (module 16) of CS2000; a workshop on CS2000 (*Countryside Survey 2000: what next?*), held in Cambridge, on 10th-11th December 2001 (see Annex 1); and independent, published research into the factors influencing the use of countryside (and other land resource) information for policy.

[1] In order to improve this situation in relation to EU policy, the EU has established a series of projects, and an international forum, under the Global Monitoring for Environment and Security (GMES) Programme. This is aimed at identifying and addressing the scientific, technical and institutional issues that inhibit use of EO data for policy support. Results from this are due in late 2003, and should feed into debate about future countryside survey in the UK.

2. THE CS2000 PROCESS

2.1 Funding and management

Funding for CS2000 was provided by a consortium of partners, led by the Department of Environment Food and Rural Affairs (DEFRA) (formerly DETR) and the Natural Environment Research Council (NERC). Other sponsors were the Countryside Council for Wales (CCW), National Assembly for Wales (NAW), Environment Agency (EA), Scottish Executive, Scottish Natural Heritage (SNH) and the former MAFF. The total direct contribution from these sponsors amounted to ca. £4.5million.

To oversee the project, a Joint Management Team and an Advisory Group were established, comprising representatives from all the sponsors. Meetings of these groups were held regularly to review and comment on progress of the survey. On completion of the CS2000 survey, and compilation of preliminary results, a workshop was held to review the results and provide interpretative information for the summary report. To compile the summary report, an editorial group was then set up, including leaders of each of the contributory modules.

Users not represented on the Joint Management and Advisory Groups were consulted independently through a sub-project on policy implications and uses of CS2000. This involved contact with representatives from 25 organisations, including government departments, voluntary agencies and universities. Following completion of the Survey, and publication of the CS2000 summary report, a policy review workshop was held, attended by ca. 85 delegates, at which the outcomes were evaluated and discussed (Annex 1). Results from both the user survey and the policy review workshop are incorporated into this report.

2.2 Modules and survey structure

CS2000 comprises two main elements:

- a field survey, based on a sample of grid squares, providing data on land cover, habitats and species abundance;
- interpretation of satellite imagery, providing a national land cover map (LCM2000).

Work on the Survey was carried out through a series of modules led by the Centre for Ecology and Hydrology (CEH). In total, 17 modules were proposed, of which 15 were let. Contracts for these modules were awarded following assessment of invited bids from institutions or individuals.

The modules established to undertake the Survey are summarised in Table 1. Modules 1-6 comprised the field survey of sample squares in England, Wales and Scotland; modules 7 and 8 constituted the national land cover mapping programme; module 11 provided the link to the equivalent Northern Ireland survey; module 10 provided links with ongoing environmental monitoring; module 13 was responsible for developing and implementing an information strategy; module 14 reviewed drivers of countryside change; and module 16 was responsible for overall co-ordination of the project and liaison with users. An extra module (module 17) was added towards the end of the study. Entitled *Finding out causes and understanding significance* (FOCUS), this was aimed at carrying out the follow-up research and analysis needed to ensure effective interpretation and application of the results. Module 12 (*Links to monitoring of agri-environment schemes*) and module 15 (*Ecological processes of change*) were not let.

Table 1. CS2000 modules

No.	Module title	Aims	Methodology
1	Survey of broad habitats and landscape features	1. estimate the extent and distribution of widespread habitats in GB 2. characterise these habitats in terms of their land cover and botanical composition and assess changes in these characteristics; 3. derive indicators of sustainable development for the wider countryside; 4. provide accessible databases containing information about the state of the British countryside; 5. provide ground reference data for the calibration and validation of the Land Cover Map 2000	1. 569 1km grid squares surveyed 2. In each square, landscape features and land cover mapped 3. < 52 vegetation plots in each square surveyed (usually <30), and all higher plants and a restricted list of lower plants recorded
2	Survey of freshwater habitats	1. provide information on the status, distribution and recent changes in freshwater habitats in GB, including assessments of freshwater biota, river habitats and water chemistry 2. provide information on the status and distribution of the macro-invertebrate fauna of streams and rivers in GB. 3. determine and evaluate change by comparison with 1990 survey data relating to the same sites 4. determine the habitat structure and degree of modification of river corridors 5. undertake a limited diagnostic survey of the chemical character of watercourses to help interpret the results of macro-invertebrate and river habitat surveys 6. investigate the relationship between habitat quality and modification of river corridors, the ecological quality of the watercourse and the condition of the surrounding countryside 7. derive indicators of status and change in watercourse and river habitat quality	1. stream samples taken to assess water chemistry 2. macro-invertebrates used to provide environmental quality assessments through RIVPACS scores 3. River Habitat Surveys (RHS) to assess river corridor habitats
3	Survey of agricultural key habitats	1. provide data on the state of arable field margins 2. assess the performance of the Arable Incentive Scheme in delivering objectives of the Biodiversity Action Plan to enhance biodiversity in cereal field margins 3. monitor the state of hedgerows, as required by the Biodiversity Action Plan	1. 100 x 1 m strip of margin in all arable fields surveyed 2. detailed information gathered on woody components of hedgerows, as part of the survey of linear features

Table 1 (continued)

4	Survey of uplands in England and Wales	1. provide reliable information (including stock data) for upland broad habitats and landscape features in England and Wales 2. provide information on the ecological characteristics of the uplands as a whole in order to provide a context for site, habitat or scheme specific monitoring 3. provide information for environmental change modelling and forecasting studies 4. establish a baseline for future detection of long term change in the character of the uplands of England and Wales	1. selection and survey of additional sample grid squares in upland areas
5	Bird populations and environmental change	1. estimate abundance of breeding birds and generate database 2. qualitative descriptions of bird assemblages with Land Classes 3. preliminary analysis of associations between bird populations and landscape and habitat composition 4. identify key habitat and landscape variables accounting for bird abundance	1. 336 1km grid squares, visited twice in spring, 4 weeks apart 2. 4 transects, 200 m apart, in each 1km square walked 3. birds recorded in distance bands 0-15m, 25-100m and > 100m from transect line
6	Soil quality and pollution	1. identify and quantify soil meso-fauna and assess soil microbial diversity 2. analyse changes in soil pH and loss on ignition over the previous 20 years 3. analyse heavy metals and organic compounds to establish a large and robust national baseline for future sampling and analytical programmes 4. investigate regional patterns of nitrogen concentrations in heather leaves 5. compare these regional patterns with rates of atmospheric nitrogen deposition 6. assess the capability to use nitrogen concentrations in heather leaves as a marker for areas where excess nitrogen deposition is likely to trigger a decline in the heather communities	1. sampling of soils and heather leaves in sample plots 2. laboratory analysis of mesofauna, microbes, pH, loss-on-ignition, heavy metals and organic compounds in soils 3. laboratory analysis of nitrogen content of heather leaves

Table 1 (continued)

7	Land cover map 2000	1. compile a land cover map, based on satellite imagery, segmenting the UK landscape into land parcels, and recording the dominant land cover and a range of other attributes for each parcel 2. generate a raster-based GIS, recording land cover on a 25 m grid (similar to LCMGB) and summary 1 km data (% cover, dominant cover per 1 km square)	1. acquisition of images, matched as far as possible to the date of the field survey 2. image segmentation (creation of land parcels) 3. derivation of reflectance statistics for each parcel 4. acquisition of ground reference data to provide 'training data' for each target land cover class 5. extrapolation of training data using a maximum likelihood classifier to attach land cover classes to the land parcels 6. use of contextual information (e.g. terrain height or soil characteristics) to enhance classification accuracy
8	Airborne scanner applications	1. evaluate use of airborne remotely sensed data to measure the extent and spatial patterns of land cover, landscape features and widespread habitats 2. derive accurate height information to define slopes, runoff patterns, individual trees etc and help in the textural identification of semi-natural vegetation 3. assess the added value provided by airborne imagery, over satellite data, for surveys of the countryside 4. evaluate the accuracy of the methods and results, by comparison with ground-based reference data	1. pre-processing of LIDSAR 2. pre-processing of CASI imagery 3. image classification 4. knowledge-based correction of classified data
9	Localised results and their use in the development of indicators of countryside character and quality	1. explore, develop and test methods for integrating field survey and satellite-derived land cover data; 2. demonstrate and evaluate the methods against user requirements, particularly in relation to the development of indicators of countryside character and	1. analyse and explore data and results from CS2000; 2. consult with users; 3. liaise with other relevant projects, including the

		quality; 3. provide integrated estimates for land cover, landscape features and broad habitats at regional scale; 4. provide a pilot dataset of estimates of land cover and landscape features for England at a 1 km square resolution: 5. publish estimates of stock and change of land cover, landscape features and broad habitats for regions and local areas; 6. quantify and explain the sources of errors at a range of scales; 7. develop and evaluate measures of landscape pattern at a range of scales, in relation to the development of indicators of countryside character and quality. 8. provide estimates of extent and changes in land use, broad habitats and landscape features; 9. provide data in a form compatible with the National Landscape Typology Database; 10. undertake analysis of data arising from CS2000 for individual one km sample squares and develop and test simple and robust measures of changes in countryside character and quality for each square; 11. advise on the interpretation and use of these results and comparisons with other information on changes in countryside character; 12. advise on the interpretation of results and the aggregation to support the development of pilot and operational indicators of change in countryside character and quality; 13. participate in consultations, expert and stakeholder workshops and presentations to ensure that user requirements are identified, clearly understood and addressed; and 14. present the results in technical reports and concise non-technical summaries.	Indicators of Countryside Character and Quality project; 4. Maintain CS2000 Web site.

Table 1 (continued)

10	Environmental change network link	1. repeat monitoring of sample plots up to at least 1999 2. determine the relationship between annual fluctuations in vegetation and weather 3. assess the extent to which vegetation monitoring in CS2000 is affected by year to year variations in weather 4. review the protocols for monitoring vegetation at ECN sites with respect to applications in the Countryside Survey	1. recording vegetation annually at ECN sites before, during and after the CS2000 field survey 2. analysis of vegetation changes in relation to factors soil and air temperature and rainfall
11	Northern Ireland countryside survey link	1. co-ordinate links with the Northern Ireland countryside survey 2. ensure common reporting standards with CS2000	1. liaison with CS2000 project 2. calculation of results in CS2000 format
12	Links to monitoring of agri-environment schemes	Not completed as part of CS2000, but CS methods were used in Countryside Stewardship baseline monitoring in England and a comparison made with results of CS2000.	
13	Scientific support and information management	1. develop and implement a dissemination strategy 2. facilitate access to data derived from CS2000 and earlier surveys, advise about data characteristics and quality, and service *ad hoc* requests for data and analyses 3. design, implement and manage the CS2000 database 4. support the synthesis and dissemination of outputs from all CS2000 modules, via the Internet, the Countryside Information System, the National Biodiversity Network and the CS2000 Summary Report 5. provide assistance and advice to users of CS2000 data and provide CS2000 data to third parties	1. develop data standards and database design 2. develop and maintain CIS
14	Drivers of countryside change	1. review and analyse the social, economic and policy drivers affecting change in the countryside 2. shape DEFRA's long term research strategy in relation to the social, economic and policy drivers of countryside change	1. review of literature and experience on rural sustainability and countryside change, agriculture and forestry 2. consultation seminar for policy-makers, researchers and academics

Table 1 (continued)

15	Ecological processes of change	Not completed	
16	Programme co-ordination and policy liaison	1. provide co-ordination of the work programme 2. develop and promote common reporting approaches and standards for all CS2000 modules 3. liaise with policy customers and identify results of significance for countryside and wildlife policies 4. ensure that CS2000 is responsive to the changing policy agenda and user needs 5. develop awareness and promote use of CS2000 amongst the user community	1. CS2000 Steering Group 2. production and editing of CS2000 summary report 3. consultation with CS2000 users 4. organisation of an 'Away Day' to review CS2000 outputs 5. production of a CS2000 review report
17	Finding out causes and understanding significance (FOCUS)	1. analyse data arising from CS2000 in terms of ecological processes and land management effects, supported by other contextual data; 2. recommend improvements to survey protocols; 3. consult as necessary to ensure that user requirements are defined and addressed; 4. publish and disseminate the results; 5. maintain the CS2000 website and facilitate Internet publication	1. analysis of CS2000 data in relation to: 1. enclosed farmland; 2. boundary and linear features 3. woodlands 4. mountain, moor, heath and down 5. rivers, streams and standing water 6. developed land in rural areas 7. agri-environment schemes

2.2.1 *Field survey*

Like its predecessors, the field survey involved visits to a sample of grid squares, stratified on the basis of 40 previously defined land classes[2]. Each sample square was described and mapped in detail using standard ecological survey techniques. Both terrestrial habitats (modules 1, 3, 4) and, where they existed, freshwater habitats (module 2) were surveyed. In order to ensure better representation of upland habitats in England and Wales, additional sample squares were selected for CS2000, targeted at these areas (module 4). To provide

[2] This represents an increase from the 32 land classes used in the previous Countryside Surveys. The additional land classes were incorporated to create land classes for Scotland and to sub-divide one of the original land classes (17) which otherwise occupied almost half of Wales.

more specific information on the performance of actions taken to implement the Biodiversity Action Plan in field margins and hedgerows, survey plots were specifically established in the margins of cereal fields, and additional data gathered on woody species in hedgerows (module 3). Information was also collected on soils and nitrogen in heather leaves (module 6) as a basis for examining changes in soil conditions and the trends in acidification. A survey of breeding birds (module 5) was also carried out, through a separate survey of 336 squares.

Field surveys were undertaken between 1998 and 2000, during which a total of 569 sample squares were surveyed in Great Britain – 366 in England and Wales, and 203 in Scotland. This represents an increase in survey intensity compared with previous surveys: 508 squares were surveyed for CS1990, for example, and only 256 in 1978. 501 squares are, however, common to both the 1990 and 2000 surveys, and can thus be used to analyse change. In Northern Ireland (module 11), which was included for the first time, smaller sample squares (0.5 x 0.5 km) were used, to reflect the finer scale of landscape variation. In total, 628 squares were surveyed in Northern Ireland, representing 1.1% of each of the 23 land classes recognised in the province.

2.2.2 Land cover mapping

As in 1990, a land cover map was also compiled using satellite imagery, based on Landsat TM data (Module 7). Complete coverage of Great Britain using these data requires 49 scenes under ideal conditions: 49 were used to produce LCMGB 1990 (Fuller *et al.* 1994b). Poor weather during the survey period for LCM2000, however, meant that a total of 79 scenes were required. For 84% of the area, summer and winter images were available, which were combined as composites; for 6% winter-only coverage was available, and for 8% summer-only. Nor could images be obtained everywhere for the target survey period of 1998. In fact, only 23% of the UK could be mapped using images for this period; for 22% of the UK, therefore, data had to be supplemented by images from other years. The remainder of the UK (54%) used data entirely from other years. For 1% of the country, cloud cover meant that no usable imagery could be obtained; data for these areas was imputed from LCMGB 1990.

Unlike in 1990, mapping involved a parcel-based (image-segmentation) approach, in which the land is divided into discrete parcels, based on spectral data from the satellite images. To inform this process, ground reference data were collected for a sample of land parcels to provide 'training data', exemplifying the reflectances for each target land cover class, subclass or variant. The training data were then extrapolated, with a maximum likelihood classifier operating on the reflectance statistics per-parcel, to attach land cover classes to the land parcels. Contextual information, such as terrain height or soil characteristics, was used as necessary and as available to enhance classification accuracy. Field survey data were also used to calibrate and validate the LCM2000 database. This allowed for the removal of systematic errors in the satellite interpretation, using a retrospective weighting to correct the classification. The final classification delivers a standard list of 24 target land cover types, selected to allow assessments, as far as possible, of widespread Broad Habitat types. Module 8 explored the use of airborne imagery, derived from Casi and Lidar sensors, to support land cover mapping.

2.2.3 Other modules

Links to ongoing vegetation monitoring, as part of the Environmental Change Network (ECN), were effected through module 10. Following a pilot study, in 1997, two further surveys were undertaken in 1998 and 1999, to coincide with the CS2000 field survey. Surveys were undertaken in mid-June to late-August. On each occasion, ten ECN sites were studied, selected to represent a wide range of vegetation types, climatic conditions and land uses. Between 11 and 23 plots of 10 x 10 metres were recorded at each site, in each of which the presence of species was recorded in 10 randomly distributed 400 x 400 mm quadrats ('cells'). Based on the results, a series of vegetation indices were computed. Initially, the plan was to analyse associations between these measures of vegetation change and a number of potentially significant environmental variables including weather, soil moisture, air pollution and grazing. In the event, results were provided only for annual weather conditions (air temperature, soil temperature and rainfall), though even these showed only weak associations with changes in the measured vegetation scores.

In order to inform interpretation of CS2000 results, other factors potentially responsible for changes in the countryside were examined as part of module 14, through a combination of literature review and expert consultation. Key drivers were considered to be national and EU policies on sustainable development, agriculture and forestry.

Module 13 was responsible for developing and implementing an information strategy for CS2000. This included provision for access to the outputs through the Countryside Information System.

Overall co-ordination of CS2000 was carried out under module 16 which provided liaison with the sponsors and users, and conducted supporting studies to define policy needs, and to develop awareness about CS2000 amongst data providers and users.

2.3 Dissemination

Information about CS2000 and results of the survey have been disseminated in three main ways:

- on the CS2000 web site, in the summary report and via CS2000 Newsletters;
- in the Countryside Information System
- as customised data sets, by negotiation with CEH.

2.3.1 The Web site, summary report and newsletter

The first of these is likely to meet the needs of many users who require either information about the Survey itself, or national or regional data summaries (e.g. for inclusion in reports). The synthesis report, *Accounting for Nature* (Haines Young *et al.* 2000), for example, includes not only a description of the Countryside Survey methodology, but also summary data on the key Broad Habitats, and a preliminary interpretation of the findings. The CS2000 Website (http://www.cs.ac.uk/) provides on-line access to these and a wide range of other summary data. During development of CS2000, information was also made available via a CS2000 Newsletter. About 1400 copies of the last issue of the Newsletter were distributed to some 900 recipients. The mailing list includes staff of government departments (mainly DEFRA), academic researchers, Country Agency staff, NGOs, the private sector, landowners and other members of the public.

Recent statistics for the Web site (for the period 1st August 2001 to 15th July 2002) report an average of 102 visitor sessions per day. The main users are from education, government departments and offices, and research or consultancy organisations. The main downloads are of the synthesis report and issues of the newsletter, with fewer requests for module final reports or results tables (151 sets of results tables have been downloaded to date, though many of these may have been as part of the process of preparing reports on CS2000 – including this one). Common keywords and terms used to access the site include 'countryside', 'survey', 'land cover map 2000', 'satellite map UK', 'vegetation', 'freshwater habitats' and 'nitrogen pollution'. Generally, it appears that the site is used primarily to obtain information about the survey, rather than for the results themselves, suggesting that demand for the summary data on-line is as yet limited.

2.3.2 The Countryside Information System

The Countryside Information System (CIS) provides a flexible, purpose-designed and efficient system for manipulating CS data both geographically and statistically, at a base resolution of 1 km. Amongst other capabilities, it enables field- and satellite-data to be integrated with each other, and both to be combined with a wide range of other data sets (e.g. OS topographic data, soils, geology and boundaries of administrative and designated areas of various sorts). The system also provides statistical reports by land class and by specified region. CIS thus provides an easy-to-use system for relatively simple exploration, mapping and reporting of CS data, and a useful gateway to the 1km-aggregated data sets. It does not, however, provide access to the individual field survey squares, and thus cannot be used to model patterns or changes in the countryside, other than on the basis of the underlying land classes. Nor is access available to the source data for the many different data sets provided through CIS: 1 km is thus the finest possible spatial resolution that can be used within the system.

Dissemination and marketing of CIS has changed in recent years. Initially it was provided on a more-or-less commercial basis, with the consequence that the user base remained small. Many potential users interviewed as part of a user survey during 1998 cited the price as a major obstacle to its purchase. Since then, the purchase price has been greatly reduced, after which the number of users increased slightly. A continued increase in uptake may be expected now that data from CS2000 are becoming available in CIS-format (data sets can be downloaded free from the Web). The main users continue to be in education (universities and colleges make up about 50% of purchasers); government and countryside organisations make up most of the remainder.

2.3.3 Customised access and analysis

For more specialist analysis of CS data, users need to negotiate with the data-holders, via CEH. Access to the original sample square data will rarely be provided, since these data are classified as confidential, under the agreement of the landowners. CEH will, however, carry out specific analyses on a contract (or, where appropriate, a shared-cost) basis.

LCM2000 is also being distributed commercially and – for eligible organisations (e.g. universities and public agencies) – under a preferential-cost licence.

3. TECHNICAL AND SCIENTIFIC ISSUES

Many factors combine to influence the utility and use of policy-related information. Policy issues and priorities clearly shape information needs and act more indirectly to determine what monitoring is carried out. Institutional characteristics of both the provider and user organisations are, for example, important in determining factors such as data policies, pricing arrangements and access rights. Ultimately, however, it is the characteristics of the data themselves that define the extent to which, and way in which, they are used.

Several different data characteristics assume importance in this context. Their information content – i.e. the scope and type of information that can be derived from them – constrains the range of applications for which they can be used and their relevance for policy. The accuracy and, especially in the case of geographic data like those from Countryside Survey, their spatial resolution limit the scales over which they can be reliably applied. The timeliness of the data (including both the time period to which they relate and the length of the time series available) determines their immediacy and shapes the type of policy question that they can be used to address. The extent to which they can be combined with or linked to other data controls how well they will fit into the wider data strategy of the users. In assessing the potential utility of CS2000, and especially possible limitations on its use, each of these factors needs to be considered.

3.1 Information content

CS2000 provides a wide range of data in a variety of forms. These include both primary datasets and derived results. The major output is, of course, the database developed as a result of the Survey, for this provides the source of almost all other information. As these data are analysed, however, a range of secondary outputs is becoming available – and this will continue to expand as further analysis is undertaken either within CEH or by outside agencies. Table 2 lists the main primary data sets produced by CS2000, and Table 3 summarises the derived statistical outputs to date.

Several different classifications of vegetation, habitat and land cover are used in CS2000 either at the survey or reporting stage. These have particular importance, for they act as frameworks for analysis of many of the data. They also act as powerful determinants of the relevance and utility of the information for policy or management. They affect, in particular, the extent to which information can be shaped to match the needs of specific policy actions or targets, and the degree of 'fuzziness' inherent in the policy or management messages that CS can convey.

Problems of classification are generated by two, contradictory factors. On the one hand, many different habitat and land use or land cover classifications have been developed and adopted for policy and management purposes. Under the UK Biodiversity Action Plan, for example, both Broad Habitats and more detailed Priority Habitats are recognised, but a wide range of other typologies are employed in other areas of policy and management: for example, NVC, Phase 1 habitats and Habitats Directive Annex 1 habitats. In addition, classifications such as the Countryside Agency's and English Nature's Countryside Character and Natural Areas provide further categorisations. These different typologies create different demands in terms of data reporting and aggregation. On the other hand, monitoring is conditioned by the classes and categories that can readily and reliably be recognised on the ground (or from space or the air). In the case of field survey, this is dependent to large extent on the local-scale visible structure and composition of the vegetation and terrain. In terms of air- or space-borne systems, much depends on the spectral emission characteristics of the vegetation and the spectral resolution of the sensors used to detect them.

Many different classifications and typologies are inherent in Countryside Survey. The stratification used to define the field sample squares, for example, is based on the 'ITE land classes' – 40 classes, defined using a statistical clustering routine on the basis of mainly physiographic features, such as altitude, latitude, longitude and climate (Bunce *et al*. 1996a, b). In the field, detailed vegetation classes are used to define and code the sample sites. Based on their species composition, the surveyed plots can also be translated into eight *aggregate classes* (general vegetation types based on the Countryside Vegetation System (Bunce *et al*. 1999). For reporting purposes, land areas are defined in relation to the *Broad Habitats*, as specified within the Biodiversity

Table 2. Primary CS2000 data sets

Spatial structure	Description	Methodology	Data content
Land cover – satellite data			
Land cover classes	Digital boundaries and attributes of 24 land cover classes	Derived from analysis of multi-spectral Landsat TM data (NB Land cover data are also reported as part of the vegetation survey – see below)	Land cover type: • *dominant class*; • *alternative class*; • *heterogeneity* (%); • *past class (%)*; Parcel area Boundary length Vegetation indices per summer and winter image Contextual information - soil type, terrain height
Soils			
Grid cells	Soil properties	3 soil cores taken at up to 5 sites associated with main vegetation plots within each of 256 1 km squares	Soil fauna, microbial activity, organic pollutants, heavy metals, pH, loss-on-ignition
Land cover – field survey			
Boundary features	All boundaries except where part or within the canopy of woodland	Features were drawn on mapping sheets and recorded using several major and minor codes to build up a detailed description. Areas and length were digitised in the lab using GIS	Land cover class, species, feature-type, management, condition
Physio-graphic features	Natural features – including lakes, ponds and ditches, un-vegetated shore, cliffs, scree and surface rocks	Features were drawn on mapping sheets and recorded using several major and minor codes to build up a detailed description. Areas and length were digitised in the lab using GIS	Primary land cover class, species present, management, condition
Structures, buildings and communicat-ions	Features associated with built and communication structures (includes building, gardens, amenity grass > 1 ha, car parks, industrial, residential, and mining, railways, roads, tracks and footpaths).	Features were drawn on mapping sheets and recorded using several major and minor codes to build up a detailed description. Areas and length were digitised in the lab using GIS	Primary land cover class, species present, management, condition

Table 2 (continued)

Forestry and woodland features	Woodland units (ranging from a single sapling to a forestry plantation).	Features were drawn on mapping sheets and recorded using several major and minor codes to build up a detailed description. Areas and length were digitised in the lab using GIS	Woodland type (e.g. individual tree, lines of trees, patch of scrub, woodland), species, age, coverage, management and feature type
Arable features	Includes most of the ground cover types in Great Britain except urban and woodland (includes semi-natural and arable cover types).	Features were drawn on mapping sheets and recorded using several major and minor codes to build up a detailed description. Areas and length were digitised in the lab using GIS	Primary land cover class, species present, management, condition
Vegetation survey			
Random plots	200m square nested plots in larger areas of open land in the 1 km survey square	5 14m x 14m plots were located at random within 5 equal-sized sectors of the 1 km square. If they fell on a linear feature, they were relocated	All vascular plant species and cover
Habitat plots	Plots were placed in semi-natural habitats not covered by the larger Random plots	5 2m x 2m plots were placed in 5 different land cover type not represented in the Random plots. Where fewer than 5 were available they were placed according to size of existing types.	All vascular plant species
Unenclosed area plots	Unenclosed Broad Habitat types	Up to 10 2 x 2 m plots placed in unenclosed Broad Habitat areas within each 1 km square. Plots were allocated according to Broad Habitats proportionally to their area	All vascular plant species
Boundary plots	Vegetation alongside field boundaries nearest to each of the Random plots	Up to 5 10m x 1m linear plots were place adjacent to field boundaries nearest to the Random plot (if within 100m).	All vascular plant species
Hedge plots	Vegetation in hedges associated with the Random plots, as close as possible to the two, furthest apart Random plots	Up to 2 10m x 1m plots, placed in hedges as close as possible to the 2 Random plots farthest apart	All vascular plant species
Streamside plots	Vegetation alongside running water features mainly rivers and streams, but also canals and ditches	2 10m x 1m streamside (S) plots plus 3 10m x 1m waterside (W) plots alongside other running water features.	All vascular plant species

Table 2 (continued)

Verge plots	Sample vegetation alongside transport routes, mainly roads and tracks.	2 10m x 1m Roadside (R) plots plus 3 10m x 1m Verge (V) plots alongside other route types.	All vascular plant species
Arable margin plots	Arable weed populations at the edge of cultivated fields	5 100 x 1 m were located adjacent to field margins centred on the B plot so that the 1 metre width is the outermost cultivated metre of the field	All vascular plant species
Hedge diversity plots	Woody species within hedgerows	10 30 m long plots placed in hedgerows within each 1 km squares; 2 of the plots included the H plots at their centre	All woody plant species and overall canopy composition
River habitats and freshwater macro-invertebrates			
Freshwater habitats	Rivers and standing freshwater (including ditches)	Stream samples were taken to assess water chemistry, and macro-invertebrates were used to provide environmental quality assessments through RIVPACS scores. River Habitat Surveys were also carried out along the same water course to assess river corridor habitats (hydromorphology).	Macro-invertebrate taxon lists and relative abundances. Ecological Quality Index (EQI) values for the biological condition of the river. River Habitat Survey data and indices of habitat quality (HQA) and modification (HMI).

Action Plan (Table 4). These have been defined within the general framework of the Phase 1 habitat classification (Nature Conservancy Council 1990) to be consistent with habitats as described by Annex 1 of the 'Habitats Directive'. Classification is based on a range of variables including environmental, vegetation physiognomy, floristic composition, land cover and land use factors.

Land cover mapping based on satellite data uses a different set of typologies. The types of land cover classes detectable from the imagery depend upon the spectral characteristics (and spatial scale) or the satellite data. This varies from one satellite, and one sensor, to another. It also varies according to the methods of image analysis used (e.g. whether automated or not, which bandwidths are selected for analysis, and how these are weighted). LCM2000 thus attempted to define land cover classes that matched as closely as possible to the Broad Habitats. Two main levels of classification were distinguished for this purpose: *target classes* (those which were intended to provide the equivalent of the Broad Habitats), and *subclasses* (which gave additional differentiation, where necessary). In addition, *variants* were recognised, to reflect local variations in land cover within Broad Habitats.

Through this approach, one-to-one associations can be created between Broad Habitats and most land cover classes (Table 5). Over-lapping relationships exist for some Broad Habitats, however, and the degree of association is in some cases weaker than others (Fuller *et al.* 2002).

Table 3. Derived statistical data from CS2000

Habitat/feature	Indicator	Measure	Years
Land cover			
Broad habitats	Stock Change	Area	1984, 1990, 1998 1984-1990-1998
Land cover types	Stock Change Flow accounts	Area	1990, 1998 1990-1998 1984-1990-1998
Landscape elements			
Standing water	Stock	Area	1984, 1990, 1998
	Change	Number	1984-1990-1998
Lowland ponds	Stock	Area	1990, 1996, 1998
	Change	Number	1990-1996-1998
Landscape pattern			
Broad habitats	Stock Change	Perimeter	1984, 1990, 1998 1984-1990-1998
Linear features			
Linear boundaries	Stock (single and multi-element)	Length	1984, 1990, 1998
	Change	Length	1984-1990-1998
Ditches and streams	Stock	Length	1984, 1990, 1998
	Change	Length	1984-1990-1998
Walls (by type)	Stock	Length	1998
Drystone walls	Condition	Completeness	1998
Hedges	Condition	Height, gappiness, stockproofness, shape, species composition, recent management	1990, 1998
Hedgerow trees	Stock	Length (by age class)	1990, 1998
	Composition	Length (by species)	1990, 1998
	Stock	Number of individuals (by age class and hedge type)	1984, 1990, 1998
	Composition	Number of individuals (by species and hedge type)	1984, 1990, 1998
	Change	Length (by age class)	1990-1998
		Length (by species)	1990-1998
		Number of individuals (by age class and hedge type)	1990-1998
		Number of individuals (by species and hedge type)	1990-1998

Table 3 (continued)

Vegetation condition			
Broad habitat	Condition	Moisture score Light score Nitrogen score Soil pH score Competitor score Stress score Ruderal score Species richness	1998
	Change in conditions	Moisture score Light score Nitrogen score Soil pH score Competitor score Stress score Ruderal score Species richness	1978-1990-1998 (stay-same, 1978-based, 1990-based and turnover analysis)
	Change	Number of plots (by aggregate class)	1990-1998 (stay-same, 1990-based, inclusive, turnover analysis)
Plant species	Change	Frequency (by broad habitat)	1990-1998
	Stock	Frequency (by broad habitat)	1998
CVS class	Stock	Frequency	1998

Table 4. BAP Broad Habitats

Broad Habitat	**Description**
Arable and horticultural	All arable crops, including cereals and vegetables, together with orchards and specialist crops such as market gardening and commercial flower growing; includes also freshly ploughed land, fallow, short-term setaside and annual grass leys
Improved grassland	Dominated by fast-growing grass species, such as rye-grass and white clover; typically on fertile soils and managed for grazing, silage or recreational purposes; management includes fertiliser application, weed control and long-term (> 1 year) rotation
Neutral grassland	Differ from acid and calcareous grasslands in not containing calcicole or calcifuge species; differ from improved grasslands in that they are less fertile and contain a wider range of grass species (rye grass is usually < 25% of cover); unimproved or semi-improved forms may be managed as hay meadows, pastures or for silage; occurring on soils that are neither acid nor alkaline

Boundary and linear features	Linear landscape features such as hedgerows, lines of trees, walls, stone/earth banks, grass strips and dry ditches; features may occur separately or in combination; includes also roads, tracks and railways in rural areas, together with their verges and cuttings

Table 4 (continued)

Broadleaved, mixed and yew woodlands	Dominated by trees that are more than 5 m high when mature, forming a distinct, though sometimes open, canopy with a cover > 20%; includes native and non-native broadleaved trees, and yew trees, where these comprise > 20% of the total tree cover; includes also scrub vegetation if the cover of woody species > 30%
Coniferous woodland	Dominated by trees more than 5 m high when mature, forming a distinct, though sometimes open, canopy with a cover > 20%; includes stands of native and non-native conifers, where these comprise > 80% of the total tree cover; includes also recently felled woodland where the intention s to return the land to coniferous woodland
Calcareous grassland	Grass and herb dominated vegetation, characteristically including a range of calcicole species; soils shallow, well-drained, alkaline, usually derived from weathering of chalk, limestone or other base-rich rocks
Acid grassland	Grass and herb-dominated vegetation on lime-deficient or acid soils, derived from acidic bedrock or from surficial deposits such as sands and gravels; characteristically includes a range of calcifuge plants
Bracken	Dominated by continuous cover of bracken (>95% canopy) at the height of the growing season, in plots > 0.25 ha in area
Dwarf shrub heath	Heath and dwarf gorse species comprising 25%+ of the vegetation cover; generally on well-drained, nutrient-poor, acid soils
Fen, marsh and swamp	Wide range of wetland vegetation, including fens, flushes, marshy grasslands, rush-pastures, swamps and reedbeds; on ground that is permanently, seasonally or periodically waterlogged; peat, peaty or mineral soils
Bog	Acid-tolerant plants such as bog-mosses, cotton-grass and cross-leaved heath on unmodified bogs; purple moor-grass or hare's-tail cotton-grass often dominant on modified bogs; usually peat-forming areas which receive mineral inputs primarily from precipitation rather than groundwater
Montane habitats	Vegetation characterised by dwarf shrub heath, snow-bed communities, sedge and rush heaths and moss heaths, and containing species characteristic of arctic or alpine areas (often 'wind-clipped' or prostrate); occurring exclusively above the former natural tree-line on mountains
Inland rock	Habitats on both natural rock surfaces (e.g. inland cliffs, caves, screes, limestone pavements) and artificial surfaces (e.g. waste tips, quarries)
Standing water and canals	Varied vegetation types, including aquatic and marginal shallow water species, occurring in lakes, meres, pools and artificial water-bodies such as reservoirs, canals, ponds, gravel pits and water-filled ditches.
Rivers and streams	Aquatic and water fringe vegetation, occurring in moving freshwater bodies, including rivers and streams; where there are no distinctive banks or banks are never over-topped, includes extent of the mean annual flood
Built-up areas and gardens	Urban and rural settlements, farm buildings, and other artificial structures such as industrial estates, commercial/retail parks, waste and derelict ground, urban parkland and urban transport infrastructure; includes domestic gardens and allotments

Table 5. Associations between Broad Habitats and LCM land cover classes (From Fuller *et al. (*2002)

Broad Habitat	**LCM Target class**	**LCM Subclasses**	**Variants**
22. Inshore sublittoral	Sea/Estuary	Sea/Estuary	sea
13. Standing water/canals	Water (inland)	Water (inland)	water (inland)
20. Littoral rock	Littoral rock and sediment	Littoral rock	rock, rock with algae
21. Littoral sediment		Littoral sediment	mud, sand, sand/mud with algae
		Saltmarsh,	saltmarsh, saltmarsh (grazed)
18. Supra-littoral rock	Supra-littoral rock and sediment	Supra-littoral rock	rock
19. Supra-littoral sediment		Supra-littoral sediment	shingle, shingle (vegetated), dune, dune shrubs
12. Bogs	Bogs (deep peat)	Bogs (deep peat)	bog: shrub, grass/shrub, undifferentiated (all on deep peat)
10. Dwarf shrub heath	Dwarf shrub heath (wet/dry)	Dense dwarf shrub heath	dense ericaceous, gorse
		Open dwarf shrub heath	open ericaceous
15. Montane habitats	Montane habitats	Montane habitats	montane
1. Broad leaved woodland	Broad leaved wood	Broad leaved / mixed woodland	deciduous, mixed, open birch, scrub
2. Coniferous woodland	Coniferous woodland	Coniferous woodland	conifers, felled, new plantation
4. Arable & horticultural	Arable and horticultural	Arable cereals	barley, maize, oats, wheat, cereal (spring), cereal (winter),
		Arable horticulture	arable bare ground, carrots, field beans, horticulture, linseed, potatoes, peas, oilseed rape, sugar beet, mustard, non-cereal (spring), unknown
		Non rotational horticulture	orchard, arable grass (ley), setaside (bare), setaside (undifferentiated)
5. Improved grassland	Improved grassland	Improved grassland	intensive, grass (hay/silage cut), grazing marsh
	Neutral/ calcareous; semi-natural/rough grassland	Setaside grass	grass setaside
6. Neutral		Neutral grass	rough grass (unmanaged), grass (neutral/unimproved)
7. Calcareous		Calcareous grass	calcareous (managed), calcareous (rough)
8. Acid	Acid grass and bracken	Acid grass	acid, acid (rough), acid with Juncus, acid with Nardus/Festuca/Molinia
9. Bracken		Bracken	bracken
11. Fen, marsh and swamp	Fen, marsh and swamp	Fen, marsh, swamp	swamp, fen/marsh, fen willow
17. Built up areas, gardens	Suburban and urban	Suburban/rural developed	suburban/rural developed
		Continuous urban	urban residential/commercial, urban industrial
16. Inland rock	Inland bare ground	Inland bare ground	despoiled, semi-natural

With the establishment of the Biodiversity Action Plan, and the adoption of a unified system of 'Broad Habitats' within this Plan (Jackson 2000), some degree of coherence has certainly been achieved in terms of the policy framework. By adopting these same Broad Habitats as the key reporting classes within CS2000, a closer link has also been forged between Countryside Survey and this policy. This will undoubtedly make the data available from CS2000 of more immediate utility for policy-related indicators.

Nevertheless, many other land cover and habitat typologies are still used in policy and management, including the Phase 1 habitat classification (Joint Nature Conservation Committee 1993), the EC Habitats Directive Annex I habitat types (Commission of the European Communities 1997) and the National Vegetation Classification plant communities (Rodwell 1991a,b; 1992; 1995; 2000). In CS1990, different reporting categories were also employed (Barr *et al.* 1993). Few of these different typologies have consistent, nested or one-to-one relationships; most showed complex many-to-many associations and overlaps. Thus, individual categories in one classification system typically relate to several classes in any other. The LUCID system, developed by Wyatt *et al.* (1993), helped to clarify these associations in relation to CS1990 by providing a look-up-table summarising the links, but data (for example on the extent of habitats or landscape types) can still not always easily be compared or transferred between different classifications because of the unknown extent of class overlaps. As a result, Countryside Survey data does not always provide estimates of habitat extent or condition that directly met the needs of many users, and translation between different operational systems can be difficult.

3.2 Accuracy and spatial resolution

Accuracy refers to the extent to which the data provided by CS2000 provide reliable and unbiased classifications of reality. Spatial resolution refers to the size of the smallest spatial units (e.g. map units or pixels) that can reliably be defined within the data. The two are closely inter-related. On the one hand, spatial generalisation represents a major source of error in geographical data such as those produced by CS2000. On the other hand, uncertainties due to sampling determine the minimum scale of reporting at which reliable estimates can be produced from the field data.

As this implies, uncertainties in CS2000 data may take many different forms and derive from many different sources. Important components of uncertainty include measurement or classification errors (e.g. in the field or laboratory), geographical errors (e.g. misplacement of sample sites or mislocation of habitat boundaries), sampling errors (e.g. under-sampling or biases in the sample design), rounding and aggregation (e.g. during generalisation of data to broader scales or classes), processing errors (e.g. during data analysis or computer manipulation), and reporting errors (e.g. during mapping or publication). Details of these possible errors and how they might propagate through the CS2000 data are not available, but will be explored as part of Module 9. Levels of accuracy in CS2000 are also not easy to quantify, not least because an explicit and independent measure of reality, against which the data can be compared, is often not available. It nevertheless merits emphasis that particular attention has been paid to error assessment and error tracking as part of the Survey, and wherever possible errors and uncertainties have been statistically quantified (e.g. through the use of Monte Carlo methods, in analysing the field survey data).

3.2.1 LCM2000

The field- and satellite-based data provided by CS2000 are structured in rather different ways and are subject to different types and levels of uncertainty. In the case of LCM2000, the basic imagery comes from the Landsat TM satellite. This gives a notional resolution of ca. 30 metres, which was then resampled to a 25 metre resolution for land cover mapping (Fuller *et al.* 1994a). During analysis, however, image segmentation techniques were used to group the native pixels into areas broadly equivalent to individual land parcels (e.g. individual fields). In the process, the data were generalised to exclude parcels smaller than ca. 0.5 ha (ca. 70m x 70m). This therefore represents the effective spatial resolution of the data, even though for reporting purposes 25 x 25 metre raster data are provided.

The major source of error in these data is the variability inherent in the spectral signatures associated with different land cover types. This occurs partly because individual land cover types are intrinsically variable (e.g. due to differences in growth stage, vegetation structure or management), but also because of the confounding effects of factors such as soils, topography and weather. The transitional nature and mosaic structure of land cover, especially in upland areas, also mean that the attempt to define discrete land parcels is in reality an attempt to impose overly simplistic order on a highly complex reality, and as such will never be wholly accurate. In some areas, too, lack of suitable time-series of imagery has meant that interpretation has had to be based on inadequate data. Together these factors make distinctions between different land cover classes on the basis of satellite imagery a probabilistic process and contribute to inevitable misclassification of some features.

Quantifying accuracy of land cover data is also inherently problematic, because of the difficulty in defining an objective and error-free reference against which results can be judged. At the outset, a target classification accuracy, when compared to field classification, of 90% was set for LCM2000. In practice, it fell slightly short of this (ca. 80%), though this apparent error is to some extent inflated by uncertainties or typological inconsistencies in the field data. Within these limits, therefore, the data provided by the land cover maps can be aggregated for reporting in the form of different spatial units, according to need, without any undue degradation of the classification accuracy. Nevertheless, errors may become significant when the land cover map is used to analyse small areas or specific land cover patches. For example, misclassification of a single, small land parcel within a 1 km square may mean that a complete habitat type is omitted from the data, even though on average for that square the land cover data still achieves an overall accuracy of 80%. Care is therefore needed when applying the data to small areas or specific land cover types, which may not be well discriminated by the satellite imagery.

3.2.2 Field data

The field survey data are affected by very different sources of error. At base, the field survey comprises detailed counts and descriptions at the scale of individual quadrats and sample plots. The raw data are therefore at an extremely fine resolution and, for all intents and purposes, essentially scale-free. The field survey, however, is confined to a set of sample 1km x 1km grid squares. Constraints thus arise when the data are used to produce estimates either for unsampled locations or for geographic regions, since this involves some degree of interpolation or extrapolation, and with these come uncertainty. How big this uncertainty is depends primarily on the degree to which the sample squares are representative of the areas of interest.

As noted previously, the sample design underlying the field survey is based on the 'ITE land classes' originally developed in the 1970s as a framework for ecological surveys in Great Britain (Bunce *et al.* 1996a, b, c). This classifies every 1km grid square in the country into one of 32 land classes[3], based on a hierarchical, statistical analysis of secondary, mainly physiographic data (e.g. on climate, latitude, longitude, altitude). In each Survey, these classes have been used as a set of strata both to locate (randomly) the field sample squares

[3] Increased to 40 land classes for CS2000 – see footnote, page 8.

and to extrapolate from the sample data to regional or national totals. Sampling of the land classes is not directly proportional to area, however, since it is recognised that some land classes are inherently more variable, or contain a wider range of habitats and vegetation types of interest for policy. As the Countryside Survey has developed, therefore, the number of sample squares in some land classes has been increased (in CS2000, for example, additional sampling was undertaken in the uplands).

The ITE land classes have stood the test of time. With the various adjustments that have been made to the sampling intensity, they appear to provide reasonably reliable estimates of the total area of habitats and vegetation types both nationally (for GB) and by country (England and Wales, Scotland). Data are also routinely reported by environmental zone[4]. In addition, relatively reliable estimates can be provided by individual land class. The field squares thus appear to provide a representative sample of the countryside at all these scales of analysis, and for each of these geographic areas.

Difficulties may arise, however, when the data are used to make estimates for other user-defined regions, and especially for smaller areas (e.g. individual counties). In these cases, two problems occur. The most common is that the number of sample squares available for the region of interest may be small, so that estimates are subject to considerable uncertainty. More rarely, the sample squares may not be representative of the area, so that estimates are biased[5]. Both problems pose restrictions on the ability to use CS2000 data for local application; in some cases, they may also inhibit their use for wider application in relation to specific types of habitat or environment. Studies of data from CS1990 (e.g. Barr 1997, Tantram 2002) have, however, shown that it is possible to estimate more specific habitat types from the field (and satellite) data provided by Countryside Survey (e.g. by using other data sets as masks or weighting variables to redefine habitat types), at least for some habitat types. Further research is in progress in Module 9 to determine whether these approaches could yield data which are sufficiently robust or reliable to meet policy needs.

3.3 Timeliness and temporal continuity

Timeliness of data is of great importance for policy. This is especially true when policies or environmental conditions are changing rapidly; otherwise, policy decisions may be nothing more than responses to historic problems, and new and emerging issues will not be addressed in time. Even where changes are slow, however, it is helpful to have up-to-date data, simply to carry conviction. In economics and other areas, that often have competing interests in relation to the countryside, policy information is updated regularly, typically over periods of weeks or months, at worst. Arguing against these interests with environmental data that appear to be several years out of date can be difficult. Currency of information is therefore critical.

[4] Environmental zones are defined both politically and in terms of broad physiographic and climatic characteristics. Seven zones are defined to represent Great Britain and Northern Ireland: zones 1-3 cover England and Wales, zones 4-6 cover Scotland and zone 7 comprises Northern Ireland.

[5] This second situation merits some explanation. As has been argued, the sample of field squares used in CS2000 appears to provide unbiased estimates when analysed in relation to the ITE land classes or broad areas such as environmental zones. However, this does not mean that it also necessarily provides unbiased estimates for other geographic regionalisations. This is especially likely to be true where the area of interest is small and localised, and poorly represented by the ITE land classes.

Given the existing and pending developments in policy relating to the countryside, CS2000 is certainly timely. Implementation of the Biodiversity Action Plan, adoption of the Water Framework Directive, further reform of the CAP and new agri-environment initiatives, possible long-term effects from the foot-and-mouth epidemic, changes in consumer attitudes and food preferences, as well as increasing pressures from urban development, recreation and climate change, all mean that the countryside is likely to change relatively rapidly in the future. CS2000 will thus act as an important baseline against which these changes can be assessed.

Nevertheless, because of these changes, CS2000 data will also tend quickly to become out of date. Much of the field survey was carried out in 1998, and a large proportion of the satellite imagery used in CS2000 derives from the same year. If the interval between surveys is maintained more-or-less in the past, the next full survey will not be until ca. 2006; and if a similar period of time is required to collate and process the data (and it seems difficult to imagine this taking much less than 2 years), then results will not be reported until 2008. Monitoring and assessment of the policies and pressures on the countryside will require data before then: many of the key policies have reporting timescales of only two or three years. Countryside Survey will therefore not be able to provide this short-term monitoring. What will be important is the ability to match and compare results from CS2000 with the purpose-designed monitoring undertaken to assess the effects of these various policies, both so that changes against baseline can be measured, and so that more local measurements can be scaled up to a national level using CS2000 as a framework. Timeliness of CS data, therefore, has to be seen not only in terms of the frequency and timing of the national surveys, but also the ability to link these to other monitoring systems. Certainly this issue of maintaining the currency of CS2000 data is an important one. It needs to be given detailed consideration in planning future surveys, and will be discussed at more length later in this report (section 5.3).

Equally important is the long-term continuity of the Survey. Until recently, this has been a major constraint, for the length of the time series available (and more importantly the number of data points within the series) was limited: although Countryside Survey has been running for over 20 years, CS1990 was only the third in this series, of which the first (in 1978) was relatively restricted in scope. As a basis for articulating trends in the state of the countryside, therefore, the information has been largely inadequate. Caution about interpreting the trends implied by previous surveys has also been warranted because of possible effects of weather and other short-term temporal effects on the consistency of the information. With few data points available, these may create a large amount of 'noise' in the time-series data, and make it difficult to detect genuine long-term trends.

With completion of CS2000, however, this circumstance has significantly changed. The fourth in the series, and the third to provi de relatively comparable and comprehensive data, it establishes what many users have acknowledged as a 'critical mass' of consistent time-series data. Comparisons with data from the Environmental Change Network (module 10 of CS2000) have also helped to quantify possible weather-related effects on the data. As a consequence, results from Countryside Survey can now begin to demonstrate valid, long-term national and regional trends.

This capability is likely to be further enhanced by recognition of the methods used in Countryside Survey as valid standards for countryside monitoring. This will enable other, more narrowly defined thematic or local surveys to adopt the same procedures, and thus produce comparable data. Over time, therefore, the number of data points available for comparison is likely to expand, enabling more subtle signatures and shorter-term trends to be identified. Such *ad hoc* or special surveys may nevertheless create difficulties unless firmly nested within a comparable survey methodology. In 1993, for example, an interim survey of hedgerows in England and Wales was carried out (Barr *et al.* 1994). Taken at face value, results from this survey suggest a ca. 13% loss of hedgerow length since the previous (1990) Countryside Survey, which was then largely recovered by the time of CS2000. Although some short-term variation in hedgerow length may be expected, in the absence of strong policy forces such rapid swings seem unlikely. More realistically, therefore, the apparent differences probably reflect differences in field methodology, survey design and uncertainties due to sample size (the 1993 survey comprised only 108 sample squares compared to 366 in CS2000). In any event, the experience illustrates the problems of comparing data from different surveys, even when conducted within a broadly consistent framework. The need for common survey standards is evident; the rigour needed to achieve them is also clear.

One aspect of Countryside Survey within which this critical mass of time series data has not yet been achieved is the land cover data. As already noted, this is primarily because systematic land cover mapping, using satellite data, only appeared as part of the Survey in CS1990; CS2000 thus represents only the second in this series. Even comparisons between 1990 (LCMGB) and 2000 (LCM2000) are severely limited, however, because of inherent uncertainties in the two data sets. Simply subtracting one map from another to identify areas of change is likely to be extremely misleading. Moreover, because errors in the two data sets are likely to be spatially structured (due, for example, to larger uncertainties in some images, geographic areas or land cover types), the data may easily give false impressions of spatial patterns of change. Statistical techniques to analyse change in the presence of such spatially structured error are also only poorly developed.

To make matters worse, the mapping methodology used to produce these land cover maps has changed since 1990, with the adoption of techniques of image segmentation in LCM2000. Direct comparisons between the two data sets are therefore impossible. Beneath this is a dilemma that faces any long-term longitudinal survey – whether to persist with what ultimately becomes an out-dated and sub-optimal technology in order to maintain consistency over time, or to adapt to new and improved methodologies as they become available. In most cases, especially as the technologies become more firmly established, this choice often becomes less stark, and backwards compatibility can often be maintained despite adaptation of methodologies. In a rapidly changing field such as remote sensing, however, consistency is harder to maintain. As with other forms of survey, problems also exist in detecting what are often small degrees of change, against a background of uncertainty in the data. These problems have significant implications, for trends in land cover are potentially highly valuable as indicators of countryside change, especially in the light of rapidly changing land use and agricultural policy. Without the ability to make such comparisons, and draw meaningful measures of change, therefore, the utility of CS2000 data as a basis for monitoring trends and land cover change is greatly reduced.

3.4 Linkage to other data sets

CS2000 provided a wealth of data; nevertheless, for many applications it will not be the only source that needs to be used. The ability to link and combine CS2000 data with data from other sources is therefore crucial.

Which data sets is likely to vary, depending upon the needs of the user. Amongst many others, particular interest tends to focus on 'upstream' data, relating for example to land management (e.g. from the agricultural 'June returns') and the various drivers of change in the countryside (e.g. land use, policy designation). For some applications, data are also needed on other characteristics of the rural environment, particularly those that directly influence ecological and land use processes – e.g. soil conditions, land suitability/capability, meteorology and pollution level.

One way of achieving this data linkage is through the CIS (section 2.3). This provides the ability to overlay and analyse data at a 1 km resolution, which for most applications is at the limit that is readily achievable using CS data. The strength of the system is that it provides automated estimates from the field data for any user-defined region (though with a constraint not to report these where the estimates are unreliable). As CIS has developed, a wider range of ancillary data sets have also been provided in CIS format, and the capability of the system has also been enhanced in various ways. Nevertheless, it has to be admitted that the system inevitably remains limited compared to the facilities now offered by proprietary geographical information systems. Many users would thus prefer to be able to extract CS2000 data from CIS and input them into a GIS, in order to have access to a wider range of analytical functions. For many research applications, there is also a need to be able to analyse the data using advanced statistical methods (e.g. kriging and Bayesian map smoothing) that are not available through CIS.

In this context, undoubtedly the main constraint perceived by many users is the lack of access to the original 1km sample squares, used in the field survey. Without these, it becomes difficult to reanalyse the CS2000 data according to need. Nor can the results of new modelling easily be validated against the field data. The opportunity to carry out such analyses in collaboration with CEH or the data holders does, of course, exist, but users are often deterred from taking this pathway because of the anticipated cost, the often exploratory (and thus not well-defined) nature of their enquiry, and in some cases a lack of confidence (e.g. the concern that they will not be taken seriously or will be scorned by the 'experts'). Rightly or wrongly, this is likely to inhibit the use of CS2000 data to some extent, as it did data from previous surveys.

4. CS2000 FOR POLICY AND RESEARCH

Countryside Survey is intended to support both policy and research in Great Britain. Its ability to do so depends, however, on the extent to which the data characteristics and qualities outlined in the previous section match the needs of users in different areas. This section therefore assesses the potential utility of CS2000 in a range of key application areas.

4.1 Supporting policy

4.1.1 Principles and concepts

The most important purpose of CS2000, and the motive for establishing Countryside Survey from the start, has been to support policy on the countryside. The countryside in the UK is subject to, and affected by, a wide range of policies relating not only to the environment but also to agriculture, forestry, regional and urban development, and transport. On the one hand, these policies create the need for information (to monitor their effectiveness and to direct new action); on the other, they act as important drivers for change in the countryside. Countryside Survey thus needs both to reflect the impacts, and to serve the needs, of these policies.

The need for information to support national policy in the UK has long been recognised. It arises both from the importance of the countryside as a national resource, and the large (and to some extent increasing) number of problems and challenges that it faces. These problems, in turn, are a consequence not only of changing technologies and practices, but also the increasing and often contradictory demands placed on the countryside (e.g. as a source of food and timber, as a catchment area for water, as a haven for wildlife, as a resource for public amenity and recreation) and the wider impact of environmental (especially climate) change. In the face of these pressures and changes, there is an evident requirement for action to protect and manage the countryside more effectively, and to make choices between different potential land uses. To support these decisions, decision makers and managers need information.

This need for information to support policy is further motivated by the costs of the interventions in the countryside – and the financial, environmental, social and political penalties for getting things wrong. For these reasons, there is a growing demand for both transparency and accountability in decision-making. The nature of many of these decisions, and the processes of reaching them, are also in many cases complex. Many of the threats facing the countryside touch upon different interests and sectors of activity (e.g. agriculture, forestry, environmental protection, tourism). Many different actors and stakeholders are also involved in the countryside. Policy and management thus require the participation and collaboration of a wide range of organisations and individuals. Under the principle of subsidiarity, responsibilities also need to be devolved to, and taken at, an appropriate level. At the same time, effective policy requires that there is a shared understanding of both the issues and the actions taken to address them at all levels of government and operation. Policy-making and management relating to the countryside thus need to be both horizontally and vertically integrated. To achieve this requires explicit information that is shared between, and accepted by, all those involved.

Other policy concepts that have emerged in recent years add to this need for information. One of these is the polluter-pays-principle, now embodied within EU legislation. This implies the availability of information both to identify and, if appropriate, prosecute those who damage the environment, and by the same token to demonstrate compliance with legislation to protect the environment. Another is the precautionary principle. Though designed to foster effective decision-making in an uncertain world – one in which dangers and consequences are not always signalled unequivocally – it nevertheless relies on the existence of information to alert the necessity for action. It thus assumes that information exists ahead of explicit need.

The principle of sustainability, which now underpins many (though far from all) the national and EU policies affecting the countryside, likewise creates a general need for information. At its heart is the principle of self-perpetuation and stability: the capability of a system such as the countryside to maintain itself in the long-term without continued loans from outside. Within the context of cost-efficient policy and wider social and economic interests, however, sustainability presents a narrow target to hit. On the one hand, even a small degree of over-exploitation or mismanagement can, if allowed to persist, cause severe and irreversible environmental damage to the countryside; on the other hand, excessive precaution against damage may act to weaken the social and economic fabric of the countryside, and lead to other losses and damage.

Against this background, 'evidence-based policy' has become a guiding precept in government in the UK in recent years. It represents a recognition that good policy must be founded on a clear understanding both of the way the world works – on the current situation, on past legacies, on trends – and of how it might change as a result of intervention. It also implies that the effects of the policies themselves must be monitored and evaluated, to ensure that they are working as intended and cost-effectively. Evidence-based policy thus requires the availability of information both *for* policy and *on* policy. It requires that this information is available in advance of policy (in order to guide action) and afterwards (to assess its performance and impact). Equally, information must be comparable geographically in order to allow sensible choices to be made between the needs of different areas; and it needs to be scalable (i.e. capable of aggregation or disaggregation to different levels of detail) in order to ensure applicability across different levels of policy. Continuity and consistency of information are thus paramount.

In the case of policies affecting the countryside, therefore, monitoring systems such as Countryside Survey are clearly vital. The extent to which CS2000 can meet the needs of evidence-based policy depend, however, on how well the information it provides matches the often contradictory demands placed on it.

These demands are considerable. Problems facing the countryside are increasingly complex, multi-facetted and inter-sectoral. Few of the processes operating in the countryside do so in isolation. Not only are species and habitats mutually interdependent, but so too are most forms of land use and economic activity. Changes or impacts in one area, or in one sector, thus frequently impinge on others, as the recent foot-and-mouth epidemic shows. As a result of the development of new technologies, new working practices, increasing integration of food production and delivery systems, diversification of rural economies and globalisation of markets, many of these problems are also operating on a far larger scale than in the past. The UK countryside itself, however, remains a finely-granulated environment, characterised by an intricate mosaic of land parcels, habitats, landscape features and communities, all of which react differently to, and are differentially affected by, changes in technology, economy or policy.

Information on the countryside, and the factors affecting it, is therefore essential to guide both policy and management. To be effective in the context of this varied and finely structured environment, however, this information needs to be geographically comprehensive and spatially highly resolved. Yet it also needs to provide the right kind of information to those who need it. This, too, poses major challenges, not only because of the many different issues, interests and actors that have to be considered, but also because of the varied character of the countryside – and the many different conceptualisations that may be made of it. Thus, classifications of habitats, land cover types and land use systems may all vary from one area or one organisation to another, as may the criteria used to judge countryside quality; the information needed to support decisions consequently varies also. Herein lie important contradictions. Within any specific application, consistency of information is vital; between different users and uses, however, diversity of information can often not be avoided, and may be essential. Satisfying these inherently inconsistent needs with consistent information is no easy task.

Many different policies are concerned with, or potentially impact on, the countryside. Many of these policies originate from the European Union. Each generates a need for information that might be met, at least in part, by CS2000. Seven key policy areas are discussed below:

- biodiversity
- sustainable agriculture
- water management
- soil protection
- urban development
- environmental pollution
- climate change

4.1.2 *Biodiversity*

With the adoption of the Habitats Directive in 1992, the concept of nature protection became firmly established in EU policy. At around the same time the UN Convention on Biological Diversity established broader obligations to conservation and sustainable use of biodiversity. As a means of implementing this in the UK, the Biodiversity Action Plan (BAP) was subsequently formulated and a series of detailed action plans were published, between 1995 and 1999. This then provides a context for a number of other country-specific policies, including the Rural White Paper and England Biodiversity Strategy (published in 2000 and 2002, respectively).

Under the BAP, three types of plan are being initiated:

- species plans – aimed at helping to protect species that are threatened
- habitat action plans – aimed at protecting key habitats
- local action plans – aimed at establishing local partnerships to support action to protect habitats and species.

Each of these types of plans invokes the need for information, both to describe the current status and trends in biodiversity, and also to monitor the effects of action in the years ahead. Together, they identify 391 species and 45 habitats (including 24 terrestrial habitats) regarded as of the highest priority for protection, and thus on which national information is needed (Table 6). In addition, about 160 local action plans are under development, that will require monitoring at the local level.

Countryside Survey clearly represents an important potential source of information in support of the Biodiversity Action Plan. As noted previously, both the field survey and the land cover map were therefore designed to provide information by Broad Habitat. These Broad Habitats do not match precisely the priority habitats for which action plans are being developed, but do act as a higher tier of classification, within which the priority habitats are nested and for which more general Broad Habitat Statements are required. They thus provide important context in terms of the distribution, character and management of the priority habitats.

The extent to which CS2000 and its predecessors can, in practice, meet the information needs of the Biodiversity Action Plan has yet to be tested. Clearly it cannot be the only, or even main, source of information, for the reporting dates for monitoring required by the BAP in most cases do not coincide with the timescale for monitoring under Countryside Survey. The scale of data required is also very different, especially

Table 6. Terrestrial broad habitats and priority habitats as recognised in the UK Biodiversity Action Plan

Broad habitat types	**Priority habitats**
1 Broadleaved, mixed and yew woodland	Upland oak woodland Lowland beech Upland mixed ashwoods Wet woodlands Lowland wood pastures and parkland
2 Coniferous woodland	Native pine wood
3 Boundary and linear features	Ancient and/or species rich hedgerows
4 Arable and horticulture	Cereal field margins
5 Improved grassland	Coastal and floodplain grazing marsh
6 Neutral grassland	Lowland meadows Upland hay meadows
7 Calcareous grassland	Lowland calcareous grassland Upland calcareous grassland
8 Acid grassland	Lowland dry acid grassland
9 Bracken	
10 Dwarf shrub heath	Lowland heathland Upland heathland
11 Fen, marsh and swamp	Purple moor grass and rush pastures Fens Reedbeds
12 Bogs	Lowland raised bog Blanket bog
13 Standing open water and canals	Mesotrophic standing waters Eutrophic standing waters Aquifer fed naturally fluctuating water bodies
14 Rivers and streams	Chalk rivers
15 Montane habitats	
16 Inland rock	Limestone pavements
17 Built up areas and gardens	

for local plans. Opportunities clearly exist, however, to use CS2000 as a contextual data source, and as a means of describing data on the extent and current quality of Broad Habitats. It thus provides a potentially useful input to the Broad Habitat Statements included in the Plan. The time series of data now available from the four completed field surveys (and especially from the last two) also mean that the Survey can ostensibly be used to show how these habitats are changing in relation to their specific biodiversity objectives. Analysis in terms of transfers between aggregate vegetation classes, and changes in indicators of vegetation condition, are especially informative in this context. However, because of limitations in sample size and survey design, these types of change estimates can only be provided for the most recent interval (1990-1998), though this is clearly the most relevant in terms of the current policy. Within the limits of compatibility (both between surveys and classification systems), the national land cover maps also provide the capability to give information on the changing extent of Broad Habitats. In all these cases, estimates are possible at the GB and country scale, as well as by environmental zone, with acceptable margins of error. The data from CS2000 thus provide a reliable baseline against which to monitor the performance of the Biodiversity Action Plan at this aggregate level, and already show early signals of the effects of the Plan in some areas. Data presented in the CS2000 synthesis report, for example, were used in the *Millennium Biodiversity Report* (UK Biodiversity Steering Group 2001) to indicate trends in the Broad Habitats. Nevertheless, as in all areas of policy and land use change, attribution of effects to specific interventions or drivers is not easy, especially on the basis of aggregate data (see Section 4.1.9).

The ability of CS2000 to provide information on the more specific priority habitats is more limited. The sampling intensity used for the vegetation surveys in CS2000 is simply not sufficient to provide accurate measures of habitat stock or condition at the local scale, and even less so to provide reliable estimates of change in local habitat characteristics. LCM2000 does provide a useful baseline on land cover distribution that may help to map habitats at the local level; if future surveys provided comparable land cover data, these might also help to monitor more obvious changes in habitat extent. For the most part, however, the Land Cover Map will not be able to identify more subtle changes in habitat condition, which often provide important early warnings of effects on the ground. For the local action plans, therefore, independent monitoring remains essential. Even so, Countryside Survey has an important role to play, by providing both a national context within which local plans can be interpreted and assessed, and against which local monitoring can be compared. Thus, it can help to determine the extent to which local trends in habitat stock or condition mirror (or contrast with) national trends for similar types of habitat. It can also provide an important framework within which to collate and integrate locally-derived information, and thus – over time – to refine regional and national estimates. To allow this, however, it is vital that local monitoring is methodologically consistent with that used in Countryside Survey. CS2000 consequently needs to be seen as providing the standard methodology for these more specific, local surveys.

4.1.3 Sustainable agriculture

Agriculture is, by its very nature, one of the most important influences on the countryside. Changes in agricultural policy, practice and technology thus act as crucial drivers of change in the countryside. As part of the European Union, it is the Common Agricultural Policy which is the major force in shaping the farmland environment in the UK.

In recent years, in recognition of the vital role of agriculture in moulding (and potentially damaging) the rural environment, major shifts in agricultural policy have begun to occur in the European Union. These policy changes take many forms and are, in practice, driven by more than environmental considerations: costs of the Common Agricultural Policy, planned expansion of the European Union, and the impact of World Trade Agreements are also strong motivating factors. In general terms, however, the new policy can be seen as one based more firmly on the principles of sustainability.

The adoption of these principles has far-reaching implications both for agriculture itself and for monitoring and management of the countryside. Sustainable agriculture is geared towards establishing viable farming systems and practices that can be maintained in the long term, without unacceptable deterioration in the environment, or other social costs. This in turn implies the ability to make informed choices about the economic, environmental and social trades-off involved in different policy measures and practices. It also means that the fine line can be trod between environmental protection and economic disability. To guide decisions about sustainable agriculture, therefore, a wide range of information is needed on the status of, and changes in, the countryside.

Although agriculture is practised, on either an intensive or extensive scale, across the large part of the UK land surface, the character of farming varies substantially. The information needed to monitor sustainable agriculture is consequently not the same everywhere. Details of what needs to be monitored, and where, will also vary as the character of farming, and the policies that affect it, themselves change. For the sake of discussion, however, it is helpful to consider information needs and the potential role of Countryside Survey in three contrasting farmland environments: areas under agri-environment schemes, areas in intensive agriculture, and 'sensitive' farmland areas (such as the marginal uplands) which are especially susceptible to change.

Monitoring agri-environment schemes

Agri-environment schemes now represent one of main mechanisms for implementing sustainable agriculture, and many of the most beneficial changes in terms of biodiversity may be expected to occur where these schemes are in operation. Areas under agri-environment schemes thus provide an important focus for monitoring. Many schemes have been introduced in recent years, with somewhat different schemes and options available in different countries. In England, they include:

- the Countryside Stewardship Scheme
- the Environmentally Sensitive Area Scheme
- the Energy Crops Scheme
- the Hill Farm Allowance Scheme
- the Farm Woodland Premium Scheme
- the Woodland Grant Scheme
- the Organic Farming Scheme

In Wales, Scotland and Northern Ireland, several variations on these schemes also exist.

None of these apply across the entire agricultural landscape, but are instead targeted at specific areas; even within these, scheme uptake also varies depending on eligibility and the individual choices of landowners. Agri-environment schemes thus represent an often complex set of overlapping mosaics within the countryside, with differing monitoring requirements. Recently, a new class of scheme has also been proposed, referred to as 'broad and shallow', which would provide a low-level entry into agri-environment practices and be more widely applicable. If funded and adopted, this would considerably extend the area of land under some form of positive environmental management.

Monitoring and assessing these various schemes in terms of their impacts on the countryside poses severe challenges. Impacts of agri-environment schemes are often likely to be seen less in terms of the emergence of new habitats or changes in the extent of existing ones, than in maintenance of (or improvements in) the biological condition of the areas concerned. These are likely to be reflected mainly in terms of species composition and abundance. Where changes occur, they may also be subtle, and some may be short-lived (especially in situations where land can be moved in and out of schemes). In other cases, effects (especially the more long-lasting effects) may occur only after a substantial latency time, or may accumulate only in the long-term. Nor are effects necessarily contained within the confines of the individual farms or land parcels in which the schemes are applied: increased connectivity between habitats and refuges, for example, may have impacts on biodiversity far more widely in the landscape; provision of improved feeding potential for raptors may affect breeding success across large areas of surrounding land. Direct on-farm monitoring is therefore vital to detect and assess the effects of these schemes, but is unlikely to reveal the full picture. A more regional and holistic perspective is also needed.

Judgements of countryside change in response to changes in policy or practice can also not be made in isolation. Monitoring within an area covered by an agri-environment scheme shows only changes in that land; it does not reveal either whether these changes are a result of the scheme, or whether they differ from (or are better or worse than) changes occurring elsewhere. The danger of the ecological fallacy thus applies, in that associations derived from aggregated data may be falsely inferred to represent specific cause-effect relationships. Two types of control data are therefore needed to interpret results from monitoring of agri-environment schemes (or any other intervention): baseline data relating to conditions prior to the intervention, and matching information from a comparable 'reference' area, not subject to the scheme. Because agri-environment schemes change over time, and because uptake of schemes by individual farmers changes, identifying control areas can be highly problematic: areas which are outside individual schemes at one time can become contained within them at another. This problem will become more acute if 'broad-and-shallow' entry schemes come into practice. Comparative assessments of the effects of agri-environment schemes in the long-term are therefore difficult without careful forethought and study design.

Monitoring intensively-farmed landscapes

Farmlands specifically targeted for environmental protection and enhancement are not the only areas of interest in terms of the agricultural landscape. A large proportion (in many areas the majority) of agricultural land still comprises relatively intensive farming that does not incorporate any special conservation measures. These areas, and the pockets of habitat that they contain, are also of great importance in terms of the status of the countryside and the impacts of farming. The importance of farmlands as a habitat for breeding and wintering birds is, for example, widely recognised. The effects of changes in these habitats on populations of farmland bird species have also been well documented. In the light of this, in 2000, the then Ministry of Agriculture, Fisheries and Food (now DEFRA) agreed a Public Service Agreement (PSA) target to reverse the decline of 20 key farmland bird species. This agreement is likely to act as an important influence on farmland practice in the coming years.

Land use change in these areas is, in many cases, marked by relatively immediate and readily identifiable changes in land cover or habitat extent: for example, by shifts in the area or distribution of crops or by changes in field layout. Many changes, however, are more subtle. In recent decades, some of the most important impacts on birds, for instance, have come from changes in practices such as the sowing dates of cereals and cutting dates and frequency of grass crops, which are not readily detectable in terms of the visible landscape. Additionally, the areas of greatest interest in terms of biodiversity within intensively farmed landscapes are often small and localised. As well as hedgerows, they include field margins and corners of fields, farm ponds and ditches, and remnant habitats (such as small coppices or field trees) often isolated within the wider cropland.

Monitoring these landscapes again poses challenges, therefore. Simple information on changes in the extent of habitat types or land cover is useful to indicate the general effects of policy or other forces acting in the countryside, but is rarely sufficient to reveal the real changes of importance. Instead, there is a need for more specific and precise monitoring methods and measures, targeted at sentinel species and more sensitive micro-habitats within the intensively farmed landscape.

Sensitive farmland areas

As the previous discussion indicates, some areas within the farmed landscape are of especial significance in terms of sustainable agriculture, because they act as refuges or vital habitats for wildlife, yet are especially vulnerable to change in farming practice or policy. Monitoring of these areas is particularly important not only because of their relative biological richness, but also because they act as sentinels of change. Within intensively farmed areas, these sensitive or sentinel areas may be localised and small. More extensive areas of sensitive landscapes also occur, however, at the margins and interfaces between different land use systems. These are often especially sensitive because they comprise areas which may switch between quite different farming systems in response to quite small changes in economic circumstance or policy.

Possibly the most obvious examples occur in the upland margins. Along the periphery of upland moorland, for example, the constant cycle of 'reclamation' and 'abandonment', has resulted in the past in the repeated retreat and readvance (albeit in a more impoverished state) of the heathland margin, as the seminal studies of Parry *et al.* (1982 and following) showed. Similar shifts in fortune affect other habitat types within these areas, including unimproved grassland and wetlands.

Monitoring these habitats thus provides a particularly sensitive barometer of the state of the farmed landscape, and gives important indications of implications for progress towards sustainable development. Because some of the changes are relatively wide-ranging and comprehensive, they are also potentially detectable using relatively coarse monitoring systems and aggregate data – for example, in the extent and condition of the aggregate classes, broad habitats and land cover classes used in CS2000. On the other hand, two factors make monitoring of these areas problematic. One is the spatial complexity of many of the habitats, which often occur as intricate mosaics. In these cases, carefully stratified and quite intensive monitoring is needed if the data are to be scaled up to a regional or national level. Another is their sensitivity not only to land use factors, but also to weather and vegetation life-stage: this means that large cyclical, or essentially random, changes may occur from year-to-year, masking or confounding land use effects. Major difficulties can therefore be encountered in extracting longer-term trends from the short-term noise within the monitoring data, especially where surveys are infrequent.

The potential of CS2000

Countryside Survey alone clearly cannot meet all the information needs of sustainable agriculture. Issues of scale and local specificity, for example, mean that its ability to provide detailed data on areas under agri-environment schemes or micro-habitats in more intensively farmed landscapes is limited. The repeat frequency for national surveys is also in many cases inadequate to detect shorter-term changes, or firmly to separate transient and reversible fluctuations from longer-term trends. In addition, explanation of changes in the farmed landscape, and prediction of future trends, requires information on more than habitats and species; they need, equally, data on the factors that motivate these changes, such as farming practice and the perceptions and attitudes of landowners or managers.

Purpose-designed monitoring is therefore essential, while a wide range of other routine information on agricultural practices also still needs to be used.

In association with these other data, however, Countryside Survey certainly has the potential to provide important information relevant to sustainable agriculture. Data from the land cover map and analysis of field data at the level of Broad Habitats clearly give information on the more general extent of, and changes in, agricultural habitats. More specific data on the micro-habitats within these areas (e.g. arable field margins, hedgerows and streamsides) give more detailed insight. Analysis at the level of aggregate classes (e.g. transfers between aggregate class by agricultural Broad Habitat) also yields important information on changes within farmed land. In this context, the various condition measures (e.g. Ellenberg scores) are especially pertinent. Important information is also provided by the data on soil characteristics (e.g. loss-on-ignition, pH) obtained from the subset of sample squares.

Because of the complexities of agricultural systems, however, outcome data (i.e. data on changes in habitats, species or other components of the environment) need to be interpreted with extreme care. As has been noted before, but merits emphasis, causality cannot always be assumed. Changes may be small but nonetheless important either because of their spatial extent or potential long-term impacts; lack of change may – if analysed properly – be as revealing as clear positive or negative trends. At the same time, there is often considerable noise in the signals detectable from these outcome data, because of limitations of sampling, short-term (e.g. year-to-year) variations in conditions, and local (e.g. field-to-field) differences. Diversification is also a feature of current policies on agriculture and the rural economy. This, too, has implications for the use and interpretation of CS data, for with increased diversity will come increased difficulties in categorising the complex (and in some cases over-lapping) land uses and land cover types. Classification errors and uncertainties will consequently tend to increase.

To make best use of CS data in this area also requires that they can be combined and compared with data from other sources – in particular, data on land management and farming practice. To date, however, the ability to link these various data sets has been constrained both by problems of access to the (non-CS) data and by the costs and complexities of data linkage. The development of GIS techniques is, to a large extent, removing this latter difficulty. Problems of data access are also being reduced in many cases by more open policies on data dissemination amongst many public agencies, motivated in part by the Internet. Significant pockets of resistance nevertheless remain. Costs of access to soils data, for example, seem to inhibit some analyses. In the past, difficulties of accessing the annual agricultural (June) returns have also often been quoted by potential users as a major example of this problem. Digitisation of the IACS data would now provide an important new data source. As in other areas, also, there is often a need to access to the field data for the sample grid squares from CS2000 (e.g. to make estimates for areas that are not inherently supported by CS2000, such as those under specific agri-environment schemes, specific farming types, or in particular sensitive areas). Constraints on access to these data can inhibit these types of application (see Section 5.2.7).

4.1.4 Water management

River catchments represent important elements in the landscape of the UK, and have for long been seen as requiring integrated management to protect both water resources and associated habitats. Different administrative structures and policy instruments have operated in different countries of the UK. In England and Wales, for example, catchment management plans were introduced in the early 1990s under the then controlling agency (the National Rivers Authority in England and Wales), but with the formation of the

Environment Agency in England and Wales in 1995, these were superseded by Local Environment Agency Management Plans. In Scotland, river purification boards held responsibility for water management until the establishment of the Scottish Environmental Protection Agency (SEPA) in 1995. Here, too, catchment management plans have been developed for a number of river basins. In the near future, however, the importance of integrated catchment and river management will become even greater, for a Water Framework Directive will soon be introduced, which will provide the framework for catchment management and water resource protection across the EU.

A key objective of the Directive is to co-ordinate many of the currently separate measures that affect water resources (e.g. the Urban Wastewater Treatment Directive and the Nitrates Directive) within a coherent structure, and to ensure that surface waters are maintained in 'good ecological status', as well as 'good chemical status'. Methods for implementing the policy have not yet been fully worked out, but a primary tool will certainly be river basin management plans defining how the objectives for each catchment will be met, and the timescale for their achievement. Detailed attention will need to be given in this to the habitats and water resources requiring protection, as well as the implications for land use. Monitoring to demonstrate the effects of the plans will also be mandatory.

The Water Framework Directive is therefore likely to have far-reaching implications both for policy and for monitoring in the countryside. Apart from its impacts on other initiatives and policy areas (e.g. agriculture), it will make the catchment a major focus for countryside management and conservation. It will also create the demand for new categories and levels of information in both devising plans and assessing their performance.

Enhanced monitoring of freshwater environments (module 2) has certainly increased the relevance of CS2000 in relation to the Water Framework Directive. As in other areas of policy, CS2000 can therefore act as a source for contextual, baseline data to inform development of the plans. Future surveys might also help to demonstrate the impacts of the Directive at the aggregate scale (e.g. by environmental zone or country) – though in practice attribution of changes in these habitats to specific policy measures, against a background of multiple and shifting policies and a myriad of other development, is all but impossible in the aggregate. The ability to provide more detailed information at the level of individual catchments or plans is much more limited. River catchments are relatively fine and localised entities compared to the reporting categories that CS2000 provides. If the methodology is kept constant (or at least backwardly compatible), the Land Cover Map can act as an important source of land cover change. But if the field data are to be of use at this scale, then substantial changes in survey methodology or major developments in analytical methods would probably be required; these would potentially jeopardise the continuity of the Survey. Here, as in other areas, therefore, it may be important to ignore the temptation to make Countryside Survey a single solution for every data need, and instead focus on ensuring good synergy between CS and other monitoring systems. By the same token, development and implementation of river basin management plans is likely to generate a wide range of new data on the countryside. As well as being a data provider, therefore, future Countryside Surveys may become recipients of this information.

In formulating and monitoring plans there is also likely to be a requirement for data on land use and management. As in other areas (see section 4.1.3) improved access to management data (e.g. from the agricultural census) is needed to facilitate these types of application.

One other potential application of CS data is worthy of consideration in this context – namely its use for flood modelling. Flood control is an important element in the Water Framework Directive, and derogations from other (e.g. ecological) requirements will be available for actions to combat flooding. Riverine flooding is also an issue of increasing public concern, and perhaps frequency, with attention focusing not only on possible effects of climate change but also the more immediate impacts or urban development and agricultural practices in flood-prone catchments. Modelling of flood risks, to guide planning and land use decisions, to quantify insurance risks, and perhaps to assess liability, is therefore of growing interest. New generation, distributed catchment models make this possible, but their data demands can be high. In particular, there is a need for small-area data on vegetation cover, soil characteristics and land use, all of which act as important controls on catchment processes and stream response. Countryside Survey (and especially LCM2000) provides an important source for many of these data, and has already been used on an exploratory basis (Beale 2002). Further research is needed, however, to assess the reliability of the data as a basis for flood modelling, and the sensitivity of the models to uncertainties (or real changes) in the data.

4.1.5 Soil protection

With the adoption of policies on sustainable development in the UK, attention (many would say long-overdue) is now being focused on the need for a co-ordinated strategy on soil resources. The case in favour of this is clear: soils not only represent a vital physical resource for agriculture but also have an instrumental role in many other aspects of the environment, including biodiversity, water resources, pollution and climate change. In March 2001, therefore, the then Ministry of Agriculture, Fisheries and Food published a consultation paper, setting out a draft soil strategy for England. This highlights the many pressures on, and threats to, soil, including loss to development and extraction, erosion, contamination, acidification, eutrophication, structural deterioration and exhaustion. It also emphasises the importance of countryside management – including agri-environment schemes – in determining the state of the soils, and the need for routine monitoring to assess the state of the resource and give early warning of adverse changes. In Scotland, SEPA called for the establishment of a similar strategy, following publication of its state of the environment report on soil quality in 2001.

In various ways, therefore, the development of a soil strategy would have implications for, and might make demands upon, Countryside Survey. On the one hand, policies designed to improve protection of the soil would inevitably affect the countryside – and the impacts would thus be expected to be detectable in future surveys. CS2000 will consequently act as a baseline against which any such changes are measured. On the other hand, CS already provides important insights into soil condition. This information comes directly through the soil sampling and comparisons undertaken in CS2000 (and explicitly referred to in the draft strategy). It also comes more indirectly from the vegetation-based quality indicators (e.g. the Ellenberg scores) reported in CS2000. These might thus be used to help formulate and target action. If the strategy is adopted, it could also be argued that the soil analysis carried out as part of Countryside Survey should be extended in future to monitor its effects. Again, this has potential disadvantages, for it may overload and distort what is already a complex and wide-ranging survey, and thereby threaten continuity of the survey. It may therefore be more effective (and safer as far as CS is concerned) to see the Survey as a framework within which other, independent soil monitoring can be structured, and with which it can be linked. That is not to say that Broad Habitats or other reporting classes used in CS200 should provide the sampling framework for soil monitoring. If monitoring data are to be extrapolated geographically, it will almost certainly be essential to use soil classes as a framework. But linkage between soil monitoring, the soil map classes, land cover and vegetation data would undoubtedly be beneficial. To achieve this requires that existing soil mapping data are fully integrated into Countryside Survey (e.g. by making them available as part of CIS). This is a need that is already evident, and has been emphasised by several current or would-be users. It will become even more acute if CS is to help serve the needs of a national soil strategy.

4.1.6 Urban development

In recent years pressures on the countryside have increased substantially. One of the most important sources of this pressure is from urban development, both in the form of expansion of major urban areas and by small-scale developments around rural settlements. In the context of changing demographics and economic conditions, the demand for house-building has increased greatly, especially in the south-east of England. Estimates are subject to review, but in the Rural White Paper, published in 2000, the need for an additional 4 million new homes was recognised, of which 40% would be planned in the countryside. In order to manage this development, guidance on development contained in PPG7 was revised, with some relaxation of the principle against development on higher grade agricultural land. Acknowledging, also, possible implications for protection of biodiversity, this revised guidance stated:

> "Where development of agricultural land is unavoidable, local planning authorities should seek to use areas of poorer quality land in preference to that of a higher quality, except where other sustainability considerations suggest otherwise. These might include, for example, its importance for biodiversity, the quality and character of the landscape, its amenity value or heritage interest, accessibility to infrastructure, workforce and markets, and the protection of natural resources, including soil quality. Some of these qualities may be recognised by a statutory wildlife, landscape, historic or archaeological designation, such as a National Park or Site of Special Scientific Interest."

Notwithstanding this guidance, and reaffirmation within the Rural White Paper of the commitment to maintain green belts, development of urban land clearly has the potential for serious effects on the countryside. Impacts might include loss of habitats not only to house-building, but also to related road development, and commercial and industrial land. Monitoring such losses is important, both to assess the effectiveness of the Rural White Paper and its associated planning guidance, and to identify the need for future policy intervention.

CS2000 represents an important source of information in this context. As well as showing national losses to development in rural areas between 1990 and 1998, the field survey provides baseline data on habitat extent that can be used to assess future transfers into built-up land.

That said, it needs to be acknowledged that the information that Countryside Survey can provide on urban land and the impacts of development is limited. About 2.5% of the land area, comprising 'core' built-up land (i.e. grid squares that contained more than 75% urban land in 1990) was excluded from the CS2000 field survey. Changes within these (e.g. due to further urban infilling) are not being monitored as part of the field survey. In other areas of built-up land (i.e. those in the urban fringes and rural settlements) mapping was also less detailed than in areas of countryside (i.e. field plots were not set up other than on road verges). Estimates of the extent of changes within urban land are therefore likely to be subject to considerable error, and in general are likely to be less than those derived from other sources, which would typically use more finely resolved definitions of urban land. Measures of transfers into and out of urban or developed land, based on the field survey, are thus also likely to be subject to uncertainty. More detailed data on the extent of built-up land are provided by LCM2000, against which future changes can be monitored at the local scale. However, even this provides only a relatively simple classification of urban land, so qualitative changes within the built-up area may not be detectable. Further analysis of these issues is being undertaken as part of Module 17 (FOCUS).

These limitations have some consequence for attempts to monitor the effects of urban development on the countryside. They mean, firstly, that the complex interactions between town and country – for example in terms of the balance of development between greenfield and brownfield sites – are not readily recognisable. Secondly, they mean that there is no explicit recognition within Countryside Survey of the important role of urban areas, neither as a refuge for wildlife species (and for some species an increasingly important one) nor as an important source of alien species in the countryside.

The utility of CS data for monitoring of the urban environment, and urban development, can be enhanced by linkage to other data sets – for example, to the Land Use Change Statistics (LUCS) and to relevant planning data. The ability to achieve this should be improved by the ongoing project to develop a National Land Use Database (NLUD). However, for the future, there would also be clear advantages in increasing the attention paid to urban development in Countryside Survey, or in developing a parallel survey of urban environments. These issues are being pursued both as part of module 9, and through related work on Countryside Quality Counts.

4.1.7 Environmental pollution

The countryside is both receptor and source for environmental pollution. Many of the pollutants derived from urban and industrial activities reach the countryside, either via atmospheric or aquatic pathways. Especially in more sensitive ecosystems, their impacts can be far-reaching – albeit often subtle and slow. Conversely, activities in the countryside – notably intensive livestock and arable farming – generate a wide range of pollutants including atmospheric emissions (e.g. ammonia, methane, CO_2), pesticide and fertiliser residues and organic wastes, which contribute to environmental problems such as groundwater pollution, air pollution, soil contamination and global warming. A number of sectoral policies (including those on agriculture, forestry, energy, transport, industry and waste management) thus need to consider the potential impacts of pollution on the countryside. Equally, changes in the countryside, including trends in land cover, land use and species composition, may have important implications in a variety of policy areas.

Policy on air pollution in both the UK and EU is driven by several rather different concerns: human health, climate change and impacts on ecology and heritage. Policies in relation to human health were set out in the National Air Quality Strategy in England and Wales (and its sister strategy for Scotland), and will in future be further developed under the Air Quality Framework Directive of the EU. These policies are primarily focused on the human living environment, and are thus concerned mainly with the urban environment. The role of Countryside Survey in relation to these is therefore somewhat limited.

In terms of longer-distant transport of pollution, the UK is signatory to a number of international conventions, most notably the UNECE Convention on the Long Range Transport of Air Pollution (LRTAP) (National Expert Group on Transboundary Air Pollution 2001). Countryside Survey data have already been used in support of these policies – for example to help model the effects of environmental acidification and eutrophication (e.g. the Global Nitrogen Enrichment thematic programme of the EU (GANE) - see http://gane.ceh.ac.uk/GANEapp/default.jsp). Measures of vegetation condition (such as the pH and fertility scores) are especially revealing in this context, as are the data on soil conditions from the subsample of field squares.

For broader scale, national impacts of this type, both the spatial and temporal scales of Countryside Survey are generally appropriate. Changes due to these effects are relatively slow, and the impacts widespread – albeit sometimes difficult to distinguish against the 'noise' of local changes. Many of the models currently available are also relatively coarse in terms of their geographic and temporal resolution. In general, therefore, CS2000 data may be considered adequate. As well as providing a basis for assessing impacts, they might also be useful in modelling ecosystem recovery.

For some issues of environmental pollution, however, there is the need to analyse CS data at sub-national scale, using spatial strata other than the environmental zones – for example, in order to assess effects within specific land use systems or in especially vulnerable areas or priority habitats. Analysis of geographic patterns in any effects, and in the changing geography of these effects over time, might equally be informative in attempting to explore causality or to apportion effects to different sources. In these cases, the spatial resolution and representativeness of CS data are likely to be limiting, and some form of interpolation or modelling will probably be needed. Further research is required to develop and test different methods and approaches.

The assessment and analysis of the impacts of pollution, whether in the countryside or elsewhere, also require more data than CS alone can provide. Information is likewise needed on other indicators of ecological change – for example for biological groups and for markers of pollution not covered by Countryside Survey. There is, therefore, considerable scope to enhance the role of CS2000 in this area by linkage with data from other sources, including the Environmental Change Network, Environmentally Sensitive Areas (ESA) monitoring, the UK Acid Waters Monitoring Network (UKAWMN), the national lichen survey (Seaward 1995-99), the new atlas of British and Irish flora (Preston *et al.* 2002) and other monitoring schemes.

4.1.8 *Climate change*

Concerns about climate change are a major driver for environmental policy in the UK and more widely. The need for action to combat climate change therefore motivates, or is reflected in, many different policy areas, including the environment, energy, and transport.

Potential impacts of climate change on the countryside – both in terms of habitats and agricultural production – are an especial concern, and have been the focus of extensive study. Examples include the Modelling Natural Resource Responses to Climate Change (MONARCH) study (Harrison *et al.* 2001) and the DEFRA-funded Regional Climate Change Impact and Response Studies in East Anglia and North West England (ReGIS) project (http://www.silsoe.cranfield.ac.uk/iwe/projects/regis/). Major pathways for change include the effects of temperature or precipitation change or increased storminess on vegetation growth, changes in the extent and activity of disease and pest species, compositional changes in the surface atmosphere, and – in response to these – changes in land use and land management practice.

Countryside Survey clearly provides an important instrument for assessing the outcomes of such changes and for informing policy. Many of the factors that inhibit its use in other policy areas, such as its spatial scale and relatively long repeat interval, are less limiting (or can even be strengths) in relation to climate change. Nevertheless, the effects of climate change are inevitably slow and subtle in most cases, and detecting them against the backdrop of the myriad other factors that influence the countryside directly from CS is unlikely to be feasible. Instead, as in other areas, attribution of change needs to be based on either detailed, field studies (e.g. the ECN), or through modelling approaches. In both cases, however, Countryside Survey has an important role, both by providing a system to scale up these results to the national level (and check for conformity with observed national trends), and as a source of data inputs for modelling climate change effects. Data from CS (or derivatives such as the UK CORINE land cover map) have already been used for these purposes: notably by the UK Climate Impacts Programme. Further application of the data can be envisaged as the spatial resolution of the climate models improves, with the consequent ability to make more localised assessments of impact.

In this area as others, however, CS data are rarely used alone. They need to be combined with geographic data on a wide variety of other factors: not only the outputs from the climate models, but also information on land use, farming structure, management and soils. As has been noted, linkage to some of these data is relatively straightforward, but access to some data sets (e.g. soils, management) remains difficult. This continues to act as a significant – even if not insurmountable – obstacle to CS use in this area.

4.1.9 *Policy analysis: prediction of change and attribution of effect*

Monitoring of existing policies and environmental issues in the countryside is clearly a major priority in relation to CS2000. If the performance or cost-effectiveness of existing policies is to be assessed, however, we need to be able to identify and quantify their effects on the environment. Equally, if policies are to be proactive and pre-emptive, there is a need to foresee problems before they occur. And if policy-making is to be effective – and if information is to drive policy rather than merely respond to it – it is essential to be able to assess and compare policy options in advance of implementation, so that the most appropriate policy measures can be selected. Policy analysis thus requires two specific capabilities: causal explanation and attribution of environmental change; and prediction of future environmental changes and policy impacts.

Explanation and prediction, however, are amongst the most challenging of tasks. Many factors confound relationships between policy and the condition of the countryside. At the very least, analysis of policy effects requires that these be controlled for, so that the 'residual' impact, that might plausibly be attributed to the policy of interest, can be identified. Stronger inference requires even firmer evidence – for example through controlled experiment.

Prediction is equally problematic. Issues for the future are not easily foreseen. There is a long list of possible issues that might need to be addressed, and selecting between them in the absence of monitoring data is often difficult – yet monitoring is rarely undertaken until a policy need has been identified. Reliable prediction of the future also requires the ability to go far beyond exploratory analysis. It depends upon the understanding of causality and the availability of models that can represent these causal associations within tolerable uncertainties. This understanding, and these models, are generally not yet available.

Nevertheless, Countryside Survey certainly can contribute to policy analysis. Used together with other relevant data sets, it can provide a basis for exploratory analysis of patterns and trends, as a basis for hypothesis development. Both geographical and longitudinal (retrospective and prospective) studies may be useful in this context. These types of analysis can equally help to calibrate and validate models (e.g. through 'now-' or 'hind-casting') – an important task in view of the often limited field-testing of many models at the landscape scale. A further potential use is to help scale up results from detailed field or experimental studies to the landscape scale – and then seek corroborating evidence in the trends and geographical patterns observed. Nevertheless, many of these types of analysis rely on the ability to link CS data to other data sets, often as a fine spatial resolution (and in the case of experimental data for specific localities). To achieve this will therefore often require access to the detailed field data that underpin CS2000. As already noted, confidentiality constraints on access to these data act to deter users and limit such enquiries.

4.2 Policy implementation and habitat management

Whilst policy sets the framework and the context for environmental protection in the countryside, the translation of these policies into practice depends fundamentally on the actions taken by land managers on the ground. Habitat management is therefore a vital factor in determining the effectiveness of these policies, and the ultimate fate of the countryside. Habitat management lies in the hands of a wide range of organisations and individuals, including conservation agencies, local authorities, voluntary bodies and individual landowners. All are likely to benefit from access to reliable information on the state of the habitats under their responsibility, and all, potentially, might therefore use Countryside Survey data to support their management decisions.

From past experience, however, actual usage seems somewhat limited. Studies of the extent to which CS1990 data were used by organisations concerned with policy implementation and habitat management (e.g. Tantram 2002) suggest that the data are regarded as of only marginal relevance. Commonly cited deterrents included the spatial scale of the data, their temporality and the classification systems, none of which were considered ideal for local application.

Despite the changes in the classification systems, this situation is unlikely to change greatly with completion of CS2000. In general, the day-to-day management decisions made about individual habitats or sites are not directly addressed by a national survey of this type. They are far better served by specific, purpose-designed monitoring and surveys, by the accumulated understanding and knowledge of the local staff, and by in-house information and reporting systems designed to capture this knowledge in a systematic way. That is not to say that such systems are always in place and effective. Indeed, only in relatively recent years have formal management information systems and associated technologies such as GIS been introduced into many of the organisations responsible for management (Briggs and Tantram 1997, Briggs *et al.* 1996). Local action, however, requires local knowledge. Rarely can the sort of broad overview provided by surveys such as CS2000 substitute for this knowledge.

Nevertheless, they can complement it. CS2000 data, therefore, do have potentially important contributions to make to management. One important contribution is by providing a national and regional context for this local knowledge – for example, by helping to show how typical the local experience is compared to other habitats of that type. Analysis of national data from Countryside Survey can also help to give insights that might not be available at the individual site level (e.g. by highlighting new threats or trends in habitat condition that are detectable only when analysed across broad areas or a number of sites). In addition, CS2000 can provide both a standard and a template for local surveys, that can improve both the quality and the comparability of habitat monitoring. The need for this is already urgent. Under the Public Service Agreement to ensure that at least 95% of all SSSIs are in a favourable condition by the year 2010 (http://www.defra.gov.uk/wildlife-countryside/consult/sssi/), for example, the JNCC has responsibility to establish Common Standards of Monitoring for SSSIs across Great Britain. At the same time, Planning Policy Guidance Note 9 (PPG9) on Nature Conservation (in England) encourages local authorities to identify and record local nature reserves. In response to this growing need for harmonisation of monitoring, JNCC has recently developed the RECORDER 2000 system to provide automatic and consistent data entry for the National Biodiversity Network by wildlife recorders. Countryside Survey clearly offers a framework within which to bring together local and site-level monitoring such as this, to help provide a broader, national picture.

By the same token, the potential exists to use these management data to complement Countryside Survey. Much of the detailed information about habitats and areas of importance lies in the hands (and filing cabinets) of those with responsibility for their management. These data have considerable potential significance beyond their local, management role. For example, they often provide the only direct observational information on changes in response to management interventions at the site level. Countryside Survey offers a framework within which to bring together and interpret these sorts of data for the wider good. Efforts to exploit this potential as part of follow-up work on CS2000, or within subsequent Countryside Surveys, are likely to be worthwhile.

4.3 Providing policy indicators

One of the consequences of an evidence-based approach to policy – and a key feature of all the areas of policy considered above – has been growing reliance on the use of indicators for policy support. Given the complexity of the real world, and the many different parties involved in managing it, there is a clear need for access to simplified, concise, interpretable and targeted information, that can convey the key messages about the status of the countryside to users, in a form that they can all understand. Indicators are considered to be one way in which this can be achieved. Properly constructed and presented, they can give clear guidance on both trends in the state of the countryside and spatial patterns and variations of relevance to policy and management. In theory (if not always in practice), indicators can thus be used:

- to highlight hotspots and problem areas, where action is needed
- to alert decision-makers to problems that might need to be addressed
- to assess the performance and impacts of policy and other interventions
- as a basis for lobbying and awareness-raising

In recent years, therefore, increasing efforts have been devoted to developing indicators for policy support, in all sorts of fields and at every conceivable level of application. A particular focus has been to support policies on sustainable development. Internationally, for example, OECD (1996), UN (United Nations 1998) and the EEA (European Environment Agency 2002) have all taken the lead in developing sets of indicators for sustainable development. In the UK, a sustainable development indicator set has been established, the *Quality of Life Count* indicators (Government Statistical Service 1999). Many similar indicator sets have been compiled at country, regional and local level (Table 7).

Amongst this large and growing number of environmental and sustainability indicators, the majority tend to focus on issues of land use, pollution, waste and climate change. Data from Countryside Survey are already being used to some extent to support the development of these indicators – for example, the national sustainable development indicators. Several factors nevertheless constrain the use of CS data for these purposes. Chief amongst them are the problems of spatial resolution, accuracy and timeliness.

Table 7. Examples of countryside-related indicators

European Environment Agency: ***Sustainable development indicators***	
• Species in dry grassland • Protection of grasslands • Pressures on grasslands • Organic farming • Nutrient surpluses • Land take by transport infrastructure	• Fragmentation of ecosystems and habitats • Ecosystem damage by air pollution • Change in area and use of grasslands • Agricultural eco-efficiency • Agri-environmental management contracts
DETR (now DEFRA): ***National indicators of sustainable development***	
• Populations of wild birds • **Trends in plant diversity*** • Biodiversity action plans • Landscape features • **Hedges, stonewalls and ponds*** • Extent and management of SSSIs • **Countryside quality***[Ψ]	• Access to the countryside* • Native species at risk • Area of woodland in the UK • Ancient semi-natural woodland • Sustainable management of woodland*
Environment Agency: ***Your environment***	
• Land use in England and Wales • **Landscape features in Great Britain*** • Area of woodland in England and Wales • Extent and management of SSSIs in England and Wales • Net loss of soils to development in England • Livestock on agricultural holdings in England and Wales • Use of pesticides in agriculture and horticulture in England and Wales	• Organic matter in agricultural topsoils in England and Wales • Consumption of inorganic fertilisers in the UK • Heavy metals in agricultural topsoil • **Trends in plant diversity in Great Britain*** • Occurrences of otters in England and Wales • Populations of wild birds in the UK • Coarse fish catches • Agricultural land use in England and Wales
Forestry Commission: ***Indicators of sustainable forestry***	
• Area of woodland • Tree Species • New woodland creation • **Loss of woodland*** • Area of managed forest • Area of each management type • **Woodlands in landscape*** • Ancient woodland • Native woodland • Native woodland condition • Richness of fauna • **Richness of flora***	• Natural regeneration of woodland • Diversity of woodland within a stand • Crown density • Damage by fire and wind • Other damage • River habitat quality • Soil chemistry • Water quality • Surface water acidification • Water yield and stream flows • Pollution incidents

Table 7 (continued)

MAFF (now DEFRA): ***Pilot set of sustainable agriculture indicators***	
• Area converted to organic farming systems • Pesticides in rivers • Pesticides in groundwater • Pesticide use • Quantity of pesticide active ingredients used • Spray area treated with pesticides • Nitrate and phosphorus losses from agriculture • Phosphorus levels of agricultural topsoils • Manure management • Use of water for irrigation	• Organic matter content of agricultural topsoils • Accumulation of heavy metals in agricultural topsoils • Area of agricultural land • Change in land use from agriculture to hard development • Planting of non-food crops • Area of agricultural land under commitment to conservation environmental conservation • **Characteristic features of farmland*** • Area of cereal field margins under environmental of agricultural land • **Area of semi-natural grassland*** • Populations of key farmland birds
Scottish Executive: ***Checking for change (consultation)***	
• Trends in biodiversity action plan priority species[Ψ]	• Trends in natural habitats[Ψ]
Welsh Assembly: A sustainable Wales – measuring the difference (consultation)	
• The populations of wild birds that are now in decline must have stabilised or started to rise by 2010[Ψ]	

*Notes: * (***Bold)*** *Based wholly or partly on data from Countryside Survey*

Ψ Under development

At the national level, spatial resolution and accuracy are not especially limiting, for as has been noted CS2000 provides reliable estimates of both stock and change at this scale. Timeliness is, however, a more serious problem. Even where not much is changing, indicators need to be seen to be up to date if they are to carry conviction. At times when policies are developing relatively rapidly – as currently in the countryside – this is even more important. If countryside issues are to be well represented by national indicators, therefore, it is important that they do not become obsolete too quickly. With national surveys only every six or eight years, and a delay of ca. two years between the survey and production of the relevant statistics, this can be a problem. It seems likely that – as with decennial population censuses – there will be a need for interim estimates, in order to meet the demand for more contemporary information at the national level. How these might be derived, and the implications for future countryside survey, will be discussed later in this report (section 5.3).

There are, however, also important needs for indicators at the regional and local level. This sector is crucial, for it comprises local authorities, regional authorities, and agencies such as National Park authorities, who ultimately carry much of the responsibility for implementation of policies on the countryside, and who have major obligations to report regularly to the public. The importance of this sector is also likely to increase as a result of regional devolution. At these more local scales, spatial resolution and accuracy become far more limiting. Data from CS2000 are therefore unlikely to provide an adequate alternative to locally derived data (e.g. from independent surveys or from the routine reporting and management systems of local authorities and agencies).

Countryside Survey data nevertheless has considerable relevance. Local indicators rarely exist wholly in isolation. Instead, they often gain value and significance when they can be linked to comparable national indicators. This both sets a context for the local indicators and provides a means of channelling local issues into the national policy debate. It is especially pertinent, therefore, when local indicators are used to support lobbying: it is rarely sufficient, for example, simply to show that a specific area is in some way impoverished or important – what is needed is to show that it is exceptional in relation to national norms. By the same token, improved consistency between local or regional and national indicators is important to encourage informed debate about national policy.

Such vertical linkage depends, however, on the upward (and downward) compatibility of the data (and methods) used to derive the indicators. Countryside Survey certainly facilitates such comparability by providing coherent and, to a large extent definitive, statistics and indicators at the national and broad regional level. It also provides a form of spatial stratification, which can be used to scale information from one level of aggregation to another – for example to extrapolate local indicators up to the regional scale. In addition, one of the strengths of Countryside Survey, which appears now to be increasingly recognised (though might still need further promotion), is that it provides a template and a standard for monitoring that can be adopted and used at the local level. In various ways it thus act as a mechanism for increased vertical integration both of monitoring effort and of the indicators that are thereby developed.

4.4 A basis for research

The link between policy and research is intimate. Because policy concerns often shape budgets for research programmes, much research shadows policy. Equally, research findings act to inform policy, not only specifically (i.e. through commissioned studies aimed at resolving policy questions), but also more generically by contributing to the debate that surrounds policy and – on occasions – by helping to raise new concerns. Monitoring and routine data collection, like that provided by Countryside Survey, typically supports and helps link the two.

This close synergy between research, monitoring and policy is certainly true in the case of the countryside (Figure 1). Monitoring of the countryside is only one stage in the process of informing policy. To translate this information into action requires both that it is analysed and interpreted and, where necessary, supported by further, in depth research. CS data can thus be used alongside other data to show how the countryside is changing, while research and modelling, using these data, can help to explore and explain why these changes are occurring. Policy – informed by these data and research results – provides the means to define how the countryside should be changing, and to set relevant targets and objectives for change and thereby guide management. Policy analysis then provides a check upon the effectiveness of policy interventions, and helps to refine or adjust policy according to need.

As this implies, development and use of Countryside Survey data is as much an issue for research as it is for policy. If it is working effectively, CS will provide both an agenda for research (on behalf of itself and the policy it supports) and core data inputs to research enquiries.

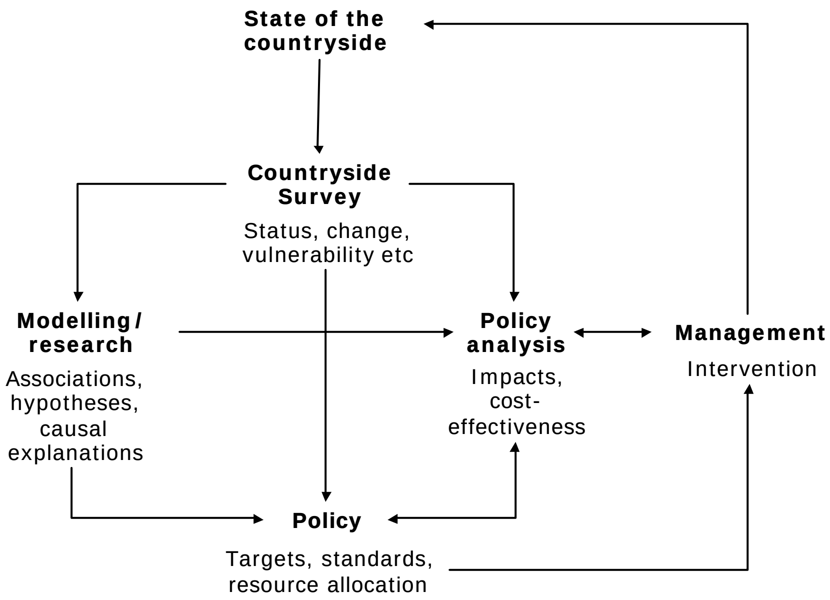

Figure 1. Countryside survey, research and policy

Many of the more immediate research needs that arise from use of CS data to support policy have been mentioned above. They might usefully be classed into four main types:

- Methodological studies – e.g. into techniques of spatial modelling, process modelling, statistical analysis and uncertainty involved in trying to obtain more information out of CS data, and to enhance Survey design.
- 'Ecological' studies, using CS and other data to analyse patterns and trends in the environment at the aggregate level, in order to develop hypotheses and provide preliminary interpretations of processes and impacts on biodiversity, habitat extent and habitat condition in the countryside.
- Basic (often experimental or observational) research, aimed at analysing causal processes within the countryside, that might help to explain spatial patterns and trends and provide detailed quantification of the impacts of policy interventions and other driving forces.
- Modelling studies, aimed at using models or scenarios to examine, often predictively, trends and processes in the countryside – e.g. in relation to climate change, habitat loss or gain, policy impacts. In these cases, CS data are used either as inputs to the models or, more rarely, as a means of validation and calibration.

Many of these studies are already being done, and the research base supporting Countryside Survey, and deriving from it, has grown considerably in recent years (Table 8). Many other research applications using CS data, some of them far removed from the core functions of Countryside Survey, also undoubtedly take place. Examples include the use of land cover data both from LCMGB and from the CORINE land cover map for modelling population distribution, to provide estimates of rurality in epidemiological studies, as inputs to studies on light pollution modelling, for tranquillity mapping and for modelling streamflow in lowland catchments.

Table 8. Examples of CS-related research

Area	Topic	Authors/source
Field survey methodology	Field mapping Sampling habitat change	Barr and Furse (in press) Cooper and McCann (in press)
Land cover mapping and remote sensing	Land cover of Jersey Parcel-based approaches to RS data Hedgerow mapping using RS data Use of CASI-Lidar data Landscape modelling and mapping	Smith and Fuller (2001) Smith *et al.* (2000); Dean and Smith (in press); Fuller *et al.* (in press) Hill *et al.* (2001a) Hill and Veitch (1999) Hill *et al.* (in press); Hill and Veitch (in press)
Habitat stock and change	Assessing stock and change in land cover and biodiversity Landscape and vegetation change Change in Broad Habitat extent Stock and change of field boundaries National scale vegetation change	Firbank *et al.* (in press) Haines-Young *et al.* (in press) Howard *et al.* (in press) Petit *et al.* (2001, in press) Smart *et al.* (in press)
Agricultural landscapes	Arable plants and farmland birds Ecological quality under agri-environment schemes	Firbank and Smart 2002 Carey *et al.* (in press)
Soils	Assessing soil biodiversity	Black *et al.* (in press)
Data analysis and data quality	Sources of error in estimating hedgerow length Statistical classification techniques	Howard (2001) Watkins *et al.* (2001)
Other applications	Habitat modelling Streamflow modelling Tranquillity mapping Health risk assessment Air pollution modelling Light pollution modelling Ancient woodland indicators	Tantram (2002) Beale (2002) EU PLAINS project (www.space.qiineteq.com/plains/www_plains1.html) SAHSU projects (de Hoogh *et al.* in press) EU APMoSPHERE project (web site not yet established) EU MANTLE project (www.mantle-project.com) Smart *et al.* (2001)

Notes: Excludes module reports, internal CS reports and commissioned studies

For many researchers, therefore, Countryside Survey is already recognised as a useful data source, and a wide range of research questions derive directly or indirectly from the Survey and its subsequent findings. Undeniably, it has a significant influence on research in the UK, across a surprisingly wide spectrum of disciplines. Nevertheless, whether or not research is either making optimal use of CS data, or providing the full level of support needed to the Survey, is open to debate. Problems and constraints commonly cited by researchers tend to be the same as those referred to by other users (not surprisingly, for the division between research and policy uses is transitional and blurred). They include:

- difficulties of access to the data (especially the field data) in a geographic format that meets the research needs – often because of problems in accessing the raw sample square data, or in deriving from these reliable area estimates for the study area of concern;
- related to this, limitations of spatial resolution and scale, especially where data are needed at sub-kilometre level (e.g. for catchment modelling);
- historically, in the case of the land cover data, problems of cost (though this may have been sufficiently addressed by LCM2000);
- lack of key attributes or information within the data set (e.g. on archaeology, landscape quality, management);
- difficulties in acquiring other data sets of a similar quality and scale to link to CS data (e.g. agricultural census data, soils);
- inappropriate land cover or habitat classifications, or inadequate representation of specific landscapes or habitats of interest, within the readily available, aggregate data;
- difficulties in extracting data sets from CIS for incorporation into other software packages;
- in some cases, the lack of suitable models and analytical techniques to enable full use to be made of the CS data.

Few of these problems are insurmountable, and in most cases researchers find ways of solving them. It also has to be remembered that researchers are frequently endeavouring to push the available data to their limits, and then expressing frustration that they will not go any further. These problems do, however, appear to act as a significant deterrent in some situations, especially for more exploratory or pilot studies. It also has to be remembered in this context that many would-be users are not specifically interested in Countryside Survey or even in the countryside: they simply need the data as part of a larger study, driven by other considerations (e.g. model requirements) and often directed at some other concern (e.g. hydrology, atmospheric pollution). In these cases, factors such as ease of access or cost can play a decisive role.

Perhaps more important in determining the shape and extent of research relating to Countryside Survey, however, is the funding regime. Over recent years frustration has been expressed (e.g. in various meetings of the Land Use Research Co-ordination Committee – LURCC) about the lack of a dedicated programme to develop uses of, or support for, CS funded by the research councils. Clearly (and understandably) much of the NERC support for Countryside Survey goes directly to the Survey itself, and to preparatory or follow-up work in CEH. Opportunities to bid competitively for funds for research projects that might explore wider applications of CS, devise and test new modelling techniques, or carry out detailed validation and inter-comparative studies are limited. It is difficult to evaluate the significance of this issue, for researchers increasingly follow funding, so latent demand is rarely expressed: if funds are not available, then researchers tend to turn to other topics. Rightly or wrongly, however, there is a perception in the university sector that research into and with CS is largely the preserve of CEH, and difficult to break into (and perhaps not worth the effort). If this is true, it is certainly regrettable, for it means that research emanating from, or that might feed into, Countryside Survey is being constrained. It also means that the core research community – like the user community for CS – is relatively small. Given the growing opportunities and need for mining the CS database for a wide range of questions, it can be argued that more effort needs to be made to open up this research community. Consideration thus needs to be given to ways of promoting and funding this process.

A further question that needs to be raised – though cannot easily be answered – is whether feedback between the research relating to CS and Countryside Survey itself is operating effectively. No doubt much of this feedback operates at the individual level – simply through professional involvement in the research community. Projects such as ECOFACT (Hill *et al.* 1999) have also contributed greatly to development of CS methodology in the past. There is, however, scope to try to capture the knowledge that surrounds CS more coherently, perhaps by developing a database of CS-related research, with an open archive of data sets and results derived from these studies, like that run by ESRC. This would have the great benefit of adding to the pool of data that researchers and others could use.

5. LESSONS FOR THE FUTURE

As the previous section has shown, CS2000 provides a significant advance on previous countryside surveys, and has the potential to serve both policy and research in a wide range of different areas over the coming years. At the same time, it is evident that use of CS2000 is still constrained in many of these areas, both because of the inevitable limitations of the data it provides and because of limitations in other relevant data sets.

It also has to be recognised that Countryside Survey comes at a cost: the direct costs of CS2000 modules, for example, was in the order of £4.5 million (excluding modules 9 and 17), and an unknown, but probably comparable, cost will eventually be incurred indirectly through research projects related to CS2000, carried out either by CEH or by other organisations (funded, for example, by government departments, research councils, the EU, or institutional research budgets). As with almost any information source, the policy and other benefits from CS2000 are largely invisible. In principle, they are represented in the form of increased effectiveness of policies on the countryside, by reduced costs of policy formulation and implementation, and by improvements in (or maintenance of) the qualities of the countryside. In many cases, also, Countryside Survey makes small but important contributions to research, policy and socio-economic well-being far beyond the countryside *per se* (e.g. through the use of the data in areas as diverse as environmental health, atmospheric pollution and social deprivation). These various benefits are difficult to evaluate in any rigorous manner, though they are potentially considerable. Whether the benefits outweigh the costs cannot at present be determined (there is, perhaps, a need for research to assess more explicitly these costs and benefits – e.g. through willingness to pay studies). Even in the absence of this information, however, it is clearly essential to consider the future of Countryside Survey as objectively as possible. The mere existence of the Survey and its continuation until now are not enough. If future surveys are to be conducted, then it is essential to be assured that it has a clear role to play, that it can serve that role effectively, and that it will in fact be used.

Three key questions therefore need to be addressed:

- should Countryside Survey be continued?
- if so, in what form (what changes to survey design should be considered)?
- when should the next survey be?

5.1 Should Countryside Survey be continued?

For all the caveats and criticisms that might be (and sometimes are) levelled at Countryside Survey, several facts are clear. It already provides definitive and crucial information in a number of key policy areas, especially in relation to biodiversity, sustainable agriculture, environmental pollution and climate change. In these areas, extensive use is made both of the data on habitat extent and measures of condition in support of policy. The land cover map is also a highly valuable source of information for policy support in a wide variety of areas (including many far beyond the concerns of biodiversity or the countryside *per se*). The value of these data has increased, in many ways more than additively, as the time series of surveys has built up, simply because each new survey adds to the capability to detect and explore trends and changes in the countryside. As noted, the policy relevance of the habitat-related information in CS2000 has also been increased by the use of Broad Habitats as reporting classes. In all these areas, therefore, Countryside Survey has shown its worth as a tool for evidence-based policy-making and policy appraisal.

It is also evident that the need for information on the countryside will increase, rather than diminish, in the years ahead. This increased demand is due, in the first place, to the need to monitor and report on existing policies (e.g. the Biodiversity Action Plan, Rural Development Plans, Sustainable Food and Farming Strategies). It will occur, secondly, because of new and emerging policies both in the UK and more widely – e.g. the Water Framework Directive, soil protection policies, and further reform of the CAP. Each of these creates the need both for baseline data, to target and provide a reference for policy, and for indicators and other measures of change to monitor trends. Countryside Survey clearly cannot meet these needs alone: in most cases, more detailed, purpose-designed monitoring is also required. But it undoubtedly provides a vital, countrywide framework and data source, for which at present there is no obvious substitute. For this reason, it needs to be continued. This, it might also be said, is the almost unanimous opinion of all those consulted in this study (Annex 1).

5.2 What changes need to be made?

5.2.1 Pressures for change

Countryside Survey faces many forces for change. Of them all, probably the most powerful are those that are acting to demand more detailed data, at a regional or local level, for these are pushing Countryside Survey beyond its current limits. To some extent the pressures are already there: as previously noted the inability to obtain reliable, local estimates from the Survey already limits its utility in the eyes of many would-be users. The pressures are likely to grow, however, as new developments occur.

Regionalisation of policy

One of the most important of these developments is regionalisation of policy. With the devolvement of many powers to national and regional institutions, the requirement is inevitably growing for information at a more regional scale. Countryside Survey was not originally conceived to provide data in this form, but with the extension of the sampled squares in CS2000, and with the development of land cover mapping, it is now feasible to provide reliable data on both habitat extent and condition at a sub-national (i.e. country) scale. Further development of this policy (e.g. to devolve more powers to English regions) would, however, generate need for further regional disaggregation of the data and may generate the need for further changes in the sample design in future.

New policy developments

A second force behind this demand for more localised data is the development of new policies, many of which targeted at more narrowly defined areas or habitats. Policies for environmental enhancement and habitat protection, for example, are increasingly implemented through schemes or legislation targeted at specific areas or categories of land. Agri-environment schemes, ESAs, SSSIs, AONBs and National Parks are all crucial in this respect. Areas under these various designations thus represent the main areas in which positive changes in the countryside can be expected, and should provide the flagship for countryside management. The EU Water Framework Directive, likewise, will focus attention (and the need for monitoring) on individual catchments. Attached to many of the policies and management plans associated with these areas are also targets and objectives on habitat condition and extent.

Effects of these policies can be monitored through Countryside Survey in general terms – by their reflection in national and regional statistics – but the Survey currently gives little specific information either about individual areas or categories of land. It cannot report directly on the achievements of agri-environment schemes, for example, nor on progress towards the government target that 95% of SSSIs in England should be in a favourable condition. It must be accepted that Countryside Survey is not designed to monitor all elements of policy or to detect and explain all their potential changes in the countryside.

Threatened and sensitive areas

The third source of pressure on Countryside Survey comes from the need to respond to threats and forces that operate differentially across the countryside. Though many threats to the countryside (e.g. from climate change) are relatively universal, they do not necessarily operate equally everywhere. Many others (e.g. soil pollution) are specific to particular habitats and areas. These vulnerable areas and habitats are not always well represented or adequately discriminated by Countryside Survey.

Intensive farming, for example, covers 46% of the UK land area. This area is subject to management systems that both differ substantially from other areas of the countryside and are intrinsically very diverse. Some of the major changes in the countryside – and certainly many of the most rapid changes – are also taking place in these more intensively farmed areas. Intensive sampling is carried out of field boundaries and many other vegetation classes in these areas, so detailed data are available. Yet they comprise only two out of the seventeen Broad Habitats recognised in CS2000. There is a consequently a tendency, at least in much of the published and readily available information, for them to be reported in less detail, and discriminated less finely, than other areas. To provide better representation of these areas also requires different types of information: data are needed not just on vegetation and wildlife species but also on soil quality and farm management.

Urban and peri-urban areas, similarly, are zones of important development and change affecting the countryside both directly (e.g. by land-take) and indirectly (e.g. through air pollution or the invasion of alien species). Currently, however, they have received less attention in analysis of CS data (though they will, perhaps, be investigated as part of the FOCUS study), with the result that implications of changes in these areas for the wider countryside are not well quantified. Coastal areas are also relatively poorly represented by Countryside Survey (especially those in the intertidal zone), although they are coming under increasing pressure in many cases from developments such as tourism and fish-farming, as well as problems of coastal erosion.

Likewise, some areas merit especial attention because they can be seen as sentinels of countryside change, often as a result of their economic or ecological sensitivity. Quite small changes in economic circumstance, land use or management practices may thus invoke rapid and significant responses in these areas. Monitoring of these areas may thus provide an early warning of pressures and changes elsewhere. Definition of such areas in the abstract is difficult – their existence depends upon the local balanced between external pressures and internal sensitivities. Examples, however, may include the upland margins (which tend to act as buffer zones between more intensively farmed and the open uplands), and wetlands (which often represent important sinks from large surrounding areas).

Technical and scientific developments

Policy and information needs are not the only forces for change. While policy may be the major driver for Countryside Survey, science, knowledge and survey technologies are the enablers. Countryside Survey needs to evolve to make the best use of these. If it does not do so, sooner or later the quality of the information it generates will be called in to question. Users will become aware that better (e.g. higher resolution, or more information-rich) data are available, and will expect them from Countryside Survey. The use of new technologies nevertheless creates tensions. Since the publication of CS1990, for example, significant advances have been made in monitoring and survey technologies, especially through Earth Observation. Already some of these have been introduced in CS2000: LCM2000, for example, was adapted to make use of improved methods for image classification. One consequence, which has not yet been addressed, is that direct comparisons between the land cover maps for 1990 and 2000 cannot be made. In the area of remote sensing, especially, this tension between old and new will continue. New satellite systems are now becoming operational (notably Envisat), that are likely to enhance further the data available for monitoring habitats and biodiversity. Future surveys need to respond to, and make use of, these.

5.2.2 How much change?

In the face of these pressures for change, Countryside Survey clearly needs to adapt. Previous surveys have evolved; future ones should do likewise. Herein, however, lies a profound dilemma.

Countryside Survey clearly needs to continue to evolve. It must do so to resolve weaknesses and gaps in the data they provide, to adapt to new policy and research demands, and to improve by making use of new knowledge and technology. It also needs to do so to ensure that the user base remains sufficiently large to finance the surveys.

Increasingly, however, the strength of Countryside Survey is the time series data it generates. To a great extent it has been the extension of this time series now to four surveys that has created what several users have described as a ‘critical mass’. The implication is that the utility of Countryside Survey is increasing more than proportionally with each new survey that it provides. The value of this time series, however, is not due simply to its continuity. It is the *consistency* of the data series (especially over the last two or three surveys) that enables data from one time period to be compared with another, and gives the ability to detect and quantify changes and trends. To maintain the sequence, therefore, each new survey must be designed so that it is comparable with those that went before.

The great challenge for Countryside Survey in the future is to resolve this fundamental dilemma. It must continue to meet the changing policy and research needs, and stay up-to-date with science and survey technology, without sacrificing its continuity with the past. Countryside Survey is not alone in facing this dilemma. It is a problem encountered by almost all long-term surveys, especially in areas of rapid policy or technological change. The air quality monitoring networks in Britain have changed substantially in recent years, for example, in response to the changing character of air pollution: traditional networks for monitoring SO_2 and black smoke have been rationalised and greatly slimmed down; in their place, new, increasingly automated networks have been established monitoring the 'modern-day' pollutants, such as particulate matter and nitrogen dioxide. Strategies for soil survey in England and Wales have been substantially reformed on a number of occasions over the last 30-40 years, with plans for national coverage being developed and partially implemented for maps, variously, at 1:63,360, 1:25,000 and 1:250,000 scale (only the last of which was ever completed), and ultimately the abandonment of national mapping altogether. This has left a number of incomplete and largely inconsistent map sets at different scales.

Examples such as these show that monitoring and survey systems can rarely stand still. But they also show that the processes of survey and monitoring are in some ways more fundamental and in many cases need to be more durable than that of the policy they serve. Most policies are inherently ephemeral. But the data that underpin policies in the countryside, that show the effects of policy, that reveal trends either in or outside the context of policy, that expose the need for new action (often long before policy-makers themselves are aware) and that feed into research, need to live in a different dimension. They can only serve these purposes if they are to a large extent independent of the policy imperative – if they can exist before the policy need arises, and survive changes in the policies. Monitoring, such as that undertaken within Countryside Survey, must clearly and unequivocally support policy (indirectly, through the medium of indicators and research if not always directly in the form of the raw information they produce). Yet Countryside Survey must also have a life of its own if it is to pre-empt and outlive immediate policy need, and provide the capability to look back on policy achievement objectively. Wholesale change, or change simply for the sake of it, must therefore be avoided. As in the past, change within limits must be the principle. Continuity and consistency should not be jeopardised.

5.2.3 Modifying the field sample framework

One of the main needs that emerges from the discussion above is for more localised and more user-specific information. At the same time, any attempts to provide such data must be implemented with care, for it would be all too easy either to make the Survey no longer financially viable, because of its inflated costs, or to destroy its long-term consistency.

In many ways the source of (and solution to) this problem lies with the field survey, for it is this that is most strictly limited in terms of its scale of application. These limitations arise primarily from the sampling framework used in the field survey. As explained previously (Section 3.1), this is a random stratified design, in which 'ITE land classes' define the strata, that are then randomly sampled in the field. Improvements in the scalability and regional accuracy of Countryside Survey might thus ostensibly be achieved either by changing the stratification system or by increasing the sample size.

Increasing the sample size

Perhaps the most obvious and direct way of improving the regional accuracy of estimates derived from the field survey would be by substantially increasing the number of sample squares. Already the sample size has been expanded considerably, from 256 in 1978 to 569 in 2000. A further 628 0.5 x 0.5 km squares have also been analysed in Northern Ireland in association with CS2000. The opportunities to increase the sample size further, however, are severely restricted. Field survey represents a major commitment, and accounts for a major part of the costs of Countryside Survey. Any substantial increase in the sample density would thus have significant cost implications for the Survey. It might also increase difficulties of completing the Survey within a sufficiently short period. Field survey can only be conducted at certain times of the year (when the botanical features needed for species recognition are identifiable). The number of surveyors who can be recruited and trained at one time is limited. Vagaries of the weather also mean that substantial parts of any one field season may be lost (as in 1998). For all these reasons, a general increase in the number of sample squares seems inadvisable. Limited increases in sampling intensities may, however, be merited in specific geographic areas, or in specific habitat types, as discussed below.

Modifying the stratification

The alternative would appear to be to modify the stratification system. This serves two, related purposes: to ensure geographical and ecological representativeness of the sample field squares, and to facilitate extrapolation of field data to regional and national level. In general, it achieves both these aims effectively. Despite changes in the reporting classes (e.g. the introduction of Broad Habitats in CS2000), it has – with some increase in sampling density in some areas – delivered acceptably accurate estimates of habitat extent and condition at national (GB), country and subnational (e.g. environmental zone) level. Nevertheless, the reliability of any estimates clearly depends on how well this stratification represents variations within the reporting areas and classes of interest. As the reporting areas required by users change – and in particular, as attention focuses on more localised areas – the adequacy of this stratification may be called into question. In particular, the need to define finer land classes, that can provide estimates of more local patterns, may arise.

The issue might be crudely illustrated in relation to a habitat type such as saltmarsh. Under the current land class system, reasonable reliable estimates may be made for environmental zones or countries. The individual land classes within which saltmarsh has been reported, however, are not confined to the coast. Any user-defined subarea that happens to contain the relevant land classes will be reported as including areas of saltmarsh, even if it lies wholly inland. This can lead not only to substantial errors in estimates of habitat extent, but also wholly counter-intuitive impressions of habitat distribution.

Several ways might be considered of reducing these types of error. One would be to change the underlying stratification. This, however, would have serious implications, for it would also require a change in the distribution of the sample squares, and would break continuity and comparability with previous surveys.

A second approach would be to define sub-units within the land classes, defined to represent more local zonations. This, however, is only likely to be effective if the sample size is also increased, in order to ensure adequate representation of each of these subzones. For the reasons discussed above, this is neither desirable nor feasible.

The third approach would be to develop more sophisticated modelling techniques, as a means of estimating the geographic distribution of individual habitats or land cover types within each land class. Plans exist to examine ways of making more local estimates from CS2000, as part of module 9. There is, however, a wide and growing body of research on so-called smart interpolation methods that offers useful approaches to the modelling of habitat distribution. Essentially, they involve the use of environmental covariates – such as altitude, slope angle or land cover data derived from LCM2000 – either to filter out areas in which the habitat is unlikely to occur (so-called control-zone methods), or to redistribute the regional or national totals probabilistically (e.g. using geostatistical techniques). Several of these methods have already been applied on an exploratory basis (Barr *et al.* 1993, Tantram 2002) and are seen to provide relatively accurate estimates for some habitat and land cover types, at least down to the county scale. Further research, with more rigorous testing and evaluation of the methods against field data, would be merited.

5.2.4 Developing the land cover map

Linking LCMGB and LCM2000

The national land cover maps produced as part of both CS1990 and CS2000 are undoubtedly important information resources. Both have wide-ranging utility, not only in relation to the countryside but also far more extensively. The satellite-derived data also provide the basis for the UK contribution to the EU land cover maps (CORINE 1990 and CLC2000).

Nevertheless, one major limitation of these two land cover maps is evident – namely the lack of direct connectivity between the 1990 and 2000 data sets. This has prevented the data being used to derive land cover change statistics and for many would-be users is seen as a major constraint on its use. It is a problem that needs to be resolved, and in principle can by reclassifying LCM2000 using the 1990 methodology. The process is likely to involve substantial cost, but these would appear to be merited by the needs of users.

Technological change and continuity

The difficulties in comparing the 1990 and 2000 land cover maps derives from the methodological changes introduced in LCM2000 – as a result of advances in image analysis made over the last 10 years. This is a problem that will not quickly disappear, and may become more severe, for remote sensing technologies are subject to major and rapid change both due to the availability of new sensors and satellites, and developments in automated image analysis.

Future surveys cannot afford to ignore these technological changes – otherwise they will quickly be seen as out-of-date and inadequate by users. But nor can they risk losing continuity with the past. The effects of introducing any methodological changes (e.g. in terms of the satellites or sensors used, or the methods of image analysis) must therefore be assessed in terms not only of the reliability of the data they provide (e.g. the classification accuracy), but also the comparability of the data over time. Where necessary, different estimates may need to be provided, one using methods that provide historic consistency as a basis for analysing change, and one giving 'state-of-the-art' estimates of current land cover pattern.

Co-ordinating land cover mapping for different user needs

Increasing demands for satellite-derived land cover data are also coming from areas other than countryside policy. The land cover classifications designed to meet the needs of Countryside Survey, therefore, may not be adequate for the wider body of users. Urban areas, for example, are often of equal if not greater importance for many applications, since it is these areas that contain the largest proportion of the population, act as the main sources of most environmental pressures, and experience the greatest environmental and social conflicts and effects. For other applications, there is a need for data on estuarine or offshore areas.

It is unlikely to be cost-effective in the long term to analyse satellite data separately for each of these applications – though some market segregation will undoubtedly be necessary. Instead, a more integrated approach to land cover mapping would seem to be needed within the UK, that considers the needs of a wider range of users. Undertaking this within the framework of Countryside Survey will probably not be feasible. Instead, Countryside Survey may need to see itself as simply one of several users who will need to collaborate in commissioning the next land cover map. If the necessary arrangements are to be put into place in time, then discussions between these users need to start relatively soon. The first step in this process should be a survey of potential users (e.g. in government departments, national research organisations, universities and regional/local authorities) to assess their need. Provision of sample data and demonstration projects from LCM2000 would clearly help to inform this process by illustrating the existing scope and character of the land cover data, and showing some of its potential applications.

The National Land Use Database (NLUD) has considerable importance in this context. This is, already, pursuing many of these activities. As yet, however, the process does not seem to have reached out effectively to many of these potential user groups, and both knowledge about NLUD and involvement in its development (e.g. within universities, local authorities) remain limited. Future development of Countryside Survey clearly needs to ensure both that close collaboration with NLUD is maintained, and that links to the wider range of users are co-ordinated.

5.2.5 Landscape quality

A developing area of policy, but one that is not yet well represented by Countryside Survey, relates to landscape quality. Formal policy instruments in this area are few, in part because it has attracted relatively little attention in the EU. Concepts of quality are also poorly evolved, and have certainly not yet been well represented in policy debates. Many of the developments and pressures operating in the countryside, however, clearly have impacts at the landscape scale, and are likely to affect its quality. The aims and purposes of National Parks also focuses on issues of amenity and landscape quality, and the need to protect and enhance these resources has been a powerful motive for establishment of new AONBs. In addition, the definition of landscape character areas has provided a framework within which to consider and monitor issues of landscape quality.

Various measures of vegetation and habitat quality are already included in Countryside Survey (e.g. through the Ellenberg scores and the macro-invertebrate surveys). However, further tools for both survey and analysis will need to be developed if issues of landscape quality are to be incorporated into the Survey in future. These are likely to require the use of both remote sensing and field-based techniques. Some work on this is already being undertaken as part of module 9, but further research to define and evaluate these methods will almost certainly be needed in time for the next survey.

5.2.6 Improving data linkage

Data from Countryside Survey should not be seen in isolation. For many users, CS is simply one of many different data sources that can be employed to support policy and research. The value and validity of CS data are also likely to be enhanced in many cases by triangulation against, or combination with, independent data on the countryside. At the same time, it is important to recognise that many of the changes seen in the countryside are not the product of the countryside *per se*, but of activities and events elsewhere in the world. It is therefore important to be able to look elsewhere for the causes and drivers of change. For all these reasons, there is a need to link CS data with data from other sources, and relating to other processes and characteristics, over a range of timescales and at a wide variety of spatial scales.

With the development of GIS techniques, methods of data integration, linkage and overlay have been enormously advanced. Many users of CS data already use these methods on a routine basis. Data linkage nevertheless poses many problems, including access to the various data sets (including, for many applications the original 1km sample data from CS), and the resolution of problems of mismatching data formats, spatial structures, definitions and scales. Data integration and linkage is also a dangerous process if users do not understand the characteristics and quality of all the data involved. There is consequently a significant demand for these various complementary data to be made available in a consistent form as part of a CS2000 ‘package’.

One of the most important is the agricultural census (June returns), since this is seen as providing vital information on land use practices that directly impact on the countryside. Other data sets that might usefully be included are:

- soils
- phase 1 survey
- Plantlife common plants survey
- designated areas (e.g. national parks, AONBs, SSSIs
- areas under agri-environment schemes, ESAs
- surface and ground water quality
- ECN sites
- agricultural land capability/suitability
- structural fund boundaries (objective 5b/2; LFAs etc)
- pollution data (e.g. from NETCEN)
- census data (from the decennial census)
- archaeological features

Likewise, there is considerable advantage in improving links with local survey and monitoring, both so that these can be set within a wider, national context, and so that CS data can be compared with, and supplemented by, more detailed data where these are available.

Extension of the time series data backwards in time would also be beneficial for some applications, especially where long-term trends are of interest. Areas within which this is possible are limited mainly by the availability of historic data. There are also likely to be severe problems in many cases in comparing data from Countryside Survey with those from other sources. Where both the need for information, and the availability of suitable data, can be justified, however, research to develop these longer time series should be supported.

One way of trying to provide this expanded and integrated data set would be by further development of CIS. The extent to which this is either feasible or appropriate, however, is open to debate. Countryside Survey, and its derivative products such as CIS, cannot be expected to do everything. Other initiatives, such as NLUD, the National Biodiversity Network, and the Multi-Agency Geographic Information for the Countryside (MAGIC) project will in principle provide the gateways to the much wider range of data that exist – albeit, not in a fully operational way perhaps for some years. It also needs to be recognised that many more advanced users of these data do not want – and would ultimately be restricted by – a system such as CIS. For many exploratory and research applications, the need instead is to integrate these various data sets within a GIS, in order to process them using more advanced (and sometimes quite idiosyncratic) statistical and spatial models and analytical tools. For these users, a more effective approach might therefore be to concentrate on providing CS and other, linked data in GIS-compatible formats.

Herein, however, lies a dilemma that has not yet been solved. On the one hand, the structure of Countryside Survey – especially the field component – and the confidentiality constraints on access to the sample grid square data mean that the data often have to be pre-processed in order to produce area estimates for further analysis: the raw data cannot simply be handed over to users in their raw form for them to do as they will. On the other hand, this restriction means that users cannot easily analyse the data along with other data sets, even if they can obtain them, unless that integration is done on their behalf. CIS does this to some extent. But its capability is limited and will ever remain so: it cannot be expected that it will provide a fully operational GIS and statistical package, with the functionality, say, of ArcMap or GRASS and S-Plus or SAS. The only alternative at present is to negotiate for CEH to undertake the processing, or provide the raw data in some anonymised form. This may be feasible when users have clear and well-defined needs; it is far less so when the requirement is for exploratory analysis or for casual and continually varying queries.

One approach that merits consideration is to develop the key functionality of CIS – namely its ability to provide estimates based on the sample field square data – as an 'add on' package to run with proprietary GIS. This would involve programming these functions in, say, VBA (to run with ESRI's ArcGIS) and Avenue (to run with MapInfo). The sample data could be securely embedded within these programs, making them unavailable to the user, but the queries relating to these sample data (e.g. production of estimates for specific user-defined areas) could be made from the GIS. The user would thus see a seamless system, managed from his or her GIS. Results from the queries of the sample data could be directly linked to, and analysed with, any other data held in the GIS, using the full range of functions available within the GIS. Using VBA would also allow direct linkage to a wide range of other software packages, such as statistical programs, as well as the full range of Microsoft package (e.g. Excel, PowerPoint, Access, Word). Other CS and CS-related data sets currently provided in CIS format, could also be made available in the relevant GIS format. This approach would thus provide full security for the sample data (as now) but would increase the functionality available to the user. It would, in practice, facilitate and legitimise something that many users already do by exporting data from CIS into their own GIS.

5.2.7 Providing access to the field sample data

As the preceding discussion implies, one of the most important weaknesses of Countryside Survey perceived by many users (or would-be users) is undoubtedly the difficulty of access to the raw data from the sample field squares. The need for access to these data arises mainly when users wish to derive estimates of habitat pattern or condition for spatial areas of their own making. For many of these applications, it has to be said, the necessity for direct user access can be avoided, since CEH can undertake the relevant analyses on the users' behalf. For exploratory analyses, where substantial costs or lengthy negotiation might not be justifiable, however, these arrangements are not always appropriate. Equally, where users want to carry out advanced spatial modelling using their own programs or models (e.g. in their own GIS), third-party analyses through CEH may be inefficient. Lack of access to these data thus acts as a significant constraint on some uses of the data.

One possible way of addressing this problem has been outlined above (i.e. secure embedding of the sample data within a GIS-compatible package). This, however, does not meet the fundamental need to be able to explore and interpret the field data from individual sample squares. If this is to be possible, users need direct access to the sample field data in a fully georeferenced form. One danger of this approach does, of course, arise: that users will misuse and misinterpret the data. This is a universal complaint by data providers, but one on which, in the end, almost all providers have to yield (even though, in some cases, this breaks their own monopoly on many aspects of data processing and analysis). The producers of data cannot be their brothers' keepers: they cannot remain responsible for what other people do with the data they produce. And when public money is used to produce the data it is difficult, except where direct threats exist to the subjects of those data (whether in the form of people of wildlife), to deny access to those who ultimately pay. Indeed, in keeping with EU policy on public access to environmental information, there is a strong imperative for their widespread release.

The more serious danger is that release of these data would jeopardise the Survey. Access to the sample data has been constrained primarily for reasons of confidentiality: agreements have been reached with land owners not to release information on individual survey sites, and there is a concern amongst those involved in the Survey that any attempt to change these agreements might threaten the continued co-operation of landowners. These concerns have some weight, for many rural landowners certainly remain very suspicious of, and resistant to, attempts to open up their accounts in ways to which other businesses are perhaps already accustomed.

This does not necessarily mean that this resistance is either well-founded or should be accepted indefinitely. Much of the information about which landowners remain sensitive, such as details of cropping and vegetation cover, for example, can – with a little determination and inventiveness – be obtained using remote sensing techniques. Many of the data needed by users pose no direct threat to confidentiality. It is therefore likely that at least some of the field data could be made available without any practical increase in risk either for landowners or for the integrity of the Survey. There is a need, therefore, to identify more clearly the reasons for landowners' concerns, and to discuss possible ways of releasing the field data whilst protecting genuine interests of commercial or personal confidentiality. Certainly, if the aim is to expand use of Countryside Survey data and to address changing policy needs, this issue cannot be ignored.

5.2.8 Improving Survey management

The timing and scope of this study has meant that it has not been possible either to observe firsthand the management processes used in CS2000 to any detailed extent, or to interview those concerned in any systematic way. Observations relating to the management processes thus derive mainly from the views and impressions of those outside the project, and are consequently inevitably partial. Further review of the management procedures, and an evaluation of their successes and failures, would be merited before any future Survey is initiated.

The organisation and management of CS2000 was done through a series of modules, overseen by a Joint Management Team, on which all the funders were represented. An Advisory Committee was also established, comprising representatives from what were seen, or volunteered themselves, as the main users.

Joint Management Team

The Joint Management Team clearly provided an important forum within which the funders could come together and review, advise on and comment on the Survey. No major problems were evident with this process, although inevitable difficulties occasionally occurred with timing of meetings and in preparation of relevant documentation. These are difficult to avoid in a large Survey, consisting of several different modules, each running to somewhat different timescales.

For the future, increasing problems may occur in defining the membership of this group and in coping with the varied interests of sponsors. Pressure to extend the range of sponsorship is likely to come from several quarters. One is the devolution of policy responsibilities for the countryside in the UK, which will mean that regional, as well as national, organisations may wish, or be encouraged, to contribute as sponsors. A second is the growing interest in Countryside Survey amongst hitherto more peripheral users (including other government departments and NGOs). A third reason to expand the range of sponsors is the likelihood of increasing funding limitations amongst some of the previous sponsors and the increasing costs of the Survey. The fourth reason for broadening the funding base is the increasing need to integrate and harmonise Countryside Survey with other monitoring activities – including land cover mapping, monitoring of protected areas, and monitoring of agri-environmental schemes.

As the Joint Management Team grows in size, and as the interests of the sponsors becomes broader, greater tensions may be expected within the management process. Competing visions of what form the Survey should take and whose interests it should serve may thus arise. These, clearly, must not be allowed to hinder or distract the scientific work. It is therefore important that they are resolved as early as possible. To this end, it will be important to define and emphasise the core purposes of Countryside Survey. The existing aims and purposes should consequently be reviewed and a new statement of purpose agreed, before plans for the next Survey are initiated. In order to ensure continuity, this is best done by the existing Joint Management Team, informed by the findings of this study.

User involvement

Similar issues arise in relation to user involvement. Notwithstanding the natural increase in user interest that has occurred as Countryside Survey has developed, the need to expand further the user base remains strong. It does so for several reasons:

- because the Survey has a potential value for a considerably wider range of users from many different sectors (as some of the applications listed in Table 8 imply);
- because of the continuing need to achieve greater integration across different policy areas (something that Countryside Survey is especially able to do);
- because of the changing demands of policy (and thus the different groups of actors) relating to the countryside – e.g. as a consequence of regional devolution and new policy initiatives such as the Water Framework Directive; and
- because of the need to ensure the long-term viability of the Survey – which can probably only be achieved if it is accepted and supported by as many as possible of those concerned with the countryside.

User involvement in CS2000 was only partial, in that representation from several key groups of users – including those from some voluntary organisations, universities, and some government departments – was limited. Although redeemed to some extent by later carrying out a consultation with many of these users as part of module 16 (see Annex 1), this had two implications. It tended to limit the range of users whose interests were represented in the planning and design of the survey; and it acted in part to alienate (or at least feed the negative attitudes towards Countryside Survey of) several potential users. For the future, it would seem more appropriate to try to redefine the key user groups, and then to invite their participation. This implies that knowledge about CS2000, and ideas and plans for the next Survey, are widely disseminated and discussed.

The mechanisms for achieving this need to be given further thought. Neither the Web site nor the CS Newsletter seems to be sufficiently effective instruments on its own. From the evidence of past usage, both tend to reach only those who make the effort to be informed – either by reading the Newsletters or by accessing the Web site. Typically these are likely to be people who already know about Countryside Survey, or who come across it when searching for a data source for a specific purpose. Wider penetration of the potential 'market' of users probably needs other mechanisms, specifically targeted at relevant user groups. One such group is users at the regional level, including local authorities. At present, these are only rare users of Countryside Survey; with devolution they will become more important players. Bringing them more actively into the debate about Countryside Survey is not easy, especially as the groups that might ostensibly represent local authorities, such as the Local Government Association, have so far proved to be only peripherally interested. One mechanism that has been successful in other contexts, however, is to run regional seminars or roadshows around the UK. This technique has been used, for example, by the

Countryside Agency in the past to promote issues and practices of relevance to local planning authorities (e.g. on indicators and state of environment reporting). The same might be used, early in the process of planning for the next Survey, to awaken interest and raise the level of understanding and involvement from local authorities.

CIS is also an important means of encouraging interest and involvement, and consideration might be given to promoting its wider use by active marketing (or even free distribution) of the system to local authorities, NGOs and universities. Linked to this, there is a need for training (e.g. in the use of CIS) to overcome the perceived (though often far from severe) barriers to use of the CS data that still deter some potential users.

At the same time, opportunities to develop and exploit Countryside Survey at the European level needs to be explored. In this context, the Global Monitoring for Environment and Security (GMES) programme, currently being developed by the Research Directorate of the European Commission, is of particular note. With the specific objective of developing more effective, coherent, long-term data provision in support of European environmental policy, this is likely to set the framework for the next generation of both satellite- and ground-based monitoring in the EU, as well as providing funding for complementary research.

Timetabling

One problem that was evident with CS2000 was the pressure which built up on the modules throughout the Survey, especially towards the end. Such pressures are inevitable in a large project such as this, and are no doubt accepted by most participants. Nevertheless, it appears that timetables for some elements of the Survey were simply too short to allow either for inevitable slippages (e.g. due to problems with fieldwork or technical difficulties with the land cover mapping), or for fully considered analysis, interpretation and reporting of the data. The quality of the summary report, and the timing and magnitude of the launch event suffered as a result.

In order to avoid this in the future, three key issues probably need to be addressed. One is for a clear agreement in advance of the ‘headline’ results (e.g. for national indicators) that need early reporting. Within the inevitable limitations of the process (many aspects of the data are inter-dependent, so individual subsets cannot always be processed or interpreted in isolation), these can then be given priority in the analysis. The second is for the development and testing of analysis methods (both for the land cover mapping and field survey) well in advanced of the Survey itself. This requires the agreement and establishment of a clear programme of research between now and the next survey. The third is to build adequate allowance into the Survey schedule for delays due to weather and other unforeseen problems.

Survey modules

Some weaknesses also appear to have occurred in relation to the modular structure. Several modules, for example, were not let, and the timing of several modules did not seem optimal for the benefit of the Survey as a whole. To those not directly involved, also, the modules seemed somewhat confusing, with several overlapping projects (e.g. undertaking field survey in different areas). To a great extent, these problems probably reflect the difficulties that inevitably occur in attempting to co-ordinate and meet the needs of different sponsors. For the future, however, it would seem advisable to streamline this structure to some extent, perhaps by defining a smaller set of core modules, focusing on the field survey, land cover mapping, data analysis and reporting. These could be supported where necessary by more specialist (and clearly identified) studies and projects – for example, designed to test and develop methods, or provide inputs from other, complementary initiatives. Co-ordination of these supporting projects should, as far as possible, be devolved to the module leaders, in order to ensure that they provide the inputs needed in the right way and at the right time.

5.3 When should the next survey be?

5.3.1 Survey frequency and response rate

The frequency of Countryside Survey, like any monitoring programme, represents a difficult balance. The cost of the Survey (and the associated processes of data analysis and reporting) are inevitable constraints, and mean that redundancy in monitoring needs to be avoided. Many changes in the countryside are also relatively slow and subtle, and can only be detected in the long term: high frequencies of monitoring may therefore add little meaningful information. On the other hand, some changes occur quickly, in which case lead times for action may be short. Separating long-term trends from the short-term noise in countryside data can also be difficult if data points are widely spaced in time. In addition, the impacts of policy need to be evaluated as soon as possible after implementation, in order to ensure that they are effective and are being properly applied. Countryside Survey, it has to be recognised, was not designed, and is inherently not capable, of providing detailed appraisals or assessments of individual policies. Nevertheless, if it is to provide even general indications of aggregate policy performance – and possible future policy need – it needs to do so in a timely manner. Turning policy and practice around takes time, and while it is happening damage may continue, and costs are accruing that might otherwise be avoided. The earliest possible warning of danger or inadequate effect is therefore needed.

For many applications, such as indicator reporting, information must likewise be seen to be up-to-date, for otherwise it may be seen as irrelevant – and of less weight than that representing other, competing interests. In this context, the expectations set by routine economic information have important implications. These data are typically available on an annual (or quarterly or even more frequent) basis and are available almost immediately after the event. Many environmental data, in contrast, are available far less frequently and have long lag times (typically of several years). This tends to weaken the arguments in favour of environmental issues in policy debates, and in some cases can even exclude these interests from the debate. This is certainly a danger in relation to Countryside Survey. The relatively low update frequency of countryside data, and the long drawn-out process of analysis and reporting, are undoubtedly reasons why few countryside indicators have been developed and adopted, and have thereby added to the perception that the countryside itself is stable and unchanging, and therefore of little immediate concern.

In the case of Countryside Survey, the dilemma of survey frequency and reporting speed is difficult to resolve. A strong case can certainly be made for more frequent (and more regular) surveys, perhaps at intervals of every four or five years, but the costs of full surveys are likely to be prohibitive. The apparent delays between survey and reporting also create frustrations for potential users. In the case of CS2000, however, efforts to speed up this process placed considerable pressures on Survey staff and added to risks of errors in analysis. CS data are also an immensely rich source of information, in an area in which causal hypotheses are often not well developed. Considerable care is therefore needed in interpretation of the data, supported by in depth analysis, if the real meaning in the information is to be extracted. Shortening or hurrying the process is thus likely to be counter-productive.

It is nevertheless a dilemma that cannot be ignored. If it is to meet policy requirements Countryside Survey must have the capability to provide a more rapid and up-to-date response to need.

5.3.2 Options for the future

A rolling programme

One possible solution to this dilemma is to establish a continuous rolling programme of survey, with different elements, or different survey squares, surveyed in different years. Ostensible benefits of this approach would be that data would be continually updated and demands on staffing could be more evenly spread (thereby enabling a core of survey staff to be maintained). As experience from other rolling survey programmes (e.g. the Ancient Woodland Inventory) show this approach has a number of serious disadvantages. Possibly the most important are the problems created for statistical analysis and interpretation of the results. Where the rolling programme involves annual survey of different sample squares, for example, definitive, date-stamped estimates of habitat extent or condition are difficult to derive (only averages across several years of survey can usually be reliably computed). Analysis of associations between different habitat characteristics – or between habitat conditions and other factors – are also complicated, because of the lack of any clear coupling between the data, in time. Causal explanations thus become more difficult to develop or confirm. In general, all statistical analyses are also likely to be subject to greater uncertainty, because of the smaller sample size of concurrently surveyed squares. Benefits in terms of survey cost may also be less than anticipated, because of duplication of travel, and the need to provide regular training and constant quality control to cope with staff turnover. For these reasons, this approach cannot be recommended.

Interim surveys

An alternative approach is to undertake more limited surveys of a subset of sample squares (e.g. in especially sensitive areas) and/or a reduced core of features of interest during intervening years. These could be used to provide interim estimates at the national level. This approach has several advantages, not least flexibility, for interim monitoring campaigns could to some extent be adapted to need (e.g. by targeting different habitats or areas, or by incorporating different measures), without undermining the long-term continuity of the Survey. The main disadvantage is clearly that it would add to the overall cost of Countryside Survey. The statistical power of the data from interim surveys may also be relatively poor because of the smaller sample size, while difficulties may be encountered in ensuring adequate quality assurance between surveys. Certainly the interim surveys carried out for field margins and ponds, between CS1990 and CS2000 have proved to be difficult to interpret in relation to results from the full surveys. Because it would offer significant improvements in timeliness and currency of the data, however, it is an approach that deserves to be considered where there is a specific need for more frequent data on specific habitats or areas.

An extended survey period

A third possibility is to maintain the current repeat interval, but to spread each survey over several (e.g. 2-3) years. Although this would not increase the survey frequency, it would have a number of merits. It offers the opportunity to spread the load on staff, avoids the need for mass recruitment and training of survey staff in a short period of time. It also provides some buffer against disruptions to the Survey by adverse weather conditions or other unforeseen events (e.g. outbreaks of agricultural diseases that might restrict access to the land). By the same token, it can help to smooth out short-term variations in vegetation or land use conditions, caused by weather or other circumstances. In practice this happened with CS2000: poor weather in 1998 led to the need to spread both the field survey and the satellite data used for land cover mapping over several years. Formalising this approach thus makes considerable sense. Since it also offers some cost saving, it clearly needs to be considered for the next Survey. If it is to be adopted, however, attention needs to be given to the structure and phasing of the field survey. Greatest savings in travel costs are likely to be achieved, for example, through a systematic 'creeping' survey (i.e. one in which each region is visited in turn, and only once, during which all the field squares are surveyed). The danger of this is that any drift in weather or other conditions over the survey is likely to appear as geographic trend in the data. The alternative – to randomise field visits to individual squares in some way – will be more costly, but is likely to provide more interpretable data.

In practice, this approach appears to offer the best solution to the tensions that have begun to appear in relation to the timing and frequency of Countryside Survey, in that it would reduce the pressures on staffing and training, while at the same time maintaining an adequate survey frequency. In this case, there seems little reason to change the repeat interval that has now become established (i.e. ca. 8 years). This would imply that the next survey should take place over the period 2005-7, with a planned reporting date of 2008.

Adoption of this approach would, however, have several implications. The first is that cycles or changes operating on a timescale of less than 8 years would continue to be masked or missed by Countryside Survey. Where these are considered important, the only solution is to organise interim surveys, targeted at the relevant area or issue, using CS-consistent survey designs. These might be funded by the relevant users.

The second is that pressures for quick reporting of results from Countryside Survey (e.g. for political purposes) would need to be controlled – though some ability to prioritise analysis would be possible, as discussed above. Careful timetabling of both fieldwork and data analysis would be essential, if distortions and biases in the results were not to occur.

The third implication of an eight-year repeat cycle is that the land cover data would become increasingly out of phase with EU timetable for updating the CORINE Land Cover Map (currently operating on a 10-year cycle). Discussions should be held with the European Environment Agency to clarify and, if possible co-ordinate, longer-term plans.

6. RECOMMENDATIONS

6.1 The continuation of Countryside Survey

Countryside Survey is widely recognised as a world leader in its field. It also has proven value as a source of support for policy. Yet it is only now, with completion of CS2000, that it is reaching a critical mass in terms of the time series of data, and thus beginning to achieve its full potential. For the future, the value of CS data will continue to grow, simply because of the extended date series. The need for these data is also increasing, however, due to the growing demand for accountability and transparency in policy, and the burgeoning pressures on the countryside. At the same time, the growing role of Countryside Survey not only as a *source* of national data, but also as a template and standard for monitoring, a *framework* for data integration, and a *repository* for local management and site-based data need to be recognised.

For all these reasons, it is wholly sensible – not to say essential – that Countryside Survey should be maintained.

6.2 Timing of the next survey

Timeliness of data on the countryside is vital, if they are to provide effective support for policy. Previous surveys have taken place at intervals of 6 to 8 years. This interval seems appropriate in view of the magnitude and rate of change in most elements of the countryside, the availability of trained staff and survey costs.

The growth in the scale of Countryside Survey has led to increased pressures on staff, and reduced the available 'slippage' time, to allow for difficulties such as poor weather conditions, that might interfere with fieldwork or land cover mapping. For these reasons, more time needs to be allowed for the completion of each survey. In the next survey, a period of ca. 4 years should thus be foreseen from the start of the field survey and commencement of land cover mapping to reporting of the results.

Based on these considerations, the next survey should start no later than the summer of 2005 and report no later than autumn 2008.

Adoption of this longer survey period will mean that a clear plan for fieldwork will need to be established in advance, and adhered to throughout the survey, in order to avoid risks of biasing the results (e.g. due to different areas or issues being surveyed in different years). Any need for early reporting of results on 'headline' issues will also need to be foreseen and prepared for, so that the relevant data analysis can be prioritised. If the process is to operate efficiently, temptations to disrupt the timetable for survey and analysis (e.g. for short-term political reasons) will need to be resisted.

Supplementary surveys, using designs consistent with Countryside Survey, could also be undertaken as appropriate in this cycle, for example to analyse the effects of specific policies or to gain additional data on specific habitats of concern.

6.3 The field survey

The general design of the field survey has stood the test of time. Changes to the survey design also need to be limited, so that continuity and consistency with previous surveys is not jeopardised. At the same time, however, adjustments will be needed – for example to enable reporting within a more devolved, regional structure of responsibilities for countryside policy.

For logistical reasons, there is only limited scope to increase the size of the field sample (i.e. the number of sample squares) beyond that used in CS2000. Small expansions may be possible in some of the habitat types and areas that are less well represented by the current sample (e.g. peri-urban areas, coastal areas) and in sentinel areas that can be considered as especially sensitive to current policy and environmental changes (e.g. marginal uplands, wetlands).

Research is also needed to develop and test methods for improving the spatial resolution of estimates derived from the field survey – e.g. using geostatistical and intelligent interpolation methods to map local habitat distributions on the basis of covariate data.

6.4 Land cover mapping

The satellite-derived land cover data are valuable sources of in formation, with uses far beyond countryside policy. These maps also form the basis for the UK contribution to the CORINE Land Cover Map.

The lack of direct comparability between data from the 1990 Land Cover Map of Great Britain and LCM2000 is problematic and needs to be resolved, so that changes in land cover over this period can be made.

Future land cover mapping will need to respond to technological advances (e.g. in satellite systems and image processing) but must maintain consistency with previous surveys. For this reason it may be necessary to plan for two sets of land cover estimates to be produced, one relating only to the contemporary land cover and based on the best available technology, and the giving measures of change, based on historically consistent methods.

Demand for land cover data is growing from users in many different areas of policy and research not directly related to the countryside. It is likely to prove inefficient and not cost-effective to carry out separate national land cover mapping for these different groups of users. Therefore, plans should be made for a co-ordinated land cover mapping programme that meets these different needs. This might require some changes to the land cover classification, especially in urban (and perhaps estuarine and coastal) areas. Responsibility for meeting these wider user needs lies, to a great extent, with the National Land Use Database (NLUD). In order to ensure that future Countryside Surveys fit into this strategy, close collaboration clearly needs to be developed with NLUD, and thence, in a co-ordinated way, with users. NLUD and its sponsors and clients will thus need to be seen as important actors within the next Countryside Survey.

6.5 Data access

Problems of access to the data also remain, and inhibit use of the data in some situations – especially for exploratory analysis or advanced modelling. For many users CIS is also a useful tool for data access and analysis. Its functionality is, however, limited; further development of CIS to provide significantly enhanced capability to access and analyse CS data is unlikely to be cost-effective. Instead, there is a need to make CIS data available in a form that can be fed directly into proprietary GIS (especially ArcGIS and MapInfo). At the same time, the functionality of CIS as a tool to analyse the field data by ITE land class also needs to be retained. This could be done by developing an 'add-on' program to proprietary GIS (e.g. in VB or Avenue) that would deliver both the sample data (in a secure, embedded form) and the relevant analytical functions in a form that could be run seamlessly from within the GIS.

Access to the raw sample square, field data remains the most important barrier to use of Countryside Survey in many people's eyes. The issues of confidentiality used justify the current restrictions on access to these data need to be re-examined in order to determine whether the data could be made available, without jeopardising the Survey.

6.6 Data linkage and integration of countryside monitoring

As the range and time series of data available from Countryside Survey have increased, so the potential to link these data to other data sets, and benefits of doing so, have grown. The means of data linkage, however, remain somewhat undeveloped, both because of the difference in survey methodologies, and because of the lack of suitable models and tools. Further efforts are therefore needed to facilitate such data linkage. Important issues to be addressed include:

- harmonising data formats between CS and other data sources;
- developing better metadata about both CS and other relevant data sources;
- improving the means of access to CS and other data.

In part, these imply technical advances. To a large extent, however, they require political and administrative action – in particular to encourage active involvement of relevant data providers within Countryside Survey, in ways that will enhance the integration of different surveys. This implies specific action to negotiate with data providers in advance of the next Survey, in order to explore ways of improving collaboration.

Amongst many areas in which improved linkage and harmonisation of monitoring would be beneficial are:

- agricultural land use
- soils
- phase 1 survey
- Plantlife common plants survey
- designated areas (e.g. national parks, AONBs, SSSIs)
- areas under agri-environment schemes, ESAs
- surface and ground water quality
- ECN sites
- agricultural land capability/suitability
- structural fund boundaries (objective 5b/2; LFAs etc)
- pollution data (e.g. from NETCEN)
- census data (from the decennial census)
- archaeological features

6.7 Meeting users' needs

Considerable improvements have been made to the dissemination of results from Countryside Survey in recent years. The summary report and use of the Web for publication of summary data tables have both been welcomed by users. The range of users is also continuing to increase.

The core set of CS users, however, remains small, and further expansion of the user base is necessary, both to achieve the full potential of Countryside Survey, and to ensure long-term support for the Survey. This implies that users are both made more aware of Countryside Survey and what it can do, and encouraged to be take part in planning the next Survey.

CIS is an important means of encouraging interest and involvement, and consideration should be given to marketing it more actively – or, preferably, offering free distribution – to targeted users such as local authorities, NGOs and universities. Training in the use of CIS specifically (and CS more generally) also needs to be offered to prospective users. In addition, roadshows and regional seminars should be set up early in the planning stage for the next Survey to raise awareness about Countryside Survey and to open up debate about how future surveys can best meet user needs.

6.8 Survey management

Opportunities to examine the management processes within CS2000 as part of this study have been limited. A further review of the management procedures, and an evaluation of their successes and failures, should be carried out before any future Survey is initiated – perhaps through meetings of the sponsors and module leaders, under the leadership of an independent chair. In future surveys, the equivalent of this study should ideally run throughout the planning and implementation phase.

The overall structure of the Survey and arrangements for its sponsorship and management have, however, proved generally successful.

Future surveys would also benefit from a more streamlined and integrated structure. One way of achieving this would be to define a small set of core modules (e.g. focusing on the field survey, land cover mapping, and data analysis and reporting) that would be responsible for completion and delivery of the survey results. These could then be supported and serviced as appropriate by more specialist modules (e.g. aimed at developing methodology or undertaking supporting research) acting under their supervision.

The trend towards regionalisation and – if successful – efforts to broaden the user base will, however, mean that a wider body of sponsors may need to be involved in future Surveys. Increased survey costs (e.g. due to the need to develop more regional levels of reporting), and efforts to integrate CS more closely with other data sources and surveys, may also make a broader funding base essential. As the range of users becomes greater, however, increased tensions may be expected within the management group. To minimise these, it is essential that the aims and purposes of the Survey are clearly stated at the start – and as far as possible held immutable thereafter. A final meeting of the current Joint Management Team should be held to review and restate these aims and purposes before preparations for the next Survey start.

Scope to extend the Survey into Europe, and to attract European funding for future surveys also need to be recognised. The Global Monitoring for Environment and Security (GMES) programme, currently being developed by the Research Directorate of the European Commission, is of particular relevance in this respect, and liaison with the GMES Steering Group should be established as soon as possible.

6.9 Research needs

Expertise relating to Countryside Survey, and experience in analysing CS data, remain rather narrowly spread. There is a need to try to broaden this knowledge by opening up CS-related research to a larger community.

One important step to achieve this should be to develop a database of CS-related research, with an open archive of data sets and results derived from these studies, like that run by ESRC.

Many of the methods, tools and hypotheses needed to carry out Countryside Survey, and analyse and interpret the results, still need to be developed. A targeted programme of research, funded by NERC, therefore needs to be started as soon as possible to support development and use of Countryside Survey.

Research is needed into survey and analytical methodologies (e.g. for assessing landscape quality, small-area spatial modelling of habitat extent, modelling uncertainty), to investigate patterns and trends in the countryside using CS data and to analyse policy and land use effects. There is also a need for research to assess the cost-benefit or cost-effectiveness of CS2000.

This research programme should be opened up on a competitive basis in order to ensure active participation and inputs of ideas and expertise from a wide body of relevant disciplines and research groups.

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Annex 1. List of organisations and individuals consulted

Organisation	**Individual**	**CS2000 workshop**	**Interview**	**Corres-pondence**
AAONB	Simon Hooton	X		
ADAS	Dr. Nigel Critchley	X		
Association of National Park Authorities	Prof Ian Mercer		X	
Association of County Councils	Ken Brown		X	
Alterra	Prof. Robert Bunce	X		
BBSRC	Mari Williams		X	
BTO	Dr. Rob Fuller	X		
CCW	Dr. Clive Walmsley	X		
CEH	Colin Barr	X		
	Simon Bird			
	Dr. Helaina Black	X		
	Dr. Peter Carey	X		
	Dr. Les Firbank	X		
	Dr. Ross Hill	X		
	Robin Fuller	X		
	Dr. Roy Haines-Young	X		
	Prof. Mike Hornung	X		
	Dr. Dave Howard	X		
	Dr. Philip Hulme	X		
	Lindsay Maskell	X		
	Geraldine McGowan	X		
	Dr. Dorian Moss	X		
	Prof. Patricia Nuttall	X		
	Dr. Sandrine Petit	X		
	Dr. Andrew Sier	X		
	Simon Smart	X		
	Rick Stuart	X		
	John Watkins	X		
Country Landowners Association	Dr. Alan Woods		X	
CPRE	Georgina Dobson	X		

Annex 1 (continued)

Organisation	**Individual**	**CS2000 workshop**	**Interview**	**Corres-pondence**
DEFRA	Stephen Cane	X		
	Dr. Peter Costigan	X		
	Dr. Jane Goodwin	X		
	Richard Findon	X		
	Alan Hooper	X		
	Deborah Jackson	X		
	Hilary Neal	X		
	Dr. Geoffrey Radley	X		
	Dr. Andrew Stott	X		
	Dr. Alison Vipond	X		
Durham University	Prof. O.W. Heal	X		
English Heritage	Peter Topping	X		
	Dr. George Hinton	X		
	Dr John Hopkins	X		
	Steve Preston			
Environment Agency	Dr. Alastair Ferguson	X		
Environment Agency	Bob Huggins	X		
Forestry Commission	Simon Gillam	X		
	Simon Pryor	X		
	Steve Smith	X		
Friends of the Earth	Matt Phillips		X	
FWAG	Richard Knight	X	X	
Game Conservancy Council	Dr. Julie Ewald	X	X	
	Stephen Tapper		X	
Highways Agency	Nicola Cheetham		X	
	Tony Sanguine	X		
IGER	Jerry Tallowin	X		
Institute for European Environmental Policy	Dr. Janet Dwyer		X	
Imperial at Wye	Dr. J. Mitchley	X		
	Dr. Clive Potter	X		
Institute of Waste Management	Mike Philpot		X	
JNCC	Marcus Yeo	X		
Local Government Association	Crispin Moor		X	
NAW	Dr June Milligan	X		
	Dr. Havard Prosser	X		
NERC	Dr. Gail Lambourne	X		

Annex 1 (continued)

Organisation	**Individual**	**CS2000 workshop**	**Interview**	**Corres-pondence**
NFU	Andrew Clark	X	X	
Nottingham Trent University	Julia Davies	X		
OECD	Dr. Kevin Parris	X		
Plantlife	Jenny Duckworth	X		
	Liz Radford		X	
	Jane Smart		X	
Plymouth University	Prof. Martin Kent	X		
Private	Jo Treweek	X		
	Dr. Tom Dargie	X		
RCEP	John Rea		X	
RSPB	Dr. Gwynn Williams	X		
RSPB Wales	Dr. Tony Prater	X		
Scottish Executive	Dr. Cameron Easton	X		
	Dr. John Hooker	X		
SEPA	James Curran		X	
SNH	Ed Mackey	X		
UCL	Prof. Richard Munton	X	X	
Silsoe College	Dr. Alison Bailey	X		
	Carol Cairns	X		
Silsoe Research Institute	Elia Nigro	X		
University College London	Prof. Richard Munton	X	X	
University College Northampton	Dominic Tantram	X		
University of Aberdeen	Eric Donnelly	X		
University of Bangor	Prof. Gareth Edwards-Jones	X		
University of Bradford	Prof. Mike Ashmore		X	
	Dr. Alistair Headley	X		
University of Brighton	Jean Lyle	X		
University of Cambridge	Dr. Ian Hodge	X		
University of Cardiff	Dr. Steve Ormorod		X	
University of Exeter	Dr. Andrew Gilg		X	
University of Leicester	Lex Comber	X		
	Paul Robinson			
University of Newcastle	Rachel Creamer	X		
	Miriam Renner	X		
University of Oxford	Dr. Iain Brown	X	X	
University of Reading	Dr. Simon Mortimer	X		

Annex 1 (continued)

Organisation	**Individual**	**CS2000 workshop**	**Interview**	**Corres-pondence**
University of Sheffield	Dr. Carys Swanwick	X		
University of Stirling	Prof. Michael B Usher	X		
University of Ulster	Dr. Alan Cooper	X		
University of Oxford	Dr. Mike Morecroft	X		
Wildlife and Countryside Link	Bryony Worthington		X	
Wildlife Trusts National Office	Derek Moore			X
Worldwide Fund for Nature	Chris Howe			X