AGRICULTURAL CHANGE AND ENVIRONMENT OBSERVATORY

SCOPING STUDY – COUNTRYSIDE SURVEY 2007 AND LINKS TO AGRICULTURE

FINAL REPORT

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EXECUTIVE SUMMARY

Introduction and Background

1. This report describes the results of a scoping study carried out for the Defra Agricultural Change and Environmental (ACE) Observatory Programme by the Central Science Laboratory (CSL) in association with the Centre for Ecology and Hydrology (CEH), with the aim of investigating opportunities to link Countryside Survey 2007 to key drivers of agricultural change, to better understand the role of agriculture as a driver of change in biodiversity, habitats and landscape features in the countryside. The ACE Observatory aims to monitor and analyse the environmental impacts of CAP reform and other key drivers of agricultural change in England.

2. Objectives include a review of past research approaches; a review of methods of enhancing the spatial and temporal resolution of CS data; a review of key agricultural data sources, analysis approaches and data access issues; potential for linking agricultural and CS data to provide evidence on key policy issues, potential new policy indicators, and recommendations for further research and development.

3. Countryside Survey (CS) 2007 is the most recent in a series of surveys carried out at intervals of 6-9 years. The main purpose of the surveys is to provide estimates of stock, condition and change in features and habitats in the UK countryside. The basic structure of the survey has been maintained to ensure consistency between surveys, though the number of squares sampled has increased over time. The three most recent surveys (1990, 1998, 2007) were accompanied by collection of satellite data for the whole country, which was then analysed to produce a land cover map.

Review of past research approaches

4. This section summarises further analyses of CS data and other datasets designed to answer specific questions of policy interest regarding causes of change.

5. ‘Processes of Countryside Change’ was a socio-economic survey of occupiers of land in the 1km sample squares used for CS1990. Socio-economic and CS1990 data were linked using a GIS. High- and low-change parcels were identified through a re-analysis of the CS1990 data. Each parcel was characterised in terms of its “environmental stock”, and this measure was then related to the farm characteristics as revealed by the questionnaire survey. A cluster analysis was carried out to classify farms into groups, according to their propensity to change in a more or less intensive direction; five clusters were identified. Although innovative at the time, the analysis was relatively simplistic and a more sophisticated approach to data collection and analysis would be required for any repeat survey, to address the range of issues currently exercising policy makers.

6. ‘Causes of Change in British Vegetation’ was one of the ECOFACT series of research projects which followed CS1990. It related ‘Indicators of Botanical Diversity’ to driving forces for change through a series of hypothesized links, and matches between observed and expected changes were scored as an indication of the strength of the evidence for the impact of each driving force. The ECOFACT project produced a robust system for analysing vegetation change. Links between driving forces and vegetation change were made through species functional traits such as Ellenberg scores and Grime’s triangle.
and the influences of agricultural drivers inferred on the basis of these; no direct links with agricultural management data were made, and this limited the scope of the analysis.

7. The ‘Drivers of Countryside Change’ project was linked to CS2000, and consisted largely of a series of reviews intended to provide a context for the interpretation of CS2000 data. These included a review of ‘Rural Sustainability and Countryside Change’, a review of the ‘Processes of Countryside Change’ study in the context of CS2000, and reviews of key trends in agriculture, agricultural trends measured by the Farm Business Survey, and an analysis of June Census data. The work did not include any direct linking of CS and agricultural datasets. The project also acted as a scoping study with a number of suggestions put forward for further work. Among those worthy of re-examination in the context of CS2007 are a study to determine how well CS samples different aspects of the countryside in relation to socio-economic criteria, and a further survey of farm structures and practices as carried out under the ‘Processes’ study, but with more detailed recording and analysis.

8. CS2000 FOCUS (Finding Out Causes and Understanding Significance) consisted of a series of pos-hoc analyses of CS2000 data to answer 17 policy questions concerned with changes in habitats and their causes. The analyses revealed some interesting insights into the nature of the observed changes, but many of the questions could not be answered adequately or only to a limited extent using CS2000 data. Attempts to understand mechanisms, were limited in some cases supporting management data, e.g. identification of set-aside to distinguish from grassland; data on fertiliser application, hedgerow management, management of dwarf shrub heath; high resolution data on atmospheric pollutants, especially ammonia.

9. Further research has resulted in a number of papers analysing vegetation change in relation to potential drivers, with particular emphasis on eutrophication. The range of issues studied included: whether field boundaries act as refugia for grassland plants; changes in species composition of vegetation types and species abundance between surveys; relationships between landscape and species diversity; causes of large-scale vegetation change; increase in lowland nutrient demanding plant species in the uplands. Most of this work used Ellenberg scores as indicators of driving forces, but more recent projects have also used atmospheric deposition data and modelled sheep grazing densities as explanatory variables.

10. To date, atmospheric N deposition has been the driver of change that has received most attention. There is potential to carry out integrated analyses using additional data to address a wider range of drivers of change in future work.

**Enhancing spatial and temporal resolution**

11. This section gives an overview of the properties of the Countryside Survey data and potential methods for data manipulation to allow comparison of CS2007 data with other datasets, with some specific examples. Possible stratifications based on agriculturally-related datasets are considered, and the scope for direct matching against some key surveys of agricultural management practices is investigated.

12. Properties of datasets that determine the best method for integration with other datasets include spatial representation (raster, vector or point), scale, distribution (e.g. patchy, continuous), and boundary type.
13. Methods for data manipulation to improve correspondence with CS data include: interpolation; stratification; aggregation and disaggregation (weighted or categorical). Examples of suggested approaches for key datasets are given.

14. Historically, comparison with other datasets has been mainly through stratification using the ITE Land Classes, with the Countryside Information System providing a dedicated software vehicle for this purpose. However, developments in GIS technology now mean that a wider range of possibilities is available. It is planned that CS data will be made available over the Internet at individual square level. Precise square locations will not be given, to preserve confidentiality and the integrity of the survey; instead, the data will be stratified in several ways. These are likely to include standard administrative area classifications (e.g. NUTS), but a range of others with relevance to agricultural land use are also suggested. These include: groupings of JCAs, Agricultural Land Classification, dominant farm type, index of specialisation; and an aquatic landscape classification. Some possibilities for developing new types of farm typologies and the potential use of farmer behavioural typologies are also discussed. In the longer term, there is potential to develop a statistical approach to producing an optimal stratification for each analysis.

15. A data matching exercise was carried out to determine the degree of matching between locations of CS squares and three sample datasets relating to agricultural management practices: the Pesticides Usage Survey (PUS), the Farm Practices Survey (FPS) and the British Survey of Fertiliser Practice (BSFP). Matching was carried out at 1km and 5km square levels. Only 0.2-0.3% of survey squares matched at the 1km$^2$ level, and 3-5% at the 5 km$^2$ level. However, the majority of CS 1km squares were within 10km of a FPS and PUS survey points, the modal distance being 2 to 3 km (i.e. just outside the 5km square used in the preceding analysis). There were more outliers for the BSFP dataset, but two thirds of CS squares were within 10km of a BSFP point. It is concluded that integration with these datasets may be best carried out through stratification by one or more additional datasets likely to influence the variables of interest.

Key agricultural data sources and access issues

16. Key agricultural and related data sources with potential for linking to CS data are briefly described, including the June Agricultural Survey, the December Survey of Agriculture, CAP payment administrative data (SPS, IACS, RLR), agri-environment scheme uptake data, livestock identification, movement and tracing schemes, Farm Business Survey (FBS), Farm Practices Survey (FPS), Farmers Voice, British Survey of Fertiliser Practice (BSFP), Pesticides Usage Survey (PUS) and Countryside Quality Counts (CQC).

17. Access and disclosure issues are discussed for the surveys identified above. Survey data in general are covered by the Data Protection Act, but access to June Survey data is also regulated by the Agricultural Statistics Act. This limits access to Defra and NDPBs acting on behalf of Defra. In addition, disclosure rules prescribe that reports based on June Survey data cannot include data relating to four or fewer holdings. Other surveys managed by Defra Surveys and Statistics division and derived datasets (i.e. those that draw a sample from the June Survey) are similarly restricted; these include the December Agricultural Survey, the FPS and the PUS.

18. FBS data are available through the UK data archive in anonymised form with location identifiers at a range of scales. BSFP data may be available with farm identifiers within Defra, but only in anonymised form to external organisations.
19. Data from the SPS, IACS, RLR and agri-environment schemes are available for research purposes. There may be a charge for provision of data from SPS, IACS and RLR. CQC data are available on the internet.

20. Difficulties arising from disclosure restrictions may be partially overcome by spatial manipulation of data to provide a dataset at a high resolution but without possibility of identifying individual farms. For example, a number of gridded versions of the June Survey have been produced for this purpose, such as that provided by EDINA in Edinburgh. Where two organisations hold restricted data at farm level, joint analyses may be carried out with each party providing data but only non-disclosive outputs being retained. There is potential for a more generic form of data access provision without transfer to the analyst through e-Science, an example being the Virtual Microdata Laboratory run by the Office for National Statistics.

Linking agriculture and CS data to provide evidence on key policy issues

21. The scoping study that preceded CS 2007 considered policy drivers for which CS data might contribute to an understanding of impacts, and also external datasets that might be linked to CS for this purpose. Those with relevance to agriculture included the ACEO programme, agri-environment scheme monitoring, LUCAS, Water Framework Directive monitoring, CQC and socio-economic and land management data, including the FBS, June Survey, December Survey, BSFP, PUS, FPS and specific crop surveys.

22. Current policy drivers of interest include the forthcoming CAP ‘Healthcheck’, and the impact of Environmental Stewardship and cross-compliance. ‘High Nature Value Farmland’ is a European level initiative to map and describe areas where farming practices are associated with high biodiversity. The ‘Ecosystems Approach’ provides a policy framework for considering environmental impacts in terms of ‘ecosystem services’. The UK recently signed the European Landscape Convention, and the CQC provides a landscape-centred assessment of changes in the English countryside. In the longer term, climate change is likely to continue to increase in prominence as a driver of both agricultural and environmental change.

23. In terms of CAP reform, CS2007 could contribute to an assessment of the value of set-aside and the need for mitigation measures to offset its withdrawal as a supply control measure. The timing of CS2007 is fortuitous, as it immediately preceded the setting of a zero set-aside rate by the European Commission, but unfortunately the sample size is likely to be small. CS2007 data and LCM2007 could also provide a baseline against which to measure any future expansion in the growing of biomass energy crops.

24. Previously, sample size has been insufficient to report on agri-environment scheme outcomes. However, with the advent of Entry Level Stewardship, covering more than 50% of eligible farmland, sample size is likely to be sufficient for CS2007 to provide useful information on some options within the scheme. Digitisation of agreement maps within CS squares would allow precise identification of options sampled, and this is recommended.

25. CS2007 could potentially provide information on the vegetation of land taken out of production under cross-compliance GAEC 12 provisions, but sample size is likely to be too small to provide representative data. CS boundary (B) plots could however provide information on field boundary vegetation managed under GAEC 14 rules.
26. There is some resistance to the incorporation of national datasets in the Europe wide mapping HNV farmland project, but LCM2007 could provide the basis for a high resolution map of HNV farmland as an aid to policy implementation at national level once definitions of HNV farmland have been agreed.

27. CS2007 could provide information for a future CQC assessment at aggregated JCA level, and the LCM could provide information at JCA level, though LCM2007 cannot be readily compared with earlier LCMs to measure change.

28. CS has been identified as the most appropriate scheme for monitoring of a range of habitats in relation to climate change, and links to the Environmental Change Network provide some continuity of measurements between Countryside Surveys, albeit at a small number of sites. CS and the LCM in conjunction with land use data have a potentially important role in monitoring climate change impacts.

29. The ‘integrated assessment’ module of CS2007 aims to interpret CS data in terms of ‘ecosystem services’. Linking to agricultural datasets could be an important aid to the interpretation of pressures on provision of these services, including atmospheric pollution and eutrophication (BSFP), habitat change (agricultural land use data), grazing pressure (June Survey/livestock identification and tracing schemes), surface drainage (aerial photos), agricultural management (BFSP, PUS, FPS).

CS as a source of data for policy indicators

30. CS data already underpins several policy indicators, but there is potential for the development of further indicators that could usefully inform current policy developments. An indicator of habitat connectivity is already under development. CS would be well suited to the production of an index of habitat diversity, a key influence on biodiversity in managed landscapes. This would complement the indicator of connectivity in analyses of countryside change and its environmental impacts.

31. Additional measures of species diversity could include beta diversity (species diversity between habitats), and diversity of upland habitats. Plant diversity in field margins could be disaggregated into those managed under cross-compliance rules, agri-environment schemes and others.

32. An indicator based on food plant abundance for one or more of the groups birds, butterflies and bees could be a useful indication of the impact of land management changes on key resources, but evidence that the chosen plants or plant groups have a limiting effect on populations would increase the value of such an indicator.

33. The importance of eutrophication as a driver of vegetation change has now been well established, and its adoption as an indicator of agricultural impacts (in conjunction with measures of agricultural and non-agricultural N outputs) could be a useful indicator.

34. CS is an important source of information on a range of soil attributes and could potentially contribute to the soil indicator and monitoring framework under development by the UK Soil Indicators Consortium.

Further research and development

35. Thirty six recommendations are made for potential further work, prioritised in three categories. Those given highest priority include the following:
   - A survey of farm structures and practices for farms in CS squares;
• Development of a classification of JCAs into ‘landscape types’;
• Development of classifications of agricultural land use based on farm level data;
• Consideration of the following as potential stratifications for CS2007 data: agricultural land classification, dominant farm type, index of specialisation, aquatic landscape classification;
• Identification of set-aside fields in CS squares and analysis of botanical composition;
• Digitisation of Environmental Stewardship agreements in CS squares and analysis of vegetation in appropriate options within agreements;
• Analysis of field boundary vegetation in relation to cross-compliance (GAEC 14) provisions;
• Investigation of the value of the British Survey of Fertiliser Practice as a source of data on nutrient inputs for the integrated assessment module;
• Investigation of value of agri-environment schemes in supporting provision of ecosystem services;
• Investigation of the potential to use the Pesticides Usage Survey in analysis of herbicides as agents of vegetation change, and impacts of pesticide application on surface water pollution;
• Disaggregation of the indicator for plant biodiversity in fields and field margins to separate margins managed under cross-compliance and agri-environment schemes from others;
• Development of species diversity indicators for upland habitats;
• Carry out a review of the importance of food plants in limiting populations, as a precursor to the possible development of an indicator based on food plant occurrence;
• Development of one or more indicators based on Ellenberg N values for different habitats;
• Ensure that the potential of CS data as a source of evidence for indicators of soil attributes is fully realised.
INTRODUCTION AND BACKGROUND

1.1 AIMS AND OBJECTIVES
This report describes the results of a scoping study carried out for the Defra Agricultural Change and Environmental (ACE) Observatory Programme by the Central Science Laboratory (CSL) in association with the Centre for Ecology and Hydrology (CEH), with the following aim:

“To investigate opportunities to link Countryside Survey 2007 to key drivers of agricultural change, in order to obtain a better understanding of the role played by agriculture as a causal agent of change in biodiversity, habitats and landscape features in the countryside.”

The specific objectives of the study are as follows:

1. Review past research approaches;
2. Consider ways of enhancing the spatial and temporal resolution of CS 2007 in order to add to its value in monitoring CAP-related change;
3. Review data analysis approaches and data access issues to ensure the survey can link to data on agricultural structures, farm types and farm management practices within the survey squares;
4. Specifically scope out potential for survey results to look at the impact of key drivers from the agriculture sector by linking the habitat and species data to changing farm management practices;
5. Review any potential indicators from the CS2007 that could enhance the monitoring programme for the Observatory in the future;
6. Review and provide any recommendations for new data from the Observatory Programme which could enhance or complement the data collected through the CS2007;
7. Propose a range of research options that could be taken forward in later work.

1.2 BACKGROUND

1.2.1 The Countryside Survey

Countryside Survey (CS) 2007 is the most recent in a series of surveys carried out at intervals of 6-9 years. Previous surveys were done in 1978, 1984, 1990, and 1998 (the last generally being known as ‘CS 2000’, because it reported in the millennium year). The survey is based on a number of sample squares, each 1km² in area. The number of squares sampled has increased over time, from 256 in 1978 to 569 in 1998. It was planned that the 2007 survey will cover 629 squares. 302 in England, 124 in Wales and 203 in Scotland. One of the reasons for the increase in number of squares was to enable separate reporting for the devolved areas of the United Kingdom.

The main purpose of the survey is to provide estimates of stock, condition and change in features and habitats in the UK countryside. In the CS 2000 report, results were presented in terms of 17 Biodiversity Action Plan ‘Broad Habitats’.

1 For further details, see http://www.countrysidesurvey.org.uk/index.html and http://www.cs2000.org.uk/
2 excluding marine habitats which were not sampled, and three additional coastal habitats for which the survey was not representative
to landscape features and habitats, data are also collected on vegetation, freshwaters and soils. The number of measurements made has increased with time.

The 1990 and 1998 ground surveys were accompanied by additional collection of satellite data for the whole country, which was then analysed to produce a land cover map. This provides valuable additional information on patterns of broad habitat distribution across the country, but has limited accuracy at local level. A land cover map will also be produced as part of the CS2007 project.

1.2.2 CS2007

1.2.2.1 Changes from previous surveys

The basic structure of the survey has been maintained to ensure consistency with previous surveys. A major change is the use of electronic data capture with portable data recorders, allowing direct download to computers, thus speeding analysis and allowing earlier reporting. Some additional parameters are being measured: field margin plots on arable land, margins managed under Environmental Stewardship, and veteran trees.

Hedges and lines of trees have been re-classified as Woody Linear Features (WLF). They are divided into those of ‘natural’ vs. ‘unnatural shape’ to distinguish the two categories. Condition attributes have been recorded.

Priority habitats have been mapped and targeted with additional plots, and field margin plots established for a new baseline. One square metre plots have been established within X plots (as recommended by Critchley et al., 2005) to enable comparison with data from previous monitoring of agri-environment schemes.

The Land Cover Map will use new imagery (previous versions used Landsat, which is no longer available), and be constructed on the basis of OS Mastermap polygons. LCM1990 was pixel based, and there were difficulties in relating the map to real world objects at a fine scale. LCM2000 was object-based, but divisions were derived from spectral characteristics of the earth Observation (EO) data rather than actual boundaries. LCM2007 will be based on actual boundaries as mapped by OS Mastermap, which will greatly increase its utility, but has the disadvantage that the new map will not be comparable with the previous Land Cover Maps, and hence will not be suitable for studying change in land cover. In order to match the EO data to OS Mastermap, some generalisation of the map was necessary, as the level of detail was greater than the resolution of the satellite imagery. The methodology for this process is described by Smith et al. (2007).

1.2.2.2 Structure

CS2007 includes the following work packages:

1. Landscape features, habitats and vegetation
2. Land Cover Map 2007
3. Freshwater module
4. Soils module
5. Reporting
6. Integrated Assessment
7. Field Survey
8. Informatics
9. Project management & external communications
1.2.2.3 Reporting

There will be a UK report but separate analyses will be carried out for Scotland and Wales. More squares have been included than previously to provide statistically robust samples in devolved administrations. The first reports are due in November 2008. Further reports on soils, microbial analysis, water invertebrates etc. will follow later.

The reporting structure will have several tiers:

1. Main results, incorporating ‘Storylines’, i.e. time series (e.g. hedgerows, arable biodiversity, eutrophication etc.) and ‘Accounting for Nature 2’, repeat of CS2000 main report (broad habitats etc.). Due November - December 2008.

2. Country-level reporting April 2009

3. Soils and Freshwater 2009-10

4. Integrated Assessment 2010

5. Land Cover Map 2009

6. Web-based dissemination of results.

7. Release of raw data for individual squares, minus locations e.g. at county level (see also section 3.6.4.7).

The integrated assessment module will consist of a programme of research questions set before the results were obtained (cf. FOCUS study of CS2000, responding to results, in which the questions were defined afterwards). The aim is to model drivers of change in relation to ecosystem services (see section 5.2.8).

1.2.3 The Agricultural Change and Environmental Observatory\(^3\)

The Defra Agricultural Change and Environment Observatory was launched in 2005, with the aim of monitoring and analysing the environmental impacts of CAP reform and other key drivers of agricultural change in England. The Observatory aims to identify significant trends in farming patterns and practices and their resulting environmental impacts, including the longer term impacts of farm practice changes.

1.2.4 Changes in agricultural policy since 1998

The period between CS2000 and CS2007 has seen two rounds of reform of the Common Agricultural Policy. The first, ‘Agenda 2000’, was less ambitious than originally intended, but did include a number of provisions which could improve the environmental imprint of agriculture. These included:

- The Rural Development Regulation, hailed as the “second pillar” of the CAP, which required each member state to draw up a rural development plan providing support for rural development under a number of headings, though only agri-environment measures were compulsory
- A horizontal regulation (1259/99), which required member states to take appropriate environmental measures, which could include mandatory environmental requirements, support for agri-environment measures or specific environmental requirements as conditions for the receipt of direct payments i.e. cross-compliance.

\(^3\) Further details of the Observatory Programme can be found at: http://www.defra.gov.uk/farm/policy/observatory/index.htm
• Area payments replacing headage payments in LFAs
• A “national envelope” which allowed national discretion in the application of a small proportion of direct payments in the beef sector, which could potentially support extensive grazing
• The ability for national governments to modulate payments in order to increase expenditure on rural development measures.

The second round of reform, which occurred in 2003 but was not implemented until 2005, was more significant. The main change in support resulting from the 2003 CAP reforms in England, under EU Council Regulation (EC) No 1782/2003, was the ‘decoupling’ of aid to producers in the principal sectors which have benefited from CAP subsidy in the past, namely: beef, arable, sheep meat and dairy. From 1 January 2005, most former direct payments to producers were combined into a single area-based payment. This was initially partially linked to levels of historic receipts but over the period to 2012 would evolve gradually into a flat rate payment per hectare of eligible land. Reform of the sugar sector was agreed in 2006, resulting in a significant cut in the guaranteed price from 2007, with compensation to producers incorporated into the decoupled Single Payment Scheme (SPS), as this proceeds.

As a result of decoupling, land which was previously used for other kinds of farm output (excluding permanent crops) and which therefore did not receive CAP direct aids, will in future be eligible for SPS, at a level which will increase gradually over the transition from a historic to a flat-rate area-based payment system.

Decoupling will mean that decisions about what and how much to produce from farmland will not affect support levels under the SPS, so farmers have greater flexibility to change their farming systems and practices in response to other market and external signals, in line with demand. However, certain safeguards were also included in the reforms to protect the environment, including cross-compliance (conditions that farmers must fulfil in order to receive SPS payments, section 5.2.4) and a strengthened rural development policy with more funding, partly paid for out of ‘modulation’, a mechanism to transfer a proportion of subsidy funding to rural development measures, including agri-environment schemes.

At the same time, a major overhaul of agri-environment schemes took place in England, with the former Countryside Stewardship and Environmentally Sensitive area schemes being replaced by the Environmental Stewardship scheme, incorporating two strands, and ‘Entry Level’, with a single area-based payment and open to all, and a ‘Higher Level’, with separate payment rates for each option and limited entry based on local targets (see section 5.2.3).

The early impacts of the most recent reform were reviewed by Dwyer et al. (2006), and this review has since been updated by Gaskell et al. (2007).

1.2.5 The scoping study

One of the activities of the ACE Observatory in its first year was to establish a monitoring framework for agricultural change and environmental impacts, and conduct a baseline assessment on which to base analyses of future changes (Boatman et al., 2006). The CS was identified in this review as a key source of data on changes in the rural environment. For some variables, it is the best source of information available. However, it has another great strength in the range of measurements made on each square, thus providing the potential for analyses of interactions between the different variables measured. However, the limited numbers of squares surveyed and the relatively long time intervals between surveys restrict the spatial and temporal resolution at which the results can be analysed.
Also, the survey does not collect data on the drivers of habitat change. This scoping study aims to investigate ways in which the value of CS 2007 outputs can be enhanced for the purposes of the ACE Observatory.

Among the conclusions of a review of lessons from the previous Countryside Survey (Briggs, 2003) was the following statement:

“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.”

The report continued:

“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.”

This scoping study will investigate the potential for realising this aspiration, which has been given added impetus through the advent of the ACE Observatory.

### 1.2.5.1 Note on presentation

During this report, similar issues arise on a number of occasions in different contexts. In order to aid the reader, cross-references to sections dealing with similar or related issues are provided throughout the text. Recommendations are identified in bold lettering as they emerge; these are then detailed in chapter 7.
2. REVIEW OF PAST RESEARCH APPROACHES

The Countryside Surveys have been designed to record and describe change in habitats and features within the countryside, but not to assess the causes of change. Therefore, the analysis undertaken for the main Countryside Surveys reports has in the past been supplemented by further analyses designed to answer specific questions of policy interest. Under this objective, these past studies will be reviewed and the applicability of the types of analysis used, their conclusions and recommendations will be analysed in terms of their relevance to CS2007, particularly in relation to the aims of the ACE Observatory.

2.3 PROCESSES OF COUNTRYSIDE CHANGE

2.3.1 Overview

Potter et al. (1996) describe the results of a socio-economic survey of occupiers of land in the 1km sample squares used for CS1990. The survey obtained data from 504 occupiers in 169 of the 254 1km squares sampled in the Countryside Survey. The sub-sample of squares in the socio-economic survey tended to be more intensively managed, contained greater proportions of tillage and intensive grass, and less semi-natural vegetation and coniferous woodland than the overall sample. Socio-economic and CS1990 data were linked using a GIS. High- and low-change parcels were identified through a re-analysis of the CS1990 data.

Each parcel was characterised in terms of its “environmental stock”. This was calculated as the sum of the area of semi-natural vegetation, deciduous woodland and extensively managed grassland in each parcel. This measure was then related to the farm characteristics as revealed by the questionnaire survey. The level of “environmental stock” was analysed by farm type, landscape type, farm area, and economic class (defined as the proportion of farm household income derived from agriculture). The nature of the “environmental stock” parameter meant that it tended to be greater on grassland farms, indeed, the authors note that over 50% of parcels on arable farms had no “environmental stock” present. Further analysis considered the extent of changes between types of land cover (tillage, intensive grass, extensive grass, semi-natural vegetation, deciduous woodland) and levels of change in botanical composition (characterised as indicating more intensive, less intensive or same intensity of management) between arable, pastoral, and marginal/upland landscapes. Changes in farm size in these landscape categories and mobility between categories were also considered.

A cluster analysis was carried out to classify farms into groups, according to their propensity to change in a more or less intensive direction. Five clusters were identified:

1. Livestock improvers and intensifiers
2. Livestock intensifiers
3. Arable intensifiers
4. Livestock extensifiers
5. Stabilisers

The proportion of each of these types making certain types of change (e.g. new buildings, drainage, more/less fertiliser etc.) was presented.
In the discussion, it was pointed out that just 17% of farmers accounted for 90% of change, and that it is important to target these if the objective is to anticipate change and promote uptake of agri-environment schemes where they will be most effective. The difficulty is in anticipating major changes under new ownership due to retirement or sale of land which has been under stable management previously.

2.3.2 Discussion

This study represents an early attempt to link CS results to management drivers. Such an approach was novel at the time and provided interesting and valuable new insights into the nature and impacts of agricultural change. However, the analysis was rather too simplistic to address the more highly developed and complex requirements of agri-environmental policy towards the end of the first decade of the 21st century. For example, “environmental stock” was measured as a combination of semi-natural vegetation, deciduous woodland and extensively managed grassland, the implication being that other types of farmland were of no environmental value. Since that time, considerable advances have been made in understanding the nature of environmental value on farmland. For example, the conservation significance of arable weeds as the most threatened group of British plant species classified by habitat, is now appreciated (Cheffings & Farrell, 2005; Still & Byfield, 2007). Furthermore, their role as a source of food for declining birds, both directly and indirectly through the invertebrate life they support, has now been realised (Marshall et al., 2003). Indeed, loss of arable habitat in grassland areas is now recognised as a potential contributing factor to declines of farmland bird species, including some in the Farmland Bird Index (Robinson et al., 2001). The definition of environmental stock used by Potter et al. (1996) therefore does not reflect the habitat requirements to fulfil the Government’s PSA target of reversing the decline in the Farmland Bird Index by 2020. In recognition of the importance of plants to other organisms of conservation concern, numbers of bird food plants and numbers of food plants for butterfly larvae were among the measures of vegetation condition reported in CS2000.

This is one example of a current policy issue which would not be addressed by the approaches used by Potter et al. (1996). There are others; for example, since the 1990s, resource protection issues have increased in prominence, with the implementation of Nitrate Vulnerable Zones from 1996 onwards to address the requirements of the Nitrates Directive, and more recently, the ongoing programme to implement the requirements of the Water Framework Directive. This came into force in December 2000, and requires all inland and coastal waters to reach "good status" by 2015. The role of agriculture as a source of air pollutants such as ammonia (Anon, 2002), and greenhouse gases such as methane and nitrous oxide has also received increasing attention, and soil management is now a key policy issue within Defra. Any repeat survey would need to give attention to management practices likely to influence resource protection issues, to complement the measurements of soil and water quality which were introduced in CS2000.

The analyses only considered general attributes of the farms in question; although aspects of farm management were recorded, these were not related to the results of the field survey on a parcel by parcel basis. Such an approach could give much greater insights into the factors affecting the observed results at a farm and field scale.

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4 Public Service Agreement
In conclusion, the Processes study was a landmark development in integrating socio-economic data with data on habitats, features and vegetation. However, the analysis was relatively simplistic in relation to today’s policy needs, and if a similar survey were to be repeated in relation to CS2007, a wider range of issues would need to be covered and much more detailed analyses would be envisaged.

2.4 CAUSES OF CHANGE IN BRITISH VEGETATION

2.4.1 Overview

This study was one of the ECOFACT series of research projects which followed CS1990, though the report (Firbank et al., 2000) coincided with the pre-publication stages of CS2000. It considered the driving forces causing change in botanical diversity, as measured by twelve “Indicators of Botanical Diversity” (IBDs), though only six of these could actually be used in relation to CS1990 data. Some of these were based on the Countryside Vegetation System (CVS), a classification system for vegetation developed specifically for analysing CS data (Bunce et al., 1999a). The CVS classes are grouped into eight “aggregate classes”; movement between aggregate classes indicates a higher degree of change than movement between classes within aggregate classes.

Driving forces were classified into ten categories, some with sub-categories, following Petit et al. (1998). However, some of these were found not to be appropriate for analysis of CS data, and so were not considered further. The IBDs and driving forces included in the analysis, and the hypothesized links between them, are shown in Table 2.1. The complete lists of IBDs and driving forces are given in Appendix 2.

Changes at plot scale between IBDs were analysed and reported by Bunce et al., 1999b. A series of hypotheses were set up linking driving forces to expected changes in IBDs, based on the scientific literature and expert opinion. The underlying theory was that if the observed changes corresponded well with each of the IBDs (selected to represent different aspects of the vegetation), there was strong evidence of the influence of the driver concerned. The matches between observed and expected responses for each IBD were classified as GOOD, MODERATE, POOR or NO MATCH, and scored using a scale of 0 (no match) to 3 (good). The sum of the scores divided by the total possible score indicated the strength of the evidence for the impact of the driving force. The method of classification is not explicitly described, but appears to have been subjective. The process is summarised in Figure 2.1.

2.4.2 Discussion

The ECOFACT project established a robust system for analysing vegetation change, suitable for application at the level of sample plots within km squares. Because plots are marked so that they can be relocated precisely, the assessment of change is very precise. The same system was used in CS2000 and will be applied in CS2007.

Table 2.1 Summary of hypothesized links between driving forces and selected Indicators of Botanical Diversity (IBD) (from Firbank et al. 2000). AC = Aggregate Class; CVS = Countryside Vegetation System.

<table>
<thead>
<tr>
<th>Driving Force</th>
<th>IBD1 Shifts between AC</th>
<th>IBD2 Shifts at CVS class level</th>
<th>IBD3 Analysis of change in functional attributes (Grime)</th>
<th>IBD5 Species richness changes</th>
<th>IBD6 Ellenberg score changes</th>
<th>IBD7 Change in freq. and cover of spp groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eutrophication</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Atmospheric deposition</td>
<td>y</td>
<td>y</td>
<td>n</td>
<td>y</td>
<td>y</td>
<td>y</td>
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<tr>
<td>Agricultural fertilisers</td>
<td>y</td>
<td>y</td>
<td>n</td>
<td>y</td>
<td>y</td>
<td>y</td>
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<tr>
<td>Waterside eutrophication</td>
<td>y</td>
<td>y</td>
<td>n</td>
<td>y</td>
<td>y</td>
<td>y</td>
</tr>
<tr>
<td>Acidification</td>
<td>y</td>
<td>y</td>
<td>n</td>
<td>y</td>
<td>y</td>
<td>y</td>
</tr>
<tr>
<td>Urbanisation and transport</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Loss of land cover to built</td>
<td>n</td>
<td>n</td>
<td>n</td>
<td>n</td>
<td>n</td>
<td>n</td>
</tr>
<tr>
<td>Road verge management</td>
<td>y</td>
<td>y</td>
<td>n</td>
<td>y</td>
<td>y</td>
<td>y</td>
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<tr>
<td>Agricultural intensification</td>
<td></td>
<td></td>
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<tr>
<td>Crop management &amp; pesticide use</td>
<td>y</td>
<td>y</td>
<td>y</td>
<td>y</td>
<td>y</td>
<td>y</td>
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<tr>
<td>Grassland cultivation</td>
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<td>y</td>
<td>n</td>
<td>y</td>
<td>y</td>
<td>y</td>
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<tr>
<td>Upland sheep grazing</td>
<td>y</td>
<td>y</td>
<td>n</td>
<td>y</td>
<td>y</td>
<td>y</td>
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<tr>
<td>Drainage</td>
<td>n</td>
<td>y</td>
<td>n</td>
<td>y</td>
<td>y</td>
<td>y</td>
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<tr>
<td>Waterside management</td>
<td>y</td>
<td>y</td>
<td>n</td>
<td>y</td>
<td>y</td>
<td>y</td>
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<tr>
<td>Forest management</td>
<td></td>
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<tr>
<td>Broadleaved planting</td>
<td>n</td>
<td>n</td>
<td>n</td>
<td>n</td>
<td>n</td>
<td>n</td>
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<tr>
<td>Broadleaved management</td>
<td>y</td>
<td>y</td>
<td>y</td>
<td>n</td>
<td>y</td>
<td>y</td>
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<tr>
<td>Conifer planting</td>
<td>y</td>
<td>y</td>
<td>n</td>
<td>y</td>
<td>n</td>
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<tr>
<td>Conifer management</td>
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<td>n</td>
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<td>y</td>
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<tr>
<td>Hedgerow management</td>
<td>y</td>
<td>y</td>
<td>n</td>
<td>y</td>
<td>y</td>
<td>y</td>
</tr>
</tbody>
</table>
The method of linking to driving forces depended on established relationships between species and environmental parameters, such as the Ellenberg system (Ellenberg, 1988; Ellenberg et al., 1991; Hill et al., 1999), which scores species according to its abundance in relation to seven scales, of which five were employed in ECOFACT: light, moisture, pH, fertility and continentality. Another system is that of (Grime, 1977) which classifies plant traits within a triangular space, the apices of which correspond to ‘competitors’, ‘ruderals’ and ‘stress-tolerators’. Based on such relationships, a series of hypotheses was established linking change in IBDs to the driving forces identified. Whilst this has enabled a useful interpretation of the likely processes underlying change, there is no direct linkage between data on environmental drivers or agricultural management and the changes observed. This limits the extent of the analysis which can be performed. For example, it was not possible to distinguish between impacts of changes in grassland management such as type of livestock, types of organic manure applied, method of grass conservation (hay/silage), herbicide use etc and nitrogen fertiliser usage, and hence, despite the potential importance of these factors, grassland management was not considered as a driving force in the analysis.

2.5 DRIVERS OF COUNTRYSIDE CHANGE

2.5.1 Overview

This project was commissioned after the data collection phase of CS2000 had been completed, but before data analysis had been completed. The aims of the project were to:

i). “Support the presentation of the first outputs from Countryside Survey 2000 with a detailed review and analysis of the social, economic and policy drivers
relevant to understanding the patterns of change detected since the earlier surveys; and,
ii). Shape DETR's long term research strategy in relation to the social, economic and policy drivers of countryside change, so that more effective and integrated policies for achieving sustainable development can be achieved.

The study was split into three modules:

1. Rural Sustainability and Countryside Change
2. Agriculture as a Driver of Countryside Change
3. Forestry as a Driver of Countryside Change

The first two of these modules are briefly described below and the resulting recommendations discussed; the third is considered to be outside the remit of this study.

In considering the scope and constraints of the study, several important points were made:

- The complexity of the issues was emphasized, and the difficulty of setting boundaries;
- The need to "link CS2000 data with other sources of information to develop an understanding of causal mechanisms" was highlighted;
- The fact that changes may arise as a result of the combined impact of several drivers was raised, thus making it impossible to ascribe a given change to a single cause.

The relevant sections of the report are summarised below, drawing out the elements of particular significance to the current study. The attention given to each section varies according to its relevance to the aims of this study.

2.5.2 Module 1: Rural Sustainability and Countryside Change

The first module aimed to "develop a conceptual framework in which the general socio-economic trends and pressures in rural areas can be understood." A review of "Rural Sustainability 1988-1998" was carried out and combined with information from other sources to produce the report. The review was largely concerned with policy developments at EU and UK level, but also included some summaries of socio-economic trends such as population change, housing, changes in rural industries and services.

The development of the concept of sustainability as key theme of rural policy was emphasized; however, it was considered that concept had been developed too late in the 1990s for major impacts on the countryside to be detected by the 1998 Countryside Survey. The need to consider the wider issues of rural development in addition to agriculture as drivers of change was highlighted, as was the growing realisation of the need for local solutions to problems. Recommendations included the following:

- future Countryside Surveys "must be better integrated with other sources of information about the structure and dynamics of rural communities"
- "a much better understanding of the rural context of individual CS2000 survey squares is required"
- this should be developed in relation to "a follow-up socio-economic survey of farm enterprises within the survey squares".

In relation to the second of these points, it was pointed out that the Land Class System was not necessarily the most appropriate method of stratification of the data
for analysis in relation to socio-economic variables, and that it would be useful to examine the possibility of alternative stratifications for this purpose. A problem with this approach was that the CS squares were chosen to be representative of the various land classes, may not be representative of the categories in a different classification. Nevertheless, it was felt that the additional understanding of the relationship between the environmental variables and the underlying drivers that would follow, would make the work worthwhile. Recognising that the CS squares may not be fully representative of the range of social and economic conditions existing in the countryside, a study was proposed “to determine just what part of the ‘rural spectrum’ Countryside Survey actually samples”. Such studies could be usefully undertaken in relation to a range of variables (Recommendation 1).

2.5.3 Module 2: Agriculture as a Driver of Countryside Change

This module contained a number of separate elements:

i. To include all the primary data collected during the 1993 Processes of Countryside Change Study in the CS2000 database;

ii. To review Processes of Countryside Change Study and the possibilities for further analysing these data in the context of CS2000;

iii. To review the changing structure of agriculture 1990-98 and the possible impacts on the stock and condition of the different land cover and habitat types in the wider countryside;

iv. To review the use of MAFF June Census at the Local Authority and District level and Farm Business Survey (FBS) data, and consider how they might help with the detailed interpretation of CS2000 results; and,

v. To develop recommendations in relation to the agricultural driver, both in the context of CS2000 and DETR's wider research programme.

The first work package covered the technical procedures required to incorporate the data from Processes of Countryside Change into the CS2000 database, to facilitate integrated analyses. Work packages (ii), (iii) and (iv) were each informed by comprehensive reviews contained in Appendices to the main report. These are summarised below, before reviewing the discussion and recommendations relating to this module in the main report.

2.5.3.1 Review of Processes study in the context of CS2000

The purposes of this review were to: (a) explain changes in the policy/economic context of agriculture since the ‘Processes’ study took place; (b) consider the farmer responses to these changes and the likely effects on land cover and ecology; (c) assess the scope for further interpreting the CS2000 results through a reanalysis of available data, but also to explore the case for a repeat socio-economic survey of the sample squares.

In considering the scope for analysing potential causes of change through re-analysis of the 1993 data, it was suggested that tests could be made for association between farms on an expansionary or contracting path, and changes in environmental stock. Such an analysis would assume a continuity of approach between 1993 and 1998, when CS2000 data were collected. No measures were proposed to account for changes in management due to factors such as change in ownership, transfer to a new generation or contracting out, since the data were collected, though it is perhaps reasonable to assume that over five years only a minority of the farms would have undergone major changes of this nature. Further analyses using data from the June Survey and the Farm Business Survey were also proposed. As far as we are aware however, no such analyses have been carried out.
A strong case was made for a repeat survey. The arguments presented were firstly that this is the only reliable way of determining cause and effect, secondly that the value of the first survey would be greatly enhanced by a repeat survey, allowing the characterisation of trajectories of change, and thirdly that some of the limitations of the first survey could be corrected and an improved baseline established for further work. Potential improvements identified included:

- Increasing the number of survey squares covered &/or targeting those important for policy purposes;
- Improving representation within squares;
- Refining the measure of environmental stock used in analyses (see section 2.3 above).

(Recommendation 2)

2.5.3.2 Review of key trends in agriculture

This was a straightforward review of agricultural trends during the 1990s, updating an earlier review of the period between 1992 and 1996 to include the years to 2000. The first section summarised the changes in agricultural policy, including Agenda 2000 and its likely implications, the second examined market trends, and the third looked at the responses of farmers to these changes in policy and market drivers.

2.5.3.3 Agricultural Trends and the FBS: Measuring changes in performance and intensity.

This review discussed changes in financial indicators of agricultural performance. Firstly trends in net farm income, prices, subsidies, and other impacts of CAP reform were summarised, then the Farm Business Survey was briefly described, and finally changes in several measure of agricultural intensity were reviewed for different farm types; these include fertiliser expenditure, pesticide expenditure, grazing livestock density and expenditure on animal feed.

2.5.3.4 Analysis of MAFF June Census data at Local Authority level for England and Wales (1988-1997)

The final review of the series complemented the previous one by providing an analysis of changes influencing the nature of agricultural land cover, based on the June Agricultural Census (now more correctly referred to as a survey). Statistics are presented on land area and holdings, changes in proportions of farm types, changes by tillage and grass area, changes in land use and agricultural outputs, changes in cropping, horticulture and grassland, livestock numbers and stocking densities, and changes in labour on holdings. Changes are summarised by region and a comparison made between LFA and non-LFA areas.

2.5.3.5 Key aspects drawn out in Module 2 section of the main report

The main report draws on the reviews described above, and also earlier reviews by Wilkinson (1997) and Little (1998), plus the report on Causes of Change in British Vegetation (Firbank et al., 2000). It is argued that the process of geographical polarisation observed in the 1980s was replaced by patterns of consolidation (fewer, larger farms), specialisation, and diversification, whilst maintaining, or increasing, management intensity. It is also suggested that market forces were the main drivers of agricultural change during the 1990s, and that changes in agricultural policy, in particular the 1992 CAP reform, had relatively little effect. A series of recommendations is presented for further work under the four headings of ‘consolidation’, ‘polarisation & specialisation’, ‘diversification’ and ‘management intensity’, with the latter being divided into ‘fertiliser and pesticides’, ‘grazing
intensity’, ‘other aspects of farm management’ and ‘environmental practice/policy’. The further work identified includes additional analyses of June Census/FBS data, and CS 2000 data in the short and longer term.

Proposed analyses involving June Census/FBS or other data include extensions of the analysis already carried out to Scotland and Wales (for consolidation, polarisation and specialisation), analysis of diversification data by Standard Statistical Region (SSR) and Countryside Survey Environmental Zone (CSEZ) and inclusion of other survey data, extension of fertiliser and pesticide analysis including use of other data sources, and distinction of ESA from non-ESA land. Short-term analyses of CS2000 data proposed included changes in cover and vegetation types and Indicators of Botanical Diversity (IBDs) by SSR, CSEZ and Processes of Countryside Change (PCC) typologies, and comparison of areas with different policy designations (LFA vs. non-LFA, CSS/ESA vs. no agri-environment scheme). Long-term analyses of CS2000 data all relate to the use of a repeat socio-economic survey similar to that carried out for the PCC report. The tabulated summary of recommendations is reproduced in Appendix 3.

2.5.4 Discussion

Drivers of Countryside Change served two main purposes. It provided a series of reviews which set contexts for the interpretation of CS2000 data, and acted as a scoping study leading to a number of suggestions and recommendations for further work. What is did not do, for the most part, is provide an interpretation of the specific drivers of changes observed from comparison of CS2000 and CS1990 data. The reviews which underpin the report, whilst interesting and valuable documents in their own right, were written largely without reference to CS data, and simply review various trends with little attempt to relate them to the findings of CS2000. The main report is largely concerned with using the supporting information to develop ideas for additional analyses that could be carried out to elucidate the impact of the drivers examined. The study provides a platform for the further investigation of relationships between socio-economic drivers and changes in habitats and vegetation observed in the Countryside Surveys, but it appears that few of the recommendations were taken up at the time. Nevertheless, some of the proposals still have relevance and are worthy of re-examination in the context of CS2007.

One proposal under Module 1 was to characterise CS squares in terms of socio-economic criteria, “to determine just what part of the ‘rural spectrum’ Countryside Survey actually samples”. The report suggests that any such work should ideally be undertaken in the context of agreed definitions of rural areas, and notes that preliminary consultations between Government departments on the development of such a typology had taken place. Since the report was written, a ‘Rural and Urban Area Classification’ has been developed by jointly by The Countryside Agency, Defra, the Office of the Deputy Prime Minister, the Office for National Statistics and the Welsh Assembly Government. This classifies areas by morphology (‘Urban’, ‘Rural town’, ‘Village’ or ‘Dispersed’ (hamlets and isolated dwellings)), and context (‘sparse’ or ‘less sparse’), and is applied at three scales: census output area, super output area and ward. In addition, the Defra Rural Evidence Hub provides access to a large amount of socio-economic data on rural areas in standard format at a range of scales. These resources could greatly facilitate the analysis of Countryside Survey data in relation to socio-economic variables characterising the broader aspects of rurality. (Recommendation 1)

7 http://www.defra.gov.uk/rural/ruralstats/leh.htm
Allied to this concept is the possibility of alternative stratifications of CS data to the Land Class system originally used as a basis for the sampling regime. The Land Class stratification is not necessarily appropriate to analysis in relation to socio-economic variables, and it would be worthwhile investigating the potential for different approaches. This issue is further considered in section 3.6.

A case is also made for a repeat of the survey of farm structures and practices carried out in the ‘Processes of Countryside Change’ study (section 2.5.3.1). As part of their case, the authors describe the importance of the dataset as deriving from “its ability to offer explanations at the parcel, square, land class and landscape level of land cover change in terms of the economic status, decision making histories and psychological motivations and aspirations of the people who actually occupy and manage farmland” and further, that “this is impossible to achieve through conventional farm surveys, no matter how well designed or complete their coverage.” Whilst both these assertions are correct, this potential does not appear to have been fully realised in terms of the analyses carried out (see section 2.3). Nevertheless, the ability to relate environmental change to socio-economic drivers at a scale and level of detail impossible to achieve in any other way is a tantalising possibility, and more achievable now than previously due to developments in Geographical Information Systems (GIS) and the ability to handle and analyse large volumes of spatially referenced data. (Recommendation 2)

2.6 CS2000 FOCUS

2.6.1 Overview

2.6.1.1 Background

CS2000 FOCUS (Finding Out Causes and Understanding Significance) consisted of a series of pot-hoc analyses of CS2000 data, further to those carried out for the main report (Haines-Young et al., 2000) to probe the data in more detail, investigate relationships and in some cases attempt to discover the reasons for observed change. The project was designed to answer 17 specific policy questions, grouped into seven topic areas. These are summarised in Table 2.2. The results were reported in two volumes, the first a summary report including implications for policy and recommendations (Barr et al., 2003), the second a series of technical reports providing the supporting evidence for each question. The objectives included acquiring and using other contextual data to assist in the analysis, interpretation and assessment, but this was done only to a limited extent.
Table 2.2. Aggregation of 15 specific research questions considered in CS2000 FOCUS, under 7 topic headings.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1 Enclosed farmland</td>
<td>1 Decline in semi-natural grasslands?</td>
</tr>
<tr>
<td></td>
<td>2 Newly cultivated land in CS2000?</td>
</tr>
<tr>
<td></td>
<td>3 Conservation value of weed species?</td>
</tr>
<tr>
<td>T2 Boundary &amp; linear features</td>
<td>4 Change in hedges 1990, 1993 and 1998?</td>
</tr>
<tr>
<td></td>
<td>5 Plant diversity, hedge characteristics, land use?</td>
</tr>
<tr>
<td></td>
<td>6 Value of hedges for birds?</td>
</tr>
<tr>
<td></td>
<td>7 Hedges that are being gained/lost?</td>
</tr>
<tr>
<td></td>
<td>8 Condition of ancient and/or species-rich hedgerows?</td>
</tr>
<tr>
<td>T3 Woodlands</td>
<td>9 Differences in estimates of woodland cover? Correspondence with AWI sites?</td>
</tr>
<tr>
<td></td>
<td>Woodland changes - where and how?</td>
</tr>
<tr>
<td>T4 Mountain, moor, heath &amp; down</td>
<td>10 Changes in dwarf shrub heath?</td>
</tr>
<tr>
<td></td>
<td>11 Increases in fen, marsh &amp; swamp?</td>
</tr>
<tr>
<td></td>
<td>12 Bracken invasion?</td>
</tr>
<tr>
<td>T5 Rivers, streams &amp; standing waters</td>
<td>13 Causes of overgrown streamside vegetation?</td>
</tr>
<tr>
<td></td>
<td>14 What and where are the new ponds?</td>
</tr>
<tr>
<td>T6 Developed land in rural areas</td>
<td>15 Habitat creation on developed land</td>
</tr>
<tr>
<td></td>
<td>16 Countryside around towns</td>
</tr>
<tr>
<td>T7 Agri-environment schemes</td>
<td>17 Agri-environment schemes?</td>
</tr>
</tbody>
</table>

2.6.2 Discussion

2.6.2.1 Interpretation of results

Whilst the analyses revealed some interesting insights into the nature of the observed changes, many of the questions could not be answered adequately or only to a limited extent using CS2000 data. In a number of cases this was due to the way the data were collected and a number of the conclusions and recommendations related to changes in protocols for data collection in future Countryside Surveys (e.g. improved recording of hedgerow condition in relation to the Habitat Action Plan (HAP) for Ancient and Species-rich Hedgerows). Many of these have been implemented in CS 2007.

Attempts were made in some cases to understand mechanisms, but these were limited by a lack of contextual supporting data, especially in relation to management. The limited ability to interpret the mechanisms underlying the changes restricts the ability to use the results predictively in terms of the impacts of future changes in land management on the habitats studied.

Some examples where lack of management information inhibited interpretation are as follows:
2.6.2.1.1 Question 1: set-aside

Changes in status of neutral, acid and calcareous grassland were analysed. For neutral grassland, there was a considerable turnover between this and other Broad Habitat types, but some of these gains and losses were probably in fact set-aside land, either being ploughed or re-classified as neutral grassland. Collection of basic information from the farmers involved, or matching to IACS data, would have greatly assisted interpretation of these results (see 5.2.2.2.1 for further consideration of set-aside). The technical report concludes: "We need to develop strategies for better joint analyses of available data on the drivers of change. Advances have been made in the statistical modelling of vegetation responses in terms of land-use and pollution but better integration is needed with socio-economic data, farm management data and cross-calibration with datasets that can help estimate climatic influences on CS responses." (Smart & Petit, 2003).

2.6.2.1.2 Question 1: fertiliser and ammonia data

Under recommendations for further work, Barr et al. (2003) comment: “Further research is required to quantify more accurately the effects of variation in the volumes of fertiliser applied to semi-improved grasslands across Britain. This research is not so much required to quantify the general impact of fertilisers on semi-natural vegetation but rather to assess the importance of this driver at the national scale. Similarly, there is a pressing need for robust but finer-grained modelling of ammonia deposition at the sub-km square level.”

2.6.2.1.3 Question 2: Conversion of unimproved Broad Habitats to arable, horticultural or improved grassland

Further information on the drivers of the observed trend towards conversion of unimproved grassland to intensive agriculture would assist interpretation and the likelihood of its continuation under a reformed CAP. The insertion of questions inserted into the Farm Practices Survey, the Farm Business Survey or the Farmers Voice survey (see sections 4.1.6 - 4.1.8) is probably the best way of obtaining this type of information.

2.6.2.1.4 Question 5: relationship between hedgerow structure and plant diversity

The lack of management data was felt to have impeded the analysis of relationships between hedge structure and plant species number. It was recommended that “more management data should be collected, either directly from landowners or indirectly form other sources”.

Several other recommendations highlight the need for additional data to aid interpretation. These include the collection of relevant data relating to agri-environment scheme agreements in CS2007.

2.6.2.1.5 Question 10: Causes for change in extent and condition of dwarf shrub heath

Changes in extent and condition of dwarf shrub heath were analysed in relation to numbers and changes in numbers of deer in Scotland (from the Deer Commission), sheep stocking density (Dragosits et al. 1988) and ammonia deposition. However, it was felt that “it is problematic to determine causes of change using currently available data, because of the lack of direct land management data and the low resolution of atmospheric deposition maps”.
2.6.2.2 Limitations of the Countryside Survey; additional data collection

The Countryside Survey is designed to provide national estimates of stock and change in measured habitats and features. Its strength is “as an integrated assessment rather than being targeted at specific indicators”\(^8\). As such, it has limitations in terms of the information which can be provided about particular habitats or types of land. The sampling design limits its ability to make good estimates for some aspects of interest, especially those which occur infrequently in sample squares, and in a number of cases FOCUS recommended additional data acquisition through surveys or other methods to complement the CS. These include:

- A national arable plant survey (Q. 3) (Recommendation 3).
- Management data for hedgerows (Q.5), dwarf shrub heaths (Q. 10) and other aspects. (Recommendation 2, see section 2.5.4)
- Data on deposition of atmospheric pollutants (especially ammonia) at a higher spatial resolution (Recommendation 4).
- A survey of rural/urban interfaces using CS methodology (to measure impacts of urban areas on adjacent countryside), should this aspect be of sufficient policy interest.

One area where CS2000 was generally unable to provide adequate information was on the effects of agri-environment schemes, because of the low incidence of land managed under agri-environment schemes in survey squares\(^9\). However, the Entry-Level strand (ELS) of Environmental Stewardship (ES), the new agri-environment scheme introduced in 2005 to replace the Countryside Stewardship Scheme (CSS) and Environmentally Sensitive Areas (ESAs) is likely to be implemented on the majority of farmland in England\(^10\), so the representation within CS sample squares will be much greater, and increase the potential to explore the impacts of ELS. However, the point is made in the FOCUS report that this “will at the same time reduce the value of CS as a control data set composed of land largely outside agri-environment schemes”. CS will continue however to provide poor representation of Higher Level (HLS) and Organic Entry Level (OELS) strands of ES, due to the much smaller areas of land in these schemes.

The potential for CS2007 to provide information relating to Environmental Stewardship is further considered in section 5.2.3.

2.7 Further research relating CS results to drivers of agricultural origin

Further research has resulted in a number of papers analysing vegetation change in relation to potential drivers, with particular emphasis on eutrophication. In carrying out this work, the following questions were addressed:\(^11\)

- What has changed? (signal detection)
- What has caused the change? (signal attribution)
- What will happen in future? (understanding mechanisms and processes).

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\(^8\) Annex 5 of the FOCUS report, p. 56
\(^9\) 15% of squares contained some land managed under agri-environment schemes; the sampling rate for land under agri-environment schemes was the same as for the countryside as a whole, i.e. 0.2%.
\(^10\) The Defra target is for 60% of farmland to be in the scheme by the end of 2007.
\(^11\) S. Smart, presentation to workshop on 3 October 2007 (see Appendix 5).
The challenge in carrying out these analyses has been to acquire explanatory variables at useful scales.

Smart et al. (2001) examined the question of whether field boundaries act as refugia for grassland plant species in intensively managed areas. The study combined an analysis of vegetation from paired fields representing different levels of management intensity at five sites, and CS 1990 data. Plant productivity was measured at the paired sites directly as N production. For CS data, Ellenberg values were used as a surrogate for N production. They found that species richness was higher on average within the field than within the field boundary when field productivity was low, but that as productivity increased, boundaries became relatively richer in species than the field as a whole. Thus at higher levels of productivity, boundaries acted as partial refugia, but because species richness at low productivity was higher in the field, some species were likely to be lost in the process of increasing productivity, as not all species present in the field were likely to be present in the boundary.

This analysis was extended by Smart et al. (2006) to cover a wider range of potential refuge habitats, including road verges, field boundaries, watercourse banks, and small biotope fragments. They tested an additional hypothesis: that as intensive land cover increases, trait values associated with high nutrient availability and competitive dominance would be represented more strongly among indicator species within refuges. The analysis focussed on indicator species of unimproved, mesotrophic and acid grasslands.

As in the previous study, the rate of reduction in indicator species richness as intensity increased was lower in the refuges than in fields. In field boundaries and road verges, species richness at lower levels of intensive land use was lower than in the fields and areal habitats, but for watercourses banks and small biotopes indicator species richness remained high as intensive land cover increased. However, plant traits associated with high fertility (specific leaf area (SLA), Ellenberg N) were more frequently represented where intensive land cover levels were high.

Smart et al. (2003) analysed changes in plant species composition between 1990 and 1998, expressed as mean Ellenberg fertility value for each fixed plot, for eight vegetation types and six environmental zones. Two thirds of tests of change in fertility value were increases and only 8% were decreases. Increasing fertility scores was found for infertile grassland, moorland, upland woodlands and heath/bog, regardless of landscape feature or environmental zone. Reduced scores were associated with arable land in Scotland, Wales and western England.

It was hypothesized that the observed increases in fertility scores reflected continuing impacts of succession, fertiliser use, grazing pressure and atmospheric N deposition, despite the fact that some of these drivers had reduced in intensity or stabilised over the period concerned. Slow response rates of upland ecosystems were considered to be responsible for the delayed impact. The negative changes were thought to result from implementation of set-aside. However, no attempts to undertake joint analyses incorporating data representing potential drivers were made in this study.

Smart et al. (2005) carried out an analysis of changed in the abundance of common plant species between Countryside Surveys carried out in 1978, 1990 and 1998 (CS2000). Species were grouped into aggregate classes as described by Bunce et al., (1999a) (see section 2.4.1). Changes in species frequency were analysed in relation to these aggregate classes; groups of plots were defined by their aggregate class in 1978 for analysis. Four traits were selected to indicate response to increases in fertility (SLA, Ellenberg N value, proportions of grass/forbs and stress – tolerance index) and three to indicate response to disturbance regime (proportion of woody species, canopy height, and ruderal index). The observed trait changes were consistent with increased fertility in habitats with inherently low availability of nutrients
(infertile grassland, heath, bog, and moorland), though it was not possible to separate the effects of N deposition, sheep grazing intensity and local agricultural improvement. In lowland linear habitats, trait changes indicated the progress of secondary succession.

Firbank et al. (2007) analysed the relationship between two measures of landscape diversity and two biodiversity indicators. The landscape diversity indicators were (a) the Shannon diversity index of broad habitat classes, and (b) the Shannon index of broad habitats with agricultural habitats subdivided into the main land cover types. These were regressed against species richness of plants and breeding birds. There were significant, positive relationships for all four combinations of landscape diversity and biodiversity indicators, but plant species richness was better accounted for by diversity of broad habitats alone, whereas breeding bird species richness was better related to diversity of broad and agricultural habitats.

Eutrophication was chosen as an indicator of agricultural impact. Direct impacts from agriculture were estimated by ‘N surplus’, calculated from the ‘ELPEN’ model based on crop area, livestock numbers and fertiliser inputs. Atmospheric deposition was also estimated. These variables were then related to Ellenberg N scores and found to explain nearly 22% of the variation between kilometre squares, with N surplus from agriculture accounting for the greater part of the explained variation. Broad habitat diversity was negatively related to N surplus, and plant species richness was negatively related to Ellenberg N score. However, there was no significant relationship between bird species richness and Ellenberg score.

Of the papers reviewed above, only Firbank et al. (2007) used external data to measure agricultural impact; the others all used Ellenberg score as a surrogate measure of eutrophication. Interestingly, Firbank et al. found that only 12.4% of variation in Ellenberg score was explained directly by N surplus, though this increased to 21.7% when atmospheric deposition was included. Thus, although agricultural N inputs influence soil fertility, the major part of the variation is accounted for by other factors.

Following on from work carried out for the FOCUS project, question 10 (section 2.6), further research carried out under the GANE project sought to quantify the contribution of different causes of large scale vegetation change. Although variance explained was low, a signal of N deposition was detected for large areas of upland and lowland habitat, and there was a significant effect of modelled sheep density (derived from agricultural census data; Dragosits et al., 1998) in upland small habitat fragments. The relationship between N deposition signal and vegetation change was tested for different Critical Loads vegetation types, and was found to be significant only for the grasslands and heaths and bogs groups.

The impact of sheep densities was one of a number of factors, including atmospheric N deposition and climatic factors, investigated as potential explanatory variables for an observed increase in abundance in upland habitats of nutrient demanding plant species more typical of lowland semi-improved grassland as part of the Defra-funded ‘Terrestrial Umbrella’ project 2001-200712. The appearance of such species was related to high N deposition and mean temperature, but species richness of these species was associated with high sheep densities. Sheep densities were derived from the EDINA AgCensus database for 2000 at 5km² scale, and change from 1969 to 2000 was also used as an explanatory variable.

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12 http://www.bangor.ceh.ac.uk/terrestrial-umbrella/index.htm
2.8 CONCLUSION

This chapter has briefly reviewed previous studies aimed at elucidating the causes of changes observed in the habitats, features and vegetation parameters recorded during Countryside Surveys. Most of these analyses have relied mainly on data collected within the Countryside Surveys themselves, and there has to date been relatively little research carried out within the CS programme which links CS data directly to other agricultural datasets, though such linkages have begun to be more evident in recent research.

The ‘Processes of Countryside Change’ study, in which socio-economic data were obtained directly from occupiers of land within the study squares, and this was related to data from CS1990. The analyses were however carried out at a high level, and there is scope for much more detailed analyses should a repeat survey of land managers be carried out. Clearly such a survey would provide the greatest scope for linking CS data with the underlying management, but there is also potential for using data from other sources to aid interpretation of the impact of agricultural drivers. In the ‘Drivers of Countryside Change’ project, data from the June Census and Farm Business Survey were reviewed along with literature on changes in agriculture, forestry and other aspects of the rural economy, but the project did not attempt any integrated analyses of these datasets with data from the Countryside Survey.

Much of the research carried out since 2000 has focussed on the impacts of atmospheric N deposition on vegetation change in semi-natural habitats. Ellenberg N scores have been used throughout as indicators of eutrophication, but recent studies have sought to relate vegetation change to modelled N deposition and (in the case of Firbank et al., 2007) N surplus arising directly from agricultural inputs. Research carried out under the GANE and Terrestrial Umbrella projects has also investigated the impact of sheep grazing densities derived from the June Agricultural Survey at 5km² scale.

In conclusion therefore, it appears that there is further potential for using additional data to aid interpretation and analyse the influence of a wider range of drivers, through integrated analyses, which has not been explored in CS-linked research to date. This potential will be further considered in later chapters of this report.
3. ENHANCING SPATIAL AND TEMPORAL RESOLUTION

3.1 INTRODUCTION
The Countryside Survey is limited both spatially and temporally. Therefore it can only have limited value for studying short-term trends. However, it may be used in a number of ways in conjunction with other datasets. The main ways that this may be possible are:

1. Countryside Survey data may give a snapshot against which more frequently collected data may be compared.

2. Links to other more spatially comprehensive datasets (e.g. the LCM) may allow for some extrapolation of the detailed countryside survey data across a wider spatial area, as well as add more detail to the other dataset.

3. Interpolating or stratifying Countryside Survey data, or other data to correspond to it, may enable a wider range of datasets to be compared with the Countryside Survey data.

This section gives an overview of the properties of the Countryside Survey data and aspects of other spatial data that are relevant when deciding how such data may be best used in conjunction with CS2007. This includes the spatial representation of the data, the spatial scale, the distribution of the data and the nature of the data boundaries and intersections. Potential methods are then summarised for data manipulation that may allow CS2007 data to be compared to other datasets, depending on the data properties. Specific examples are then given for each of the proposed measurement categories for CS2007, indicating a range of possibilities for using CS2007 data in conjunction with other existing datasets.

Stratification of CS data is a key method of linking data collected at different scales, and possible stratifications based on agriculturally-related datasets are considered. Finally, the scope for direct matching against some key surveys of agricultural management practices is investigated.

3.2 CS2007 DATA PROPERTIES
CS2007 survey is essentially a ‘raster’ dataset with incomplete coverage. This is because this data comprises a stratified, random sample of 1x1 km squares across Britain. This grid has the British National Grid as its basic spatial unit. Complete coverage of broad habitat information is achieved by matching the land class(es) assigned to any given 1x1 km squares in the UK with the sample information (every square in the UK is assigned to a land class). This then forms a complete raster dataset of broad habitats at the 1x1km scale across the UK.

Data that are also collected at this scale and resolution, using the same 1 x 1 km grid, may have little or no problem integrating with CS2007. Other data require summarising at the scale and spatial structure of CS2007 in order to integrate with it. The methodology used to integrate datasets will depend on the data that are to be integrated with CS2007. There is no single ‘one-size-fits-all’ solution. Different techniques are needed for different cases. However, it is possible to broadly categorise the range of possible datasets, from which it is possible to identify potential advantages and disadvantages of each dataset type according to its properties and identify methodologies that may be appropriate with which to integrate data of each type with CS2007. This depends on the way data are represented in
the Geographic Information System (GIS), the size of the units of the data in relation
to the units of CS2007, and the spatial distribution of these units.

3.3 PROPERTIES AND CATEGORISATION OF SPATIAL DATASETS

3.3.1 Spatial representation of data
Not all data are collected as gridded (raster) data. Other forms include vector data
and point data. Vector data are in the form of lines or polygons, for example data
on rivers or fields (e.g. Rural Land Register (RLR)). Point data are collected at
specific locations with spatial co-ordinates, such as LUCAS.

3.3.2 Spatial scale of data
Where CS2007 grid cells nest within larger units, the data values for those units need
to be disaggregated to the level of CS2007. However, where collection units are
smaller than CS2007, data need to be aggregated together. Methods employed to
do this will be determined by the structure of the data and its spatial representation,
as well as the relationship of the data boundaries with the boundaries of CS2007
squares (see 3.3.4 below).

3.3.3 Distribution of data
Some data may have a patchy distribution, such as LUCAS, that may not clearly
correspond to the CS2007 structure. Other data may vary continuously across the
landscape, such as soil properties.

3.3.4 Data boundary intersection
For raster or polygon data that are not at the same scale as CS2007, a key issue is
whether the boundaries of the data align with CS2007 (i.e. align with the GB Grid).
For example, data measured in 100 x 100 m squares are more easily aggregated to
the 1km grid if these squares fit within the GB 1km grid. If not, judgements must be
made as to how the intersection of boundaries will be handled. Examples of
boundary intersection are given in Figure 3.1.

From Figure 3.1, A1 and A2 show the CS2007 cell within a larger area. Therefore,
the single value for the larger area could be used for comparison with the CS2007
cell; this assumes that the grid cell is representative of the larger area. In B1 and B2
the CS2007 grid square is not completely enclosed and its boundaries intersect
those of the larger data units. Therefore values from all areas that are intersected by
the CS2007 grid cell need to be combined in some way to correspond with the cell.
In C1 and C2 the data units are smaller than the CS2007 grid cell, where the CS2007
grid cell intersects these areas in a similar way to B1 and B2. Therefore each data
unit has its own values and these values need to be combined to compare with
CS2007 data.

The main problem when the boundary of another dataset is intersected by CS2007 is
how to combine the data values of the other dataset in order to assign a combined
value to the area corresponding to the CS2007 cell. It is important to consider the
underlying distribution of the data, and what the data represent.
3.4 METHODS FOR DATA MANIPULATION

A summary of possible approaches to manipulation of data to improve correspondence with CS data is given in Table 3.1. Further detail for each method is given in Appendix 4.

3.5 DATASETS AND APPROPRIATE MANIPULATION METHODS

Table 3.2 groups some example datasets by the most likely method that would be needed to manipulate the dataset for it to correspond to CS2007. These tables are in order of the broad measurement categories for CS2007.

If data requiring aggregation/disaggregation are raster data that align with the CS2007 grid but are larger or smaller in scale, it may be possible to use unweighted simple aggregation/disaggregation to match the data to CS2007.

3.5.1 Aerial Photos/digital imagery

Aerial photos are only likely to provide useful information at a very fine scale of analysis, for example to validate a small number of CS2007 sample points for specific measurements. However, when used for this purpose they will give very good data. A number of sources of aerial photos are available. Two of the best are:

- OS Mastermap imagery 25 cm resolution.
- Defra 10km and 1km squares (total coverage of England, but rolling programme over a period of 5 years so each photo may be up to 5 years old).
Table 3.1 Possible methods with which to manipulate data so that it may correspond better with CS2007, given the category of the data characteristic.

<table>
<thead>
<tr>
<th>Data characteristic</th>
<th>Data category</th>
<th>Suitable method description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spatial representation</td>
<td>Raster data</td>
<td>Determine spatial scale correspondence with CS2007 and boundary intersection.</td>
</tr>
<tr>
<td></td>
<td>Vector data</td>
<td>Determine spatial scale correspondence with CS2007 and boundary intersection. Conversion to raster that corresponds to CS2007.</td>
</tr>
<tr>
<td>Point data</td>
<td>Interpolation (if appropriate) and conversion to raster corresponding with CS2007. Stratification may be more appropriate, where the point data can be grouped and averaged across a relevant area of a polygon dataset (for example stratifying by a land use dataset for tree numbers). This could in turn be converted to a raster corresponding with CS2007.</td>
<td></td>
</tr>
<tr>
<td>Spatial Scale</td>
<td>Same spatial unit</td>
<td>No need to aggregate/disaggregate data. May require simple area unit conversion (e.g. metres to km).</td>
</tr>
<tr>
<td></td>
<td>Larger spatial unit</td>
<td>Disaggregation of data required.</td>
</tr>
<tr>
<td>Smaller spatial units</td>
<td>Aggregation of data required. This may use a sum, average, maximum or minimum value of the smaller dataset within the CS2007 grid cell area. Where smaller units are not equal in size, this may be weighted (e.g. by spatial area of the smaller unit).</td>
<td></td>
</tr>
<tr>
<td>Distribution</td>
<td>Categorised</td>
<td>If the same spatial unit is used by the dataset as CS2007 there is no problem. However, if not, aggregation or disaggregation will depend on the nature of the categories, perhaps involving some value judgements as to how to combine categories or prioritise.</td>
</tr>
<tr>
<td>Patchy</td>
<td>Ignore areas where no data exist in analysis. Assume nearby data values are the same and use these. Use a statistical method to estimate gaps based on an intermediary dataset. Spatially interpolate to estimate missing data.</td>
<td></td>
</tr>
<tr>
<td>Discrete</td>
<td>Values may be combined by aggregation or dissagregation, using a sum, average, maximum or minimum value, if the spatial unit does not correspond to CS2007.</td>
<td></td>
</tr>
<tr>
<td>Continuous</td>
<td>Aggregate data similarly to the smaller spatial unit (above), using a sum, average, maximum or minimum value of the continuous dataset within the CS2007 grid cell area. Where smaller units are not equal in size, this may be weighted (e.g. by spatial area of the smaller unit).</td>
<td></td>
</tr>
<tr>
<td>Data boundary intersection</td>
<td>Area surrounds CS2007 cell</td>
<td>Apply the value of the larger area to the cell area.</td>
</tr>
<tr>
<td></td>
<td>Larger area units intersected by CS2007 cell</td>
<td>Where there is no single value for each data unit an appropriate value is assigned by disaggregating the data from the larger area then aggregating the values within the area of the CS2007 cell. This may be weighted (e.g. by relative spatial area within the CS2007 cell).</td>
</tr>
<tr>
<td></td>
<td>Smaller area units intersected and contained by CS2007</td>
<td>Aggregate the data using a sum, average, maximum or minimum value of the smaller dataset within the CS2007 grid cell area. Where smaller units are not equal in size, this may be weighted (e.g. by spatial area of the smaller unit).</td>
</tr>
</tbody>
</table>
Table 3.2  **Summaries of key datasets with potential for linkage to the Countryside Survey, with suggestions for linking methods.**

<table>
<thead>
<tr>
<th>Dataset</th>
<th>Description</th>
<th>Data type</th>
<th>Notes</th>
<th>Suggested data linking technique/methodological issues</th>
<th>CS2007 measurement groups suitable for comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td>LUCAS</td>
<td>Information on land use, land cover and environmental features. Data on crop yields and management.</td>
<td>Point survey</td>
<td>First survey: 774 primary sampling units (PSUs) in the UK, each comprising ten secondary sampling units (SSUs) in a grid covering 1.5km x 0.6km (0.9 km²). 143 spatial correspondences between LUCAS and CS data (measured at 1km² scale) (McKay et al., 2005), however recent changes detailed below will affect this correspondence. LUCAS is currently under revision, however expected shift to 1km PSU grid and a change from UTM to Lambert projection, using a single grid origin across the EU. There will be no SSUs.</td>
<td>Interpolation/match up dataset</td>
<td>Land use/land cover</td>
</tr>
<tr>
<td>IACS</td>
<td>Cropping at field scale</td>
<td>Point data (with unique land parcel identifier enabling spatial match with RLR)</td>
<td>Potential to match with RLR data (mapping of holdings), but IACS codes are not as detailed as they used to be (detailed crop codes up to 2004).</td>
<td>Match up datasets or stratification.</td>
<td>Land use/land cover</td>
</tr>
<tr>
<td>June Survey</td>
<td>Holding-level data on land use, crops, livestock, labour, horticulture and glasshouse.</td>
<td>Polygons (Holdings)</td>
<td>Incomplete UK coverage. Data for year 2000 more complete (census every 10 years), but still substantial level of non-response).</td>
<td>Categorical aggregation/disaggregation</td>
<td>Land use/land cover</td>
</tr>
<tr>
<td>Dataset</td>
<td>Description</td>
<td>Data type</td>
<td>Notes</td>
<td>Suggested data linking technique/methodological issues</td>
<td>CS2007 measurement groups suitable for comparison</td>
</tr>
<tr>
<td>----------------------------------------------</td>
<td>------------------------------------------------------------------------------</td>
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<td>---------------------------------------------------</td>
</tr>
<tr>
<td>Rural Land Registry</td>
<td>Ownership of all agricultural land in the United Kingdom, along with woodland and marginal land on which grants or subsidies are to be claimed.</td>
<td>Polygons (Land parcels)</td>
<td>Useful to match with other datasets such as IACS. Shows spatial extent of farms and individual fields. Only applies to farms receiving Single Farm Payment &amp;/or in Environmental Stewardship Scheme</td>
<td>Match up datasets or stratification.</td>
<td>Land use/land cover</td>
</tr>
<tr>
<td>National Inventory of Woodland and Trees</td>
<td>Current dataset represents aerial photos of 2ha+. New survey currently being conducted will represent ½ha+.</td>
<td>Polygon data.</td>
<td>Work already being done to integrate with LCM2000</td>
<td>Categorical aggregation/disaggregation: Area weighted average technique.</td>
<td>Other Landscape features and habitats</td>
</tr>
<tr>
<td>Ancient Woodland Inventory</td>
<td>Ancient woodland of 2ha+.</td>
<td>Polygon data.</td>
<td></td>
<td>Match up datasets or stratification.</td>
<td>Other Landscape features and habitats</td>
</tr>
<tr>
<td>Woodland Grant Scheme Database</td>
<td>Areas of privately-owned woodland receiving grants under the Woodland Grant Scheme (WGS) and Scottish Forestry Grant Scheme (SFGS). Includes new planting &amp; restocking.</td>
<td>Polygons based on OS Mastermap.</td>
<td></td>
<td>Match up datasets or stratification.</td>
<td>Other Landscape features and habitats</td>
</tr>
<tr>
<td>Generalised Land Use Database (GLUD)</td>
<td>Polygon data categorizing land parcels into 9 key themes (based on Mastermap).</td>
<td>Land parcels</td>
<td></td>
<td>Categorical aggregation/disaggregation</td>
<td></td>
</tr>
<tr>
<td>Land Use Change Statistics</td>
<td>Datasets showing changes in broad land use categories. Changes may have occurred within a 5 year window.</td>
<td>Land parcels</td>
<td></td>
<td>Categorical aggregation/disaggregation</td>
<td>Land use/land cover</td>
</tr>
<tr>
<td>Dataset</td>
<td>Description</td>
<td>Data type</td>
<td>Notes</td>
<td>Suggested data linking technique/methodological issues</td>
<td>CS2007 measurement groups suitable for comparison</td>
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</tr>
<tr>
<td>Farm practices survey</td>
<td>Covers a variety of topics, including some relevant to crop management, though its main theme is waste management, particularly livestock wastes.</td>
<td>Holding</td>
<td>Could be linked to June Survey polygons. Only partial UK coverage (3000 approx).</td>
<td>Stratification by farm type.</td>
<td>Land use/land cover, Freshwaters, Soils</td>
</tr>
<tr>
<td>EA General Quality Assessment Scheme</td>
<td>Covers chemical quality and nutrient status of rivers, as well as biological quality and aesthetic quality.</td>
<td>Polygon: local authority</td>
<td></td>
<td>Weighted aggregation/disaggregation: Area weighted average technique</td>
<td>Freshwaters</td>
</tr>
<tr>
<td>National Soil Inventory</td>
<td>Soil, terrain and land use data.</td>
<td>Point samples from the intersects of a 5 km grid over the whole of England and Wales</td>
<td>Sample point data may be available (standard info is 5 km grid).</td>
<td>Interpolation or Weighted aggregation/disaggregation: Area weighted average technique</td>
<td>Soils</td>
</tr>
<tr>
<td>British Survey of Fertiliser practice</td>
<td>Data on fertiliser use</td>
<td>Aggregate (crop type), but recent data at holding data may be available</td>
<td>Holding: could be linked to June Survey polygons that can be disaggregated to link to CS2007. Only partial UK coverage (1500 approx).</td>
<td>Match data or stratification (e.g. with Land Cover Map)</td>
<td>Soils</td>
</tr>
<tr>
<td>NATMAP – the National Soil Map</td>
<td>Soil series attribute and function values.</td>
<td>Polygon</td>
<td></td>
<td>Weighted aggregation/disaggregation: Area weighted average technique</td>
<td>Soils</td>
</tr>
<tr>
<td>Dataset</td>
<td>Description</td>
<td>Data type</td>
<td>Notes</td>
<td>Suggested data linking technique/methodological issues</td>
<td>CS2007 measurement groups suitable for comparison</td>
</tr>
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<td>----------------------------------------------------------------</td>
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<td>----------------------------------------------------------</td>
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</tr>
<tr>
<td>Pesticide Usage Survey</td>
<td>Pesticide use by crop.</td>
<td>Field level data, from random stratified sample of fields.</td>
<td>Every 2-4 years.</td>
<td>Stratification (e.g. by farm type, using June Survey?).</td>
<td>Freshwaters, Soils</td>
</tr>
<tr>
<td>Agri-environment schemes</td>
<td>Farm management practices with environmental benefits.</td>
<td>Point data at field or farm scale</td>
<td>Environmental Stewardship option locations are also mapped, not digitised. Could link data at field level to RLR</td>
<td>Match data</td>
<td>Other Landscape features and habitats, Freshwaters, Soils</td>
</tr>
<tr>
<td>Farm Business survey</td>
<td>Survey of individual farms</td>
<td>Anonymised data available at farm level</td>
<td>Individual farm locations not available but could be linked through stratification e.g. JCA, farm type, etc.</td>
<td>Stratification</td>
<td>Land use/land cover, Soils</td>
</tr>
<tr>
<td>December Survey</td>
<td>Similar to June survey (see above)</td>
<td>Similar to June but smaller sample (c. 20,000)</td>
<td>Incomplete UK coverage</td>
<td>Categorical aggregation/disaggregation</td>
<td>Land use/land cover</td>
</tr>
<tr>
<td>Countryside Quality Counts</td>
<td>Aggregated measure of landscape change at JCA level. Also measures for each of 9 'themes', including agriculture.</td>
<td>JCA level</td>
<td></td>
<td>Stratification</td>
<td>Land use/land cover, Other Landscape features and habitats</td>
</tr>
<tr>
<td>Dataset</td>
<td>Description</td>
<td>Data type</td>
<td>Notes</td>
<td>Suggested data linking technique/methodological issues</td>
<td>CS2007 measurement groups suitable for comparison</td>
</tr>
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<td>-----------------------------------------------</td>
</tr>
<tr>
<td>Atlas of British Flora</td>
<td>Plant data for individual species</td>
<td>Presence/absence in 10km squares. The availability of data at resolutions higher than 10km square varies between sources.</td>
<td>Categorical aggregation/disaggregation.</td>
<td>Other Landscape features and habitats</td>
<td></td>
</tr>
<tr>
<td>Land cover map</td>
<td>Census of land cover produced from satellite imagery.</td>
<td>Polygon, 2007 LCN will be linked to Mastermap</td>
<td>Match data or stratification.</td>
<td>Land use/land cover.</td>
<td></td>
</tr>
</tbody>
</table>
3.6 STRATIFICATION OF CS DATA

3.6.1 The ITE Land Classification

A key method of linking data collected at different scales is through stratification in relation to an independent classification of the datasets concerned. In the past, stratification of CS data has generally been by the ITE Land Classification System, which provided the basis for the stratification of sample squares for the first Countryside Survey in 1978 (Bunce et al., 1996a, b). The classification was produced using multivariate analytical techniques applied to a range of environmental variables. Originally piloted in Cumbria using principal component analysis and a clustering procedure, it was extended to national level in 1977 using “indicator Species Analysis” (Hill, Bunce & Shaw, 1975), a forerunner of the more widely used “TWINSPAN” (Hill, 1979). The analysis included 281 attributes of 40 variables, of which 75 attributes were identified as indicators of the 32 land classes that resulted. The variables fell into five categories: climate, geology, topography, coastal features, and human geography. Only squares at the intersections of a 15 x 15m grid were classified due to limitations in computing power, but later all GB squares were classified (Bunce et al., 1996a, b).

For reporting purposes, the landscape classes were aggregated into four broad ‘landscape types’: arable lowlands, pasture-dominated lowlands, marginal uplands, and uplands. For CS2000, the number of land classes was increased to 40, to allow for separate reporting of results for Scotland, following devolution. In addition, the landscape types were replaced by six ‘Environmental Zones’ (Haines-Young et al., 2003).

3.6.2 The role of the Countryside Information System

The ITE Land Classification system was used as the basis for the Countryside Information System (Howard et al., 1994)\(^\text{13}\), which was developed to enable CS data to be easily linked to other environmental datasets, such as those provided by MAGIC\(^\text{14}\) and the National Biodiversity Network\(^\text{15}\). Originally devised in the late 1980s, it was developed in the early 1990s to support and analyse CS1990 data and was first marketed in 1994. It has been a major vehicle for dissemination and basic analysis of CS1990 and CS2000 data, both from survey squares and land cover map census data. However, developments in technology and analytical techniques, particularly Geographical Information Systems (GIS) led to a recommendation in the CS2007 scoping study that the needs of expert users should be re-evaluated prior to the next survey, and consideration should be given as to the best way of taking data delivery forward (Critchley et al., 2005).

A recent study by Watkins et al (2006) reviewed the CIS and its use in CS data dissemination, and produced an outline strategy to improve the use of CS data, mapping the reporting requirements against IT tools including the CIS, according to their fitness for the purposes identified. They identified four types of requirement for data users:

1. Discovery of candidate datasets
2. Access and/or delivery of selected datasets

\(^{13}\) http://www.cis-web.org.uk/
\(^{14}\) http://www.magic.gov.uk/
\(^{15}\) http://www.nbn.org.uk/
3. Browsing and assessment of datasets for suitability
4. Analysis and presentation of data.

They mapped these requirements against types of IT tools as in the following table.

**Table 3.3  Fit of user requirements to IT tools (from Watkins et al., 2006).**

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Web services</th>
<th>CIS</th>
<th>Analytical packages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dataset discovery</td>
<td>√√√</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Access &amp; delivery</td>
<td>√√√</td>
<td>√√</td>
<td>x</td>
</tr>
<tr>
<td>Browsing &amp; exploratory analysis</td>
<td>√</td>
<td>√√</td>
<td>√</td>
</tr>
<tr>
<td>Detailed analysis</td>
<td>x</td>
<td>√</td>
<td>√√√</td>
</tr>
</tbody>
</table>

√√√: best fit; √√: good fit; √: some fit; x: poor fit

On the basis of this analysis, a strategy was proposed for the future dissemination of CS data. The internet would be the principle method for data discovery and distribution of CIS, and for including CS data into other environmental networks. Linking through gateways such as SPIRE, MAGIC, EDINA and NBN would be an important part of the discovery strategy.

The internet would also be the principle method of delivery of datasets to potential users. Anonymised (aggregated) raw data should be provided in CIS, GIS and tabular formats, supported by licensing and uploading facilities. Square locations would need to be protected, hence precise locations would not be provided. CIS facilities would be developed to allow import and export in different formats, especially GIS, and improved capabilities to link to new data via the Internet.

A limited range of rapid access tools could be provided via the Internet, and an ongoing development programme of web-based tools for browsing and exploratory analysis was recommended. However, CIS was also seen as having a continuing role in this area, and development of an improved interface with greater accessibility was recommended. Detailed analysis was likely to be increasingly carried out by GIS, and Internet provision of data in GIS-friendly formats would be required. Further development of CIS analytical tools was therefore not recommended, but better links to GIS and statistical software packages would be useful, along with CIS capabilities for browsing the results of analyses.

### 3.6.3 Stratification of CS2007 data

The original land classes were based on factors which it was thought would not change greatly, e.g. climate, soils, topography. It is now clear that climate, at least, is not static. Furthermore, different types of stratification may be more appropriate for certain types of analysis, including those involving links to agricultural data. New tools mean that stratification of CS data need no longer be restricted to Land Classes, instead, different types of stratification could be made available to suit different types of analysis.

It is intended that CS2007 data will be disseminated via the Internet, and that disaggregated data for individual squares will be available as recommended in the CS scoping study (Critchley et al., 2005), though not with precise spatial identifiers in order to preserve confidentiality regarding square locations. Instead, data for individual squares will be available stratified by a range of administrative and
environmental classifications. Those under consideration at the time of writing (February 2008) included the following:

- Administrative counties
- Unitary authorities
- Government office regions
- Environmental Zones
- Joint Character Areas
- Landscape Character Areas
- Catchment Areas
- Sub-catchment areas
- Water Framework Directive River Basin District Areas
- National Parks
- Scottish National Parks
- Areas of Outstanding National Beauty
- LBAP/LA areas
- Less Favoured Areas

3.6.3.1 Analysis based on alternative stratifications: the example of Joint Character Areas

A difficulty with many of these classifications lies in the number of categories. Whilst it is pertinent to those concerned with a particular locality to know which squares are situated within their area of interest, care needs to be taken with the interpretation of data relating to such limited areas. This may be illustrated by reference to Joint Character Areas (JCAs), which are becoming increasingly accepted as a framework for landscape and land management policy implementation and monitoring. For instance, they form the basis for setting Environmental Stewardship local targets, used to inform the development and assessment of applications for agreements under the Higher Level strand. JCAs are also the building blocks for the ‘Countryside Quality Counts’ indicator of landscape change. However, there are 159 JCAs in England, which vary considerably in size, but only 289 kilometre squares were surveyed in CS2007, an average of 1.8 CS squares per JCA. Clearly, many JCAs will have no CS squares within them at all, but those containing CS squares will only have very few. It would not therefore be realistic to consider these squares as representative of the JCA as a whole, yet there is a danger that such assumptions could easily be made. Clearly, appropriate caveats need to be clearly stated and guidance offered as to the interpretation of data stratified in relation to such classifications.

For analytical purposes, aggregation of units offers a way of achieving more meaningful results. Reporting of CS results using aggregations of JCAs was recommended as an option by Critchley et al. (2005). For JCAs, a classification into ‘landscape types’ was developed by the former Countryside Agency for their own use. It must be emphasized that this classification was subjective, and not intended for wider application without further work, but it serves to illustrate the type of aggregation that might prove useful for analysing CS data. Groupings of JCAs and numbers of JCAs in each group were as follows:

- Chalk wolds and downs (9)
- Claylands (6)
- Coal measures (3)
- Coast (low-lying) (14)
- Coast (rugged) (9)

16 http://www.cqc.org.uk/
• Conurbation (3)
• Estuary (3)
• Fens, levels and marshes (6)
• Forests and parklands (11)
• Limestone hills (8)
• Limestone wolds (6)
• Lowland heath (4)
• Lowlands (9)
• Magnesian limestone (2)
• Moorland and moorland fringe (8)
• Sandstone hills and ridges (11)
• Upland (15)
• Upland fringe (9)
• Vales and valleys (20)

For many purposes this classification would still be too detailed, with some categories containing very few JCAIs, and some further aggregation would be desirable.

A preliminary grouping of JCAs into agricultural landscape types has been produced by Swanwick et al. (2007), for use in valuing agricultural landscapes. This was developed through a heuristic, rather than an analytical, approach and the authors suggest that it would require further refinement and discussion before being used for more detailed work. They distinguish six categories:

• Eastern arable agricultural landscapes
• South eastern wooded mixed agricultural landscapes
• Chalk and limestone mixed agricultural landscapes
• Western dairying and mixed agricultural landscapes
• Upland fringe dairying and stock rearing agricultural landscapes
• Upland agricultural landscapes.

In addition, coastal and urban areas are identified, and a further category entitled "other", which includes those rural JCAs that do not fit into the above six types, including the New Forest, the Forest of Dean, Breckland and the Broads.

The authors suggest that further subdivisions would be possible if considered appropriate, for example, separating the “levels and moors” (equivalent to the “Fens, levels and marshes” category in the more detailed grouping above, except that this also includes the Broads), and the heavily wooded or former forest landscapes, comprising four of the JCAs included in the “Forest and parklands” category of the Countryside Agency classification.

This type and scale of classification could form an appropriate basis for stratifying CS squares for the purposes of analysis in relation to agricultural landscapes, though further work would be required to investigate its application and further develop the approach based on analytical criteria (Recommendation 5).

3.6.4 Potential stratifications relating to agriculture

Agricultural activities affect over three quarters of the land surface of the UK, and so are major determinants of the nature of most of our landscape. Accordingly, stratifications that reflected the nature and intensity of land use could be useful for investigating the impact of elements of agricultural management as drivers of change in the environmental attributes measured by the CS. A range of stratifications could
be envisaged, depending on the specific purpose of the analysis. Some potential possibilities reflecting aspects of agricultural land use are considered below.

For some purposes, stratification by climatic and/or edaphic data that influence agricultural activities and habitats/vegetation characteristic of an area may be appropriate. A large range of such datasets are available and many have already been used in earlier analyses of CS data. They are already well known and understood by CEH; accordingly they are not considered in detail here.

### 3.6.4.1 Agricultural Land Classification

The Agricultural Land Classification (ALC) provides a method for assessing the quality of farmland. It was developed for use in the Planning System for development, to enable informed choices to be made about future land use. The presumption is that “where significant development of agricultural land is unavoidable, poorer quality land should be used in preference to that of higher quality, except where this would be inconsistent with other sustainability considerations.”

The classification is based on the long term physical limitations of land for agricultural use:

- **Climate**: temperature and rainfall; aspect, exposure and frost risk.
- **Site**: gradient, microrelief and flood risk.
- **Soil**: texture, structure, depth and stoniness; chemical properties which cannot be corrected.

The physical limitations of land have four main effects on the way land is farmed. These are:

- the range of crops which can be grown
- the level of yield
- the consistency of yield
- the cost of obtaining the crop

The combination of climate and soil factors determines soil wetness and droughtiness. Wetness and droughtiness influence the choice of crops grown and the level and consistency of yields, as well as use of land for grazing livestock.

The ALC is concerned with the inherent potential of land under a range of farming systems, and is not influenced by the current agricultural use, or intensity of use. However, as the yield potential, and hence potential profit margins, are related to the grade of land, levels of input use and intensity of management would be expected to be higher on the better grades of land. Furthermore, the grade affects the value of agricultural land, so buyers of high grade land are likely to want to maximize yields in order to see a return on their investment.

There are five grades, with grade 3 subdivided:

- Grade 1 (excellent)
- Grade 2 (very good)
- Grade 3: 3a (good)
  - 3b (moderate)
- Grade 4 (poor)
- Grade 5 (very poor)

Data and maps are available on the MAGIC website\(^\text{17}\). The data are mapped at a 1:250,000 scale (see Figure 3.2) (**Recommendation 6**).

\(^{17}\) [www.magic.gov.uk](http://www.magic.gov.uk)
3.6.4.2 Farm typologies

3.6.4.2.1 Defra farm type classification

Defra classifies farms according to their type and size\(^\text{18}\). These are used for various purposes, but particularly for reporting of the June Agricultural Survey and Farm Business Survey. Farm types are determined by the enterprises present on the farm; if there is more than one, their relative contributions are weighted using Standard Gross Margins (SGMs). A farm is allocated to a particular type when the contribution of a crop or livestock type comprises more than two-thirds of its total SGMs. Where none of the enterprises contributes more than two thirds, the farm is labelled as ‘mixed’.

Clearly the potential enterprises available will be related to the grade of the land, as determined in the Agricultural Land Classification, and as farmers generally will naturally tend to choose the most profitable land uses farm types, there is a strong relationship between dominant farm types in an area and the grade of the land (Figure 2.1).

Dominant farm type, expressed at an appropriate scale (e.g. Figure 2.1), could be used as a stratification for CS data for analyses relating to agricultural variables. Gridded versions of June Survey data are available e.g. from EDINA agcensus (see section 4.3.1.1).

Table 3.4 Defra farm type classification

<table>
<thead>
<tr>
<th>Robust Type</th>
<th>Main Farm Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Cereals</td>
<td>1 Cereals</td>
</tr>
<tr>
<td>2 General Cropping</td>
<td>2 General Cropping</td>
</tr>
<tr>
<td>3 Horticulture</td>
<td>3 Specialist Fruit</td>
</tr>
<tr>
<td>4 Specialist pigs</td>
<td>4 Specialist Glass</td>
</tr>
<tr>
<td>5 Specialist poultry</td>
<td>5 Specialist Hardy Nursery Stock</td>
</tr>
<tr>
<td>6 Dairy</td>
<td>9 Dairy (LFA)</td>
</tr>
<tr>
<td>7 Mixed</td>
<td>16 Cropping &amp; Dairy</td>
</tr>
<tr>
<td>8 Cattle &amp; Sheep (LFA)</td>
<td>11 Specialist Sheep (SDA)</td>
</tr>
<tr>
<td>9 Other Types</td>
<td>22 Specialist Set-aside</td>
</tr>
<tr>
<td>10 Cattle &amp; Sheep (lowland)</td>
<td>15 Cattle &amp; Sheep (lowland)</td>
</tr>
<tr>
<td>11 Specialist Pigs</td>
<td>12 Specialist Beef (SDA)</td>
</tr>
<tr>
<td>12 Mixed</td>
<td>17 Cropping, Cattle and Sheep</td>
</tr>
<tr>
<td>13 Mixed Grazed livestock (SDA)</td>
<td>18 Cropping, Pigs &amp; Poultry</td>
</tr>
<tr>
<td>14 Various grazing livestock (DA)</td>
<td>19 Cropping &amp; Mixed Livestock</td>
</tr>
<tr>
<td>15 Cropping &amp; Mixed Livestock</td>
<td>20 Mixed Livestock</td>
</tr>
<tr>
<td>16 Mixed</td>
<td>21 Non-classifiable holdings: Fallow</td>
</tr>
<tr>
<td>17 Mixed</td>
<td>22 Non-classifiable holdings: Other</td>
</tr>
</tbody>
</table>

LFA – Less Favoured Area; SDA – Severely Disadvantaged Area; DA – Disadvantaged Area

Figure 3.2 Agricultural land classification and dominant farm types at 5km$^2$ scale for England.
3.6.4.2.2 Other farm typologies

Whilst useful for many purposes, the Defra farm type classification only relates to the dominant enterprise, and therefore does not capture all the information available about the crops grown and livestock kept on any individual farm. There is the potential to develop new typologies which take into account a wider range of information about each farm, including for example areas of crops, numbers of livestock, farm size etc. Some preliminary work in terms of potential analytical techniques was done by Boatman et al. (2006), but further development is needed. Possible approaches would be to use a grid overlay approach as in Boatman et al. (2006), to produce a cellular classification at, for example, 1km² scale. Alternatively, an interpolation technique such as kriging (Table A.1) could be used to create a land use surface. This method also allows calculation of prediction errors (Recommendation 7).

Another possibility arising from the workshop was the economic stratification of CS data. The most likely basis for this would be the FBS, with economic data linked to CS through farm type.

3.6.4.2.3 Index of specialisation

For many decades, there has been a trend of increasing specialisation of operations on individual farms and a decline in mixed farming, accompanied by a polarisation of arable cropping in the east and livestock production in the west. Increased specialisation in terms of agricultural enterprises results in reduced habitat and landscape diversity, with consequent impacts on biodiversity.

Recent work carried out by the ACEO has resulted in the development of an index of specialisation, based on June Agricultural Survey data (Clothier, 2008). This has been calculated at holding, parish, county, regional and national level, as the sum of squares of SGM coefficients for ten enterprises: arable; vegetables; fruit; nursery stock, bulbs and flowers; beef cattle; dairy cattle; pigs; sheep; poultry; horses and goats. A diversity index based on the Simpson index was calculated as 1-$\Sigma p^2$, where $\Sigma p^2$ is the specialisation index.

Relating an index of habitat diversity¹⁹ from CS data to the farm diversity index could be a useful exercise in determining the amount of variation in habitat diversity that could be accounted for through agricultural survey data. A close relationship would allow agricultural survey data to be used predictively to interpolate spatially or extrapolate temporally from CS results.

Similar analyses could be carried out in relation to the Land Cover map data. (Recommendation 8).

3.6.4.3 Farmer behavioural typologies

Factors such as those considered in the Agricultural Land Classification determine the potential of land in a location to produce agricultural commodities, but not all farms in an area have the same enterprises or approach to management. Clearly, as businessmen, farmers and farm managers are strongly influenced in their decision making by economic criteria, but other factors such as environmental or family or lifestyle objectives also influence decisions. Such objectives are generally long-term, in contrast to the short-term nature of economic drivers. Furthermore, the character of the decision-maker may affect choices between alternative business trajectories or day-to-day management practices. Such influences mean the not all farmers will

¹⁹ see section 6.4.2
respond to policy changes or other initiatives in the same way, and an understanding of the range of responses and underlying motivations could enable better predictions of the nature, direction and speed of reactions to new policy developments.

A considerable amount of research has been carried out into the behavioural motivations of those in charge of agricultural land management, which has resulted in the derivation of behavioural typologies. Such a classification was developed by Potter et al. (1996) as part of the Processes of Countryside Change study (see section 2.3). More recently, the University of Reading, in conjunction with ADAS, carried out a large-scale study of farmer behaviour and motivations, resulting in two behavioural typologies (Garforth & Rehman, 2006).  

One of the typologies was based on responses to the ADAS ‘Farmers Voice’ survey (see section 4.1.8), the other was derived from a postal questionnaire designed for the purpose (Table 3.5).

<table>
<thead>
<tr>
<th>Types identified from Farmers Voice</th>
<th>Types identified from Reading postal survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexible strategist</td>
<td>Lifestyler</td>
</tr>
<tr>
<td>Dedicated producer</td>
<td>Business/entrepreneur</td>
</tr>
<tr>
<td>Survivor</td>
<td>Family orientated</td>
</tr>
<tr>
<td>Environmentalist</td>
<td>Enthusiast/hobbyist</td>
</tr>
<tr>
<td></td>
<td>Independent/small farmer</td>
</tr>
</tbody>
</table>

Ideally, the behavioural types of the decision-makers managing the land surveyed by CS would be determined directly, as done by Potter et al. (1996). In the absence of such a study, if such behavioural types could be linked to farm types and/or other characteristics, they could be used to weight responses in predictive or interpretive analyses of underlying drivers of change detected by the Countryside Survey. The ‘Processes of Countryside Change’ study distinguishes between arable and livestock farmers in its typology. The University of Reading study did investigate whether there were any relationships between behavioural types and farm types, though it did note that farm types were a better predictor than behavioural types in terms of intention to change the farming system in response to the Single Farm Payment. (Recommendations 9, 10)

3.6.4.4 Environmental burdens and resource use

Intensity of agriculture can be measured in terms of a range of attributes indicating impacts on the environment, but also in terms of resources utilised in agricultural production. An example of such an analysis is provided by recent work carried out by Cranfield University (Williams et al., 2006). They used Life Cycle Assessment (LCA) to quantify the resource use and emissions arising from the production of ten key commodities in England and Wales: bread wheat, potatoes, oilseed rape,
tomatoes, beef, pig meat, sheep meat, poultry meat, milk and eggs. Results were expressed per tonne of production for each commodity in terms of Primary Energy Use (GigaJoules), Global Warming Potential (GWP; t CO$_2$), Eutrophication Potential (kg PO$_4^{3-}$), Acidification Potential (kg SO$_2$), Pesticide use (dose/ha), Abiotic Resources Used (ARU; kg antimony), Land Use by grade (ha) and, for crops, Irrigation Water (m$^3$).

If output data were converted to an area basis using appropriate yield figures, they could potentially be related to measures of stock and change in environmental variables measured by CS for land uses related to the commodities assessed. A wider range of agricultural products will be assessed through ongoing work\textsuperscript{23}, including biofuels (Recommendation 11).

3.6.4.5 Aquatic habitats

Brown et al. (2006) have developed a classification of landscapes according to the morphological and physico-chemical properties of the constituent waterbodies, in order to provide a framework for analysis of the impacts of pollution by pesticides on aquatic organisms. They distinguished 12 hydrogeological classes for agricultural areas and a 13\textsuperscript{th} class for non-agricultural land. Countryside Survey (2000) data were used in conjunction with a range of other datasets to describe the spatial abundance and morphological/physico-chemical properties of the waterbodies.

The landscape classes are characterised in terms of the dominant types (rivers, streams, ponds, ditches) and length or number of waterbodies, groundwater, dominant water flow, agricultural land use and distance of waterbodies from the nearest arable land. Data on agricultural land use were used in conjunction with pesticides usage data to estimate pesticide loads in the different landscapes. Statistical comparisons of morphological and water chemistry characteristics for the different types of water body between landscape classes were carried out.

The authors drew attention to the scarcity of data on ditches and ponds. Ditches are the waterbody type occurring most frequently in agricultural areas, whilst ponds are isolated with generally little or no flow, and so are particularly susceptible to pollution impacts, as pollutants are likely to persist for longer periods than in linear waterbodies. A potential source of additional data on ponds is the National Pond Monitoring Network\textsuperscript{24}. (Recommendations 12, 13)

Although the classification was designed for use in pesticide risk assessment, it could also provide a useful framework for analysis of risk from other pollutants such as nutrients. A version already in use by CEH is shown in Figure 3.3 (Recommendation 14).

3.6.4.6 Statistically determined stratification

In the longer term there is the potential to develop a statistical approach to stratification that provides a solution giving the greatest reduction in variance in relation to the question being considered, as an alternative to pre-defined stratifications that could increase variability and hence reduce the power of the data. This could be conceived as a set of statistical tools such as kriging, possible attached to CIS. A different stratification would be derived for each analysis and a measure would also be provided of its effectiveness in explaining variation (Recommendation 15).

\textsuperscript{23} Further development work is in progress as Defra project IS0222 (Developing and delivering environmental Life-Cycle Assessment (LCA) of agricultural systems).

\textsuperscript{24} http://www.pondnetwork.org.uk/Main/about.aspx
3.6.4.7 Use of stratification in provision of access to CS2007

As mentioned previously, it is intended that, following production of the first report, CS data will be made available to external organisations at the level of individual squares, but without specific spatial identifiers, to maintain confidentiality concerning precise locations. In addition to the standard classifications listed in (section 3.6.3), stratification by agriculturally orientated categories could facilitate analyses relating to impacts of agricultural management. Among those described above, suitable classifications for stratification could include Agricultural Land Classification, dominant farm type, index of specialisation, aquatic landscape classification (Recommendation 16).

Figure 3.3 Distribution of British aquatic landscape classes
3.7 DATA MATCHING OF CS SQUARES WITH SAMPLE SURVEYS OF AGRICULTURAL MANAGEMENT PRACTICES

In contrast to agricultural land cover data, data on management practices are derived from sample surveys covering relatively small numbers of farms. It is therefore of interest to see to what extent matches between these surveys and CS squares might be possible. The following section details the results of a data matching exercise carried out to provide a rapid indication of matches between the locations of CS squares and three major agricultural survey datasets:

- The Pesticide Usage Survey (PUS)
- The Farm Practices Survey (FPS)
- The British Survey of Fertiliser Practice (BSFP)

Data were only available for England for the PUS and FPS, so they are only compared with CS squares for England. BSFP data were available for the whole of Great Britain. Pesticides Usage Surveys are carried out for a range of crops, but most of the land area is covered by the arable and grass/fodder crops surveys, so the most recent versions of these were used (2005 for grassland & fodder crops, 2006 for arable). FPS and BSFP data were for 2007.

3.7.1 Methods

Because of data confidentiality considerations and time limitations, the overlay process was undertaken as a combined effort between CEH and CSL, CEH providing CS square locations and CSL contributing PUS, BSFP and FPS sample locations in such a way no data exchange was necessary. This saved time necessary to negotiate confidentiality agreements with data owners.

3.7.1.1 Data matching statistics

Each 1km CS square was converted to a 5km x 5km (25 km$^2$) square as shown in Figure 3.4. The number of data points for each agricultural dataset within all 5km squares was then determined as well as within each 1km square, using ArcGIS. This approach was adopted because the survey points for each agricultural dataset refer to the whole farm area (data may be taken at any spatial location on that farm and are only referenced to the farm business location). Few farms will be entirely located within the 1km square in which the centroid (the grid reference of the point used as a spatial identifier) is located. Matching at a larger scale therefore gives a more realistic idea of the potential spatial agreement between the datasets.

3.7.1.2 Spatial concentration of data matches

The spatial results of the data matching cannot be displayed at the scale of 1km or 5km squares (as CS survey site spatial locations must be protected) so the information on the number of agricultural survey points within each 5km square was aggregated to 100km squares across the UK. This allowed the construction of maps using ArcGIS that show the spatial concentration of matching datasets across the UK. Although the information conveyed by these maps is limited, they do give a rough idea of the density of matches in different parts of the country.

3.7.1.3 Distances of Agricultural datasets from CS squares

For each agricultural dataset, distances were calculated (using ArcGIS) for each CS square to give statistics on the minimum distance of a data point from the square.
3.7.2 Results

3.7.2.1 Data matching statistics

The Farm Practices Survey data points had the most spatial matches with both the 1km CS squares and the enlarged 5km x 5km squares, having twice as many matches as either the PUS or BSFP datasets. However, the percentages survey sample points matching CS square locations was low for all datasets (Table 3.6).

<table>
<thead>
<tr>
<th>CS squares</th>
<th>PUS</th>
<th>FPS</th>
<th>BSFP</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 km</td>
<td>52 (4.2%)</td>
<td>123 (4.8%)</td>
<td>67 (6.5%)</td>
</tr>
<tr>
<td>1 km</td>
<td>4 (0.3%)</td>
<td>5 (0.2%)</td>
<td>3 (0.3%)</td>
</tr>
<tr>
<td>Total survey points</td>
<td>1243</td>
<td>2576</td>
<td>1030</td>
</tr>
</tbody>
</table>

Table 3.7 shows the numbers and percentages of CS squares that have at least one agricultural survey data point either within the square or within a 5km x 5km square centred on the CS square. Although only between 0.5% (BSFP) and 2.5% (PUS) of CS squares had agricultural survey points within the 1km square, between 11% and 36% had a data point within the 5km x 5km square centred on the CS square.

<table>
<thead>
<tr>
<th>CS squares</th>
<th>PUS</th>
<th>FPS</th>
<th>BSFP</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 km</td>
<td>46 (17.2%)</td>
<td>96 (35.8%)</td>
<td>60 (11.3%)</td>
</tr>
<tr>
<td>1 km</td>
<td>4 (2.5%)</td>
<td>5 (1.9%)</td>
<td>3 (0.5%)</td>
</tr>
<tr>
<td>Total survey points</td>
<td>268*</td>
<td>268*</td>
<td>591</td>
</tr>
</tbody>
</table>

*England only
Figure 3.5 Number of (a) Farm Practices Survey, and (b) Pesticide Usage Survey data points that are within 5km CS squares, summarised at the 100km grid level.
Figure 3.6  Number of British Survey of Fertiliser Practice data points that are within 5km CS squares, summarised at the 100km grid level.

3.7.2.2  Spatial concentration of data matches

The densities of matches between CS square locations with FPS and PUS at 100km$^2$ scale are shown in Figure 3.5, and the corresponding densities for the BSFP are shown in Figure 3.6. For the FPS, the greatest concentrations appeared to be in the middle and south of the country, but many squares contained a large amount of sea. Taking into account the area of land in each square, the distribution was relatively even. This was also the case for the PUS, though there appeared to be a higher concentration in central East Anglia.

For the BFSP, matches were more unevenly distributed, with concentrations in southern Wales, central northern England and Yorkshire. Most 100km squares in Scotland and central and southern England contained few or no matches (Figure 3.6).
Figure 3.7: FPS distances from CS squares

Figure 3.8: PUS distances from CS squares
Figure 3.9: BSFP distances from CS squares (final column shows the frequency of distances greater than 21 km).

Figure 3.10: Distance of FPS, PUS and BSFP data from CS squares as cumulative percentage frequency (BSFP distances greater than 21 km condensed into final data point).
3.7.2.3 Distances of Agricultural datasets from CS squares.

For the FPS and PUS datasets only CS squares within England were included in the analysis as the surveys are only conducted in England. The BSFP results also include Wales and Scotland. Figure 3.7 to Figure 3.9 show the frequency distribution for the distances of each agricultural dataset from CS squares across England (for the FPS and PUS) and across Great Britain for the BSFP. Figure 3.10 compares the three surveys in terms of cumulative proportions within increasing distances from a square.

The majority (98.5%) of CS 1km squares were within 10km of an FPS survey point, 86.9% were within 10km of a PUS point. The modal distance for these two surveys was 2 to 3 km (i.e. just outside the 5km square used in the preceding analysis). There were a number of outlier data points at large distances for the BSFP dataset, probably due to the analysis being at the scale of the UK rather than just England. In terms of CS squares 62.6% were within 10km of a BSFP point.

3.7.3 Discussion and Conclusions

Unlike the CS, samples are not constant for the agricultural practice surveys (though some BSFP farms are re-sampled in subsequent years, using the 'panel' approach), and so matches would vary between successive Countryside Surveys.

It would be possible to use the Rural Land Register to overlay maps of survey farms onto CS squares, and relate information from the surveys directly to observations made on fields within the squares. However, the RLR is a very large dataset that is difficult to work with in ArcGIS at the UK scale. Alternatively, centroid locations of fields from the SPS could be used to map survey farms onto CS squares, which would be computationally much easier and lead to little loss of precision, except possibly for very large areas of rough grazing etc.

This approach could be taken in future projects for a more accurate assessment of the spatial correspondence between CS data and these three datasets, but the relatively small number of potential matches identified here suggests that the information gleaned from direct matching would be limited. However, a large proportion of survey sites were within a few kilometres of CS squares, and could provide information on local variations in practice that could be related to CS data.

It is suggested that any such exercise should be preceded by a preliminary analysis of data from the surveys to determine the extent of any such local variation. For example, if rates of fertiliser application or types of pesticide used on a particular crop can be shown to vary spatially, then relating CS data to fertiliser or pesticide data from nearby farms could pay dividends. However, it is probable that any such variation in agrochemical use would be related to climatic and/or edaphic factors. For example, dominant weed species, and hence herbicide choice, vary with soil type; crop pests, and hence insecticide use, are more likely to be influenced by climatic effects. Fertiliser use is determined by yield potential of the crop, which is a primarily a function of soil type, modified by other factors (see section 3.6.4.1). Farm type is also likely to influence input usage. Thus stratification of both CS data and data on input use by one or more additional, according to the purpose of the analysis, could provide the most useful way forward (Recommendation 17).
4. KEY AGRICULTURAL STATISTICS DATA SOURCES AND ACCESS ISSUES

4.1 DESCRIPTIONS OF KEY DATASETS

Agricultural statistics are a potentially important source of information to aid interpretation of Countryside Survey data. In particular, datasets that cover the majority of the agricultural land area are of significance, as there is likely to be a high degree of matching with CS squares. These include the June Survey, SPS data and the Rural Land Registry. The information presented below expands and updates that originally collected for a previous Observatory project (Boatman et al., 2006\(^{25}\)). The list below covers key datasets but is not comprehensive and readers are referred to Boatman et al. (2006) for a more complete list of survey and other data collected.

4.1.1 June Survey

The June Agricultural Survey, is a key source of data on farm businesses. This was formerly an annual census of all farms in the UK, but since 1995 has been a sample survey, though a full census is carried out every ten years to comply with EU regulations; the last such occasion was 2000. The name ‘June Census’ has continued to be used, but it is now more correctly known as the June Survey. It is one of the longest running continuous data sets, having begun in 1866\(^{26}\). Information is collected on the area of land owned and rented, the areas of individual crops grown, numbers of each type of livestock, numbers and categories of people working on the holding, and non-agricultural activities. Provisional results are available three months after data collection, and final results after seven months. There are currently around 190,000 agricultural holdings in England, many of which are very small. The sample sizes used in recent years are between 45,000 and 75,000, and larger holdings are sampled at a higher rate than smaller ones.

Data summaries are available on the Defra website at regional, county, local authority and ward or (since 2004) super output area level.

One limitation of the data is that the survey records relate to 1 June in the year of survey. For cropping, this is generally not a problem as usually only one crop is grown on a field each year. However, livestock numbers can fluctuate throughout the year, with movements between parts of a holding at different locations, between farms or even to different parts of the country. Thus livestock data cannot be used to provide a reliable estimate of numbers present for the whole year. There is also no information recorded on housing of livestock or distribution on the farm, and in the uplands the situation may be further complicated by grazing on common land. Use of livestock data to estimate grazing intensity must therefore be done with great care and awareness of the limitations of the dataset. From 2008, June Survey livestock data will be replaced for statistical purposes by data from the Cattle Tracing Scheme (see section 4.1.5.1).

There are also spatial limitations to the interpretation of the data. Figure 4.1 shows issues arising from the reporting of the data at parish level, but also neatly illustrates the difficulties arising at a range of scales from the way in which holdings are


\(^{26}\) http://www.defra.gov.uk/esa/work_htm/publications/cs/farmstats_web/History/history_census.htm
distributed. However, the SPS could be used to improve the mapping of holdings onto squares, either using the RLR or field centroid locations.

### Limitations of Parish Agricultural Statistics

- **Statistically insignificant farms which may be really extensive but have little agricultural activity**
- **Farm making return for another parish, but part of the farm is in this parish**
- **Farm making return for this parish, but part of farm is in another parish**
- **Livestock feeding here but numbers returned in another parish**
- **Farm having return made in another parish in respect of another farm with which it is amalgamated**
- **Farm making return for this parish which includes information in respect of another farm(s) in another parish with which it is amalgamated**
- **Farm making return for this parish, but part of farm is in another parish**

**Figure 4.1** Spatial limitations to interpretation of June Survey data (reproduced from EDINA agcensus website[^27])

[^27]: http://edina.ac.uk/agcensus/agcen2.pdf
4.1.2 The December Survey of Agriculture

This complements the June survey, with data on autumn/winter sown wheat, barley, oats, beans, oilseed rape and linseed, as well as cattle, sheep, pigs, fertiliser stocks, hay and silage. The sample of farms is however considerably smaller (e.g. 19,700 in 2005). Data are collected in December.

4.1.3 CAP payment administration data

4.1.3.1 Single Payment Scheme (SPS)

Data on farms claiming Single Farm Payments are maintained by the Rural Payments Agency. Claims are made annually and data are held at field level. Details potentially available include areas of eligible land and set-aside entitlements, organic registration, cropping, common land grazing rights and factors affecting cross-compliance. Unfortunately, the cropping categories have been designed for administrative purposes and are not as useful as the former IACS categories, though it is possible that a reversion to the more detailed categories may occur in future. Categories included in the 2007 form were:

- Set-aside, including Multi-annual non-food crops (e.g. short-rotation coppice, Miscanthus), Farm Woodland Scheme and Agri-environment scheme land on set-aside
- Permanent pasture
- 'Other crops' including flax, hemp, hops, dehydrated fodder crops and permanent crops
- Forest, woodland
- 'General', including land not in production, other eligible and non-eligible crops, and land in agri-environment schemes that does not fit elsewhere
- temporary grass
- energy crops receiving aid
- protein crops receiving protein crop premium
- nuts, including almonds, hazelnuts, pistachios and walnuts.

Most commonly grown crops are included in the category ‘other eligible crops’ under ‘General’, and cannot therefore be distinguished.

The form requests information relating to cross-compliance conditions that will be applicable on the farm. Tick boxes are provided for a range of information, including the following:

- Classification as Special Protection Areas (SPAs) under the Wild Birds Directive
- Classification as a Special Area of Conservation (SAC) or awareness of any European protected species
- Inclusion in a Nitrate Vulnerable Zone
- Use of sewage sludge
- Keeping of pigs, goats, sheep, cattle or other livestock
- Use of crop protection products, herbicides or growth regulators
- Sites of Special Scientific interest (SSSIs)
- Scheduled Monuments
- Visible rights of way

28 The general set-aside code (SA1) was removed from the 2008 form, due to the setting of a zero rate for set-aside. The SA2 and SA3 codes for energy crops and agri-environment scheme land, and the OT2 code for cross-compliance GAEC 12 land remain
- Burnt heather, rough grass, bracken, gorse and *Vaccinium*
- Agricultural land not in production during the year
- Stone walls
- Hedgerows
- Watercourses
- Intention to convert any permanent pasture during the year

### 4.1.3.2 IACS

Prior to the introduction of the SPS, The IACS (Integrated Administration and Control System) recorded cropping and forage area for all farms applying for the Area Aid Payments between the 1992 and 2003 reforms of the CAP. Most crops were identified individually, thus giving field-specific cropping information for most farms in the country. The information for each field/land parcel is linked spatially to a point within the field. The data are therefore the most spatially accurate available for the period concerned. The last year of collection was 2004.

### 4.1.3.3 Rural Land Register

The Rural Land Register (RLR) holds digital maps of all registered land parcels, and is maintained by the Rural Payments Agency (RPA). All land must be registered on the RLR in order to be eligible for payments through the Single Payment Scheme (SPS) or the Environmental Stewardship Scheme (ES). From 1 April 2008 land will also need to be pre-registered on the RLR to be eligible for payments through the English Woodland Grant Scheme.

The Rural Land Register thus contains digital maps of the vast majority of agricultural land in the UK, which if used in conjunction with SPS data also provides information on agricultural land cover (though limited because of the imprecise crop codes; see above). However, it should be remembered that a number of small farms and holdings not eligible for SPS are not registered, though these cover only a very small proportion of the total agricultural area.

### 4.1.4 Agri-Environment scheme uptake

Data on uptake of the Environmental Stewardship Schemes is available through [GENESIS](http://www.natureonthemap.org.uk/), the IT software created to manage applications and agreements. A variety of pre-defined reports are available; bespoke reports can also be requested. Data include the area of land in each strand (Entry Level, Organic Entry Level and Higher Level), and amounts of each option. Option location identifiers vary according to the option concerned. Whole field, part field and margin options are identified by the field in which they occur, but boundary options (e.g. options for management of hedges, ditches, stone walls) are identified only at farm level, because they cannot be assigned to a specific field, as are rotational options (e.g. stubbles, conservation headlands), because they occur in different fields each year. Each farm has a map showing the location of options on the farm, but most of these are not held electronically; instead they are scanned from paper originals. It would be possible to digitise them for use with a GIS, but this would be time-consuming.

Maps showing the locations of agreements (with supporting data on type of agreement, farm name and area of agreement) are available via the website ‘Nature on the map’ run by Natural England, though no details of options are given.

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4.1.5 Livestock identification, movements, and tracing schemes

In order to limit the spread of livestock diseases such as foot and mouth during an outbreak, there are strict rules controlling the identification and movements of livestock and schemes apply to cattle, sheep, goats, pigs, deer and horses.

4.1.5.1 Cattle

It is a requirement under European Law that keepers of cattle record in their herd register the details of every birth, every movement on and off the holding, and every death of their animals. All cattle born after 1 January 1998 must have a Defra approved ear tag in each ear (double tagging). In addition, all cattle born since 1 July 1996 must have passports, recording where they have been throughout their lives. All movements, sales and purchases must be notified to the British Cattle Movement Service (BCMS) within 3 days of the movement taking place and are recorded on a central register, the Cattle Tracing System (CTS). BCMS is the specialised cattle tracing organisation for Great Britain and is part of the Rural Payments Agency (RPA). Thus, it is possible to determine the number of animals present on a holding at any point in time.

From June 2008, Defra will be using data from the CTS in the place of information from the annual June and December agricultural surveys.

4.1.5.2 Horses

Horses and ponies are now also required to have passports. After 28 February 2005, animals without one cannot be sold, bought, exported, slaughtered for human consumption, moved to attend a competition or show, or moved to new premises for breeding. The National Equine Database has been developed to record details of every horse issued with a passport.

4.1.5.3 Sheep and goats

From January 2008, new rules apply for sheep and goats. All animals must be tagged before 9 months old (or 6 months if housed indoors) and, in any event, before they leave their birth holding. A record must be made of all movement within 36 hours of moving the animals on or off the holding, and a movement document filled in each time animals are moved between one holding and another. The movement document must be sent to the Local Authority within three days of the movement.

4.1.5.4 Deer

Farmed deer must be uniquely identified by a tag if they have been tested for tuberculosis or when they leave the farm of origin. When deer are moved the person who takes delivery of the animals must report the movements to the local authority within 3 days using the standard movement document. Deer will be included in the Defra Livestock Register.

The most useful datasets are likely to be those for cattle and horses, because the animals have individual passports, so it is possible to discern the number of animals present at a given location at a particular time. For sheep, goats and deer, this is not the case.

4.1.6 Farm Business Survey

The Farm Business Survey provides information on almost every aspect of the businesses surveyed, including: profitability and performance of farm business, costs, revenues and margins of farms and farm enterprises, location, physical and environmental characteristics of the farm, machinery, labour use, and contracting arrangements, assets, liabilities and debt servicing, (all in relation to the agricultural business only), plus output and costs of non-agricultural activities on farm, and other sources of farmer/spouse income. The data are collected by Farm Business Survey Research Centres, based at the Universities of Cambridge, Exeter, Newcastle upon Tyne, Nottingham, and Reading plus Imperial College, London and Askham Bryan College, York. The FBS is a panel survey designed to allow accurate estimates of year-to-year changes. A proportion of holdings are replaced each year and there is a maximum length of time individual holdings remain in the survey, in order to ensure that the survey remains representative.

Because of the amount of work involved in collecting the information, the FBS sample size is limited: up to the 2003/04 accounting year, the sample size for the England FBS was 2250 farm businesses, but from 2004/05, it will be 1850 businesses. This clearly limits the spatial resolution of analyses which can be undertaken with confidence. However, the detailed nature of the information collected does allow for in-depth analysis of the functioning of the business. Also, the sample tends to capture larger farms only, so results are biased in that direction.

In recent years, the CEH land class has been collected for FBS farms, which would provide an easy means of linking to CS data, though it may not be the most appropriate method of stratification.

4.1.7 Farm Practices Survey

The Farm Practices Survey (FPS) is a sample postal survey conducted in March to investigate the impact of farming on the environment. It has been conducted annually from 2004. The 2007 survey form was sent to 6,000 holdings. Questions change from year to year; each survey is designed from scratch and questions are retained or recalled from a previous survey or new topics introduced according to the policy issues that are topical at the time. A timeline of topics covered in each year of the survey is available on the Defra website. A summary of the topics addressed in 2007 is shown in Figure 4.2.

4.1.8 Farmers Voice

Farmers Voice is an attitude survey conducted by ADAS each year. It was first carried out in 1999, and further surveys have been performed in 2000, 2002, 2004, 2005 and 2006. In 2005, 12,000 questionnaires were sent out, with a 10% return rate. Data are analysed by farm type, farm size and Government Office region. As for the FPS, questions vary somewhat between surveys. Raw data are not accessible, but bespoke analyses can be commissioned at a cost. The ACE Observatory has commissioned analyses of the results in 2005, 2006 and 2007.

4.1.9 British Survey of Fertiliser Practice

The British Survey of Fertiliser Practice (BSFP) is an annual, nationally representative, survey based on the selection of a random stratified sample of farms from mainland Britain, using the Agricultural Census as a sampling framework. Like the Farm Business Survey, it is a ‘panel survey’, i.e. a proportion of the sample is retained between surveys. It was formerly overseen by a committee known as the ‘BSFP Authority’, which included Defra (chair), the Agricultural Industries Federation and ADAS. The survey is now run by the Defra Farm Surveys and Statistics team, though the data are still collected by an external contractor.

Fieldwork takes place between May and August, the results of which are published the following Spring/Summer. The main purpose of the survey is to estimate average application rates of nitrogen, phosphate and potash used for agricultural crops and grassland. Information is also collected on applications of sulphur fertilisers, organic manures and lime. However, information on organic manures is more limited than that presented on inorganic fertilisers. The survey was first carried out in 1942. Aggregated data have been obtained for Great Britain since 1983, the first year that the existing survey in England and Wales was extended to Scotland, where it is managed by the Scottish Executive Environment and Rural Affairs Department.

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33 see http://statistics.defra.gov.uk/esg/ace/research/published/index.htm
4.1.10 Pesticides Usage Survey

The Pesticide Usage Survey (PUS) is a rolling programme of surveys covering different crop groups, carried out at varying intervals by the Central Science Laboratory. From 1990, arable surveys have been conducted every other year, and surveys of all other crop groups survey on a 3-4 yearly cycle within England and Wales (Table 4.1), though surveys for most crop groups date back at least to the 1970s. Parallel surveys are carried out in Scotland by the Scottish Agricultural Science Agency (SASA)\textsuperscript{35}, and in Northern Ireland by the Agri-Food & Biosciences Institute (AFBI)\textsuperscript{36}.

Table 4.1 Pesticides Usage Survey years since 1990 for crops in England.

<table>
<thead>
<tr>
<th>Year</th>
<th>Arable Crops</th>
<th>Bulbs and Flower Crops</th>
<th>Fodder, Forage and Grassland Crops</th>
<th>Protected Crops</th>
<th>Hardy Nursery Stock</th>
<th>Hops</th>
<th>Mushrooms</th>
<th>Orchard Crops</th>
<th>Soft Fruit Crops</th>
<th>Vegetable Crops</th>
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<td>2007</td>
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</table>

\textsuperscript{1} Data not yet available.

All holdings are selected from a random sample, stratified by holding size and region. A fresh random sample is selected for each survey. The information is collected on a field by field basis for each crop and is then raised using data from the Agricultural Census returns to give national estimates of usage. For arable crops, the sample represents 5% of the total area of crops grown in England; for other crop groups the proportion is higher. Usage is reported as spray hectares and tonnes of active ingredient for each active ingredient on each crop. In addition, area treated and weight applied for each pesticide group, number of products applied, area treated as percentage of area grown, average application rate, timing of applications, reasons for application and sprayer water volumes are also reported for each crop.

\textsuperscript{34} Includes protected crops, vegetables, grassland and fodder crops, outdoor bulbs and flowers, hardy nursery stock, hops, orchards, soft fruit, grain stores and potato stores.

\textsuperscript{35} http://www.sasa.gov.uk/

\textsuperscript{36} http://www.afbini.gov.uk/
An interactive website\[^{37}\] provides facilities for the extraction of data in tabular or graphical formats for individual crops and pesticides, and reports can also be downloaded from the CSL website\[^{38}\]

### 4.1.11 Countryside Quality Counts

The Countryside Quality Counts (CQC) project\[^{39}\] was developed to provide evidence about the ways that the character of the English landscape has changed, at a JCA level (Haines-Young, 2007), and to provide an indicator of change in countryside quality. The project began in 2002, and has so far made retrospective assessments for two periods, 1990-1998 and 1999-2003.

The first stage in the project was to draft a profile of each JCA, based on published character area descriptions (Countryside Commission, 1999), augmented with material from additional sources. Each profile consisted of a series of statements describing the JCA, and what types of change would sustain or strengthen, erode or transform its character. These profiles were then validated through a consultation process. Next, the magnitude of change and its direction was assessed for each JCA, using a range of datasets for each of seven themes: woodlands and trees, boundary features, agricultural land cover, settlement and development patterns, semi-natural habitats, historic features, river and coastal features.

For each theme, landscape change was categorised as one of the following: ‘Maintained’ (sustained), ‘Enhancing’ (strengthening), ‘Neglected’ (weakened or degraded) or Diverging (eroding or transforming). Judgements were then weighted according to their contribution to overall character, leading to an integrated assessment for the JCA in question. Finally, the assessment was reviewed in a second round of consultation, to give an indication of the reliability of the final result.

### 4.2 ACCESS AND DISCLOSURE ISSUES

Most datasets are affected by limitations on access to raw data, for reasons including the protection of owner IP, maintenance of respondent confidentiality and protection of the integrity of the survey where repeat visits are carried out. This latter reason prevents the general disclosure of locations for CS survey squares; as the same squares are visited for each survey. If the locations became widely known, there is a danger that this knowledge could influence land management within the squares, so that they would no longer be representative of the UK countryside.

In general, data collected for surveys, tracing schemes etc. are covered by the Data Protection Act. In limited circumstances, information, including personal and commercial information, may have to be released if requested under the Environmental Information Regulations 2004 or the Freedom of Information Act 2000. However, Defra, its agencies and local authorities undertake to keep information confidential where possible, and meet their duties under the Data Protection Act 1998.

Data access issues affecting key agricultural datasets, in so far as these can be determined, are summarised below. Precise conditions applying would need to be confirmed with the data supplier on a case by case basis.

\[^{37}\] \url{http://pusstats.csl.gov.uk/}
\[^{38}\] \url{http://www.csl.gov.uk/newsAndResources/resourceLibrary/articles/puskm/index.cfm}
\[^{39}\] \url{http://www.cqc.org.uk/}
4.2.1 June Survey

4.2.1.1 Access to data

The following information was kindly provided by the Defra Surveys, Statistics and Food Economics Division:

Access to June Survey data is regulated by the Agricultural Statistics Act 1979 as amended, which permits access to (among others but the following are the most relevant here):

- Ministers in charge of any Government Department and to any person exercising functions on behalf of any such Minister. Access is also allowed to Defra supported Non-Departmental Public Bodies (NDPBs) only when they are acting on behalf of Defra. Such access normally requires the signature of a Defra representative before data can be released, to ensure that the purpose is directly in support of a Defra (Ministerial) purpose and so conforms with the terms of the Act. Data are provided only for the specific piece of research identified.

- To any person to whom the Minister considers that disclosure is required in the national interest. To activate this route, Ministerial approval needs to be applied for, supported by a very strong case, demonstrating that necessary consultations had been carried out and that there was no sensible alternative. This power has not been used in the past and is unlikely to be used in future without very good reason. Therefore any release of data for analyses relating to CS data would need to take place under the provisions of the previous bullet point.

Even where requests for data can be met within the constraints of the Act, account also has to be taken of the Data Protection statement that accompanies survey forms. The only relevant use that currently specified is ‘Defra Divisions, Defra sponsored or supported research bodies conducting statistical surveys or studies’. As a Defra sponsored research project, the Countryside Survey would qualify under this provision. Any data provision would have to be subject to signature of a confidentiality and disclosure agreement, with clear Defra support. Such agreements usually specify a date by which the data must be destroyed on completion of the analysis for which they were provided.

Although these conditions appear to be very restrictive, in practice, access can almost always be obtained, at least in England, by researchers working on projects with Defra funding or support.

4.2.1.2 Reporting restrictions

According to the provisions of the Agricultural Statistics Act, in order to protect confidentiality of contributors, reports based on June Survey data cannot include any data relating to four or fewer holdings.

The restrictions applying to June Survey data also generally apply to other data collected and managed by the Defra Surveys and Statistics Division, such as the December Agricultural Survey and the Farm Practices Survey.

4.2.2 Single Payment Scheme, IACS and Rural Land Register

SPS and RLR data are regulated by the Data Protection Act. Under the terms of this Act, data can be supplied for research purposes on production of an appropriate business case. A charge may be payable (C. Martin, RPA, pers comm.).
4.2.3 **Agri-Environment scheme uptake**

Live Environmental Stewardship holding information is available for use by contractors to Defra. The dataset is updated on a monthly basis and is usually prepared for the 15th of the month (P. Dutton, Natural England, *pers. comm.*).

4.2.4 **Livestock identification, movements, and tracing schemes**

Data on cattle, sheep and goats are available to researchers within Defra and its agencies through the RADAR system.

The Data Protection statement for the Cattle Tracing System, as given on the Defra website, is as follows:

"We will protect any personal data we receive in line with the Data Protection Act 1998. We will use the data primarily to support the application to which it relates. In the case of the Cattle Tracing System (CTS) we will use the data to register cattle and their movements. But we may also use it, in line with the Data Protection Act and in keeping with the safeguards of that Act, for other purposes connected with:

- administration of the Common Agricultural Policy, ERDP and other aid schemes;
- the production and safety of food;
- management of land and other environmental controls;
- animal health and welfare; and
- occupational health and welfare.

Customer research activities aimed at improving the service provided by the RPA, DEFRA or other DEFRA Agencies.

When required to do so we may pass data to other organisations, for example to Customs and Excise for import or export purposes, or to local authorities for milk or health purposes. We may also use the data we collect in connection with the Agricultural Census to produce statistics that do not identify individuals. We may also use the data when we must comply with the Environmental Information Regulations 2004; and the Freedom of Information Act 2000. We will ensure that individuals can easily exercise their rights of access to their personal data held by RPA.

Unlike the CTS, which is centralised, records for sheep and horses are held by local authorities and so are less likely to be easily obtainable. Also, sheep do not have individual passports, making accurate estimation of numbers at a given location at a particular time very difficult.

4.2.5 **Farm Business Survey**

4.2.5.1 **Access to data**

Anonymised data at farm level can be obtained through the UK Data Archive\(^40\) for authorised research projects. Registration is required with the Economic and Social Data Service (ESDS), and standard conditions of use of data apply. In addition, ESDS is required to request permission from the depositor prior to supplying the data. Before access is granted, all users must sign a confidentiality statement and data must be destroyed or returned on completion of the study.

Grid references are removed from the data to preserve confidentiality, but location identifiers are provided at a range of scales including region, Government Office

\(^{40}\) [http://www.data-archive.ac.uk/](http://www.data-archive.ac.uk/)
Region, County, Metropolitan County or Unitary Authority, JCA, River Basin Catchment Area etc. The confidentiality rules for the FBS are very strict, so access to exact locations of farms is not possible.

4.2.5.2 Reporting restrictions
Signature of the confidentiality agreement obliges the user to refrain from:

- the publication of statistical tables which show information relating to less than 4 farms in any cell, or of tables from which such information can be deduced
- publishing statements which include information about an individual farm whether directly identifiable or not
- attempting to match any farm accounts provided with any other individual farm, business or personal data.

4.2.6 British Survey of Fertiliser Practice
Anonymised holding level data are potentially available, subject to appropriate confidentiality agreements, by arrangement with the Defra Farm Surveys and Statistics team. The level at which locational information would be provided is not clear but would have to be at a scale considered not to be disclosive. However, because of undertakings to preserve anonymity of contributors, identifiable data cannot be disclosed outside Defra, and are not generally disclosed even within Defra for historic data. Analyses of identifiable data may be possible for future datasets by arrangement with Defra, but without disclosure of identifiers to external organisations such as CEH.

4.2.7 Pesticides Usage Survey
Access and reporting restrictions are as for the June Agricultural Survey.

4.2.8 Countryside Quality Counts
The full assessments for each JCA are published on the project website41.

4.3 OVERCOMING ACCESS RESTRICTIONS
In many cases, there are mechanisms for obtaining access to data under license, as outlined above. However, there may be some instances where disclosure issues prevent access to datasets at the level required for analysis. Potential alternative approaches to allow analyses to be carried out without direct access to the data are described below.

4.3.1 Spatial manipulation of datasets
Data may be spatially manipulated to provide an alternative representation at an appropriate spatial scale for comparison with other datasets such as CS, at the same time removing associations with specific fields/farms, thus removing concerns relating to the protection of client confidentiality. Several examples of this approach exist in relation to the June Survey, where data have been converted to a grid square format.

41 http://www.cqc.org.uk/
4.3.1.1 EDINA agcensus

The most readily available form of gridded agricultural land use data is that produced by EDINA, a JISC National Data Centre based at the University of Edinburgh. The Edinburgh University Data Library has developed algorithms which convert the data for recognised geographies, obtained from the government departments, into grid square estimates. The raw data are transformed into grid square data by defining the each geography (e.g. parish, in the case of Scotland) in terms of 1km squares. This framework is used in conjunction with a classification of the land-use of the same 1km grid squares, the Land use Framework. Agricultural Census items are distributed over those 1km grid squares with the land use category suitable for the census item in question. However, release of the data at a resolution of 1km$^2$ is deemed too disclosive, so the data are aggregated to 2km, 5km, 10km grid squares for general release through a subscription service.

The seven land use categories used to distribute the data are as follows:

- Agricultural land
- Upland
- Woodland
- Restricted agriculture – natural
- Restricted agriculture – artificial
- Urban
- Inland water

At the time of writing, 2, 5 and 10 km$^2$ grid data for England are available up to 2004, and data for Scotland and Wales up to 2006.

4.3.1.2 Other grid-based datasets

In a recent RELU project at the University of York, ward-level June Survey data were disaggregated using a method based on genetic algorithms GA) to produce a 1km$^2$ dataset, which was then linked to bird and mammal survey data at the same resolution. The CEH Land Cover Map 2000 was used as a basis for allocating land use. Results from GA analysis gave probabilities that a grid cell with a known land cover was being used for a particular land use.

Central Science Laboratory in conjunction with the Defra Agricultural Change and Environment Observatory (ACEO) developed a pilot 1km$^2$ map for two 100 km squares based on a combination of IACS data and the Rural Land Register (RLR) (Boatman et al., 2006). Land parcels identified by the RLR were assigned crop identities (including permanent and temporary grass) based on IACS data, thus providing a map based on field–level data which was far more accurate than previous versions based on the June Survey (see also section 0 and Figure A.1). However, some problems were still experienced, arising from inaccuracies in spatial identifiers and assignations of more than one crop to a field. The report of this work is available on the ACEO website.

4.3.2 Combined institute analysis

Where two institutes wish to carry out an integrated analysis of datasets, but there are restrictions on release of data held by both organisations, a rapid solution may be

42 http://edina.ac.uk/agcensus/
43 Integrating Spatial Data on the Rural Economy, Land Use and Biodiversity. RELU project RES-224-25-0099, principal investigator Piran White. Further information at:
http://www.relu.ac.uk/research/projects/White.htm
obtained by a member of one institute visiting the other with data held on a CD or other media and joint analysis carried out without the need for data exchange. The results need to be presented in an agreed format that does not transgress disclosure restrictions. This method was used for comparing CS square locations with sample locations for several agricultural datasets (see section 3.7).

4.3.3 e-Science and data access

A possible future solution to access problems caused by disclosure issues could be achieved through developments in "e-Science". One role of e-Science is in providing technical solutions to distributed databases, particularly relevant to agri-environmental data that are collected and held by very diverse organisations (e.g. the NERC data grid\textsuperscript{45}). However, e-Science can also enable distributed computing (where computation has to be performed in a secure environment away from the user), and the management of access rights to data and computation resources. Along with existing projects, such as the Defra SPIRE programme (Shared Spatial Information Repository), e-Science could play a pivotal role in facilitating the future development of technology for access to agri-environmental data.

The AgriGrid working group\textsuperscript{46} is currently exploring the potential for various e-Science/Grid technologies to provide access to agri-environmental data. Systems currently in use that have been discussed as a potential model include the Office for National Statistics (ONS) "Virtual Microdata Lab", that enables access to restricted governmental datasets by businesses and academia (Figure 4.3). The VML at ONS gives access to Identifiable business microdata, some Census data, health and morbidity figures etc.

Currently, access to the VML is restricted to users from government offices (i.e. connected to the gsi network). For researchers from other institutes and universities, a secure data service is provided.

Researchers have to visit the VML and use dedicated terminals to carry out analyses. Only VML staff can upload or release data to researchers. Users are given a training session on disclosure control before accessing data. The technology permits access to data but not downloads, and outputs are vetted by VML staff to check compliance with disclosure restrictions before release.

In future, it is possible that a system could be developed to provide remote access through a secure interface, allowing use of data for analyses from the home institute.

\textsuperscript{45} http://ndg.badc.rl.ac.uk/
\textsuperscript{46} http://www.niees.ac.uk/working_groups/agrigrid.shtml
Figure 4.3 The principles behind the ONS VML. Data is accessed by a remote user (researcher) via a secure server, where they can read data, use it and write to output which is then transferred ONLY to a ONS staff member to check for disclosure before release to the user (Source: Felix Ritchie, ONS).
5. LINKING AGRICULTURAL AND COUNTRYSIDE SURVEY DATA TO PROVIDE EVIDENCE ON KEY POLICY ISSUES

5.1 INTRODUCTION

This chapter builds on the information gathered and described in previous chapters to consider how CS data might be used to investigate the impact of key drivers from the agriculture sector on changes in measured variables. Firstly, recommendations made by the scoping study carried out prior to CS2007 will be briefly reviewed to set the scene. Further consideration will then be given to those drivers of interest in the context of the current study.

5.1.1 Policy drivers

The scoping study which preceded CS2007 considered policy drivers for which CS data might contribute to an understanding of impacts, as part of the ‘Policy Review and Forward Look’ (ADAS Consulting Ltd., 2004). A hierarchy of information needs was established, and is listed in Appendix 5 for reference.

It is not intended that this list will be revisited in its entirety here. Instead, key drivers of interest in the context of the remit of the ACEO will be considered, and the potential use of CS2007 to provide information on their impacts discussed. Current policy drivers of interest include the forthcoming CAP ‘Healthcheck’, and the impact of Environmental Stewardship and cross-compliance (both of which represented major changes to the incentivisation of environmentally sustainable management, associated with the CAP reform implemented in 2005).

‘High Nature Value Farmland’ is a European level initiative to map and characterise areas where farming practices are associated with high biodiversity, as a basis for conservation measures.

A policy framework for considering environmental impacts is provided by the ‘Ecosystems Approach’, which considers such impacts in terms of changes to the ‘ecosystem services’ provided. This underpins Module 5 of the reporting programme for CS2007. CQC provides an alternative view of change in the countryside, concentrating on landscape but with some consideration of habitats and biodiversity. The potential for development of links between CS and CQC is the subject of current scrutiny.

In the longer term, climate change is likely to continue to increase in prominence as a driver of both agricultural and environmental change. In concert with the ACEO remit, the potential impacts of climate change via changes in agriculture, and the associated environmental effects, will be briefly considered.

5.1.2 External datasets

A number of datasets that could potentially be linked to CS data to elucidate the impact of agricultural and other countryside management practices have been described in chapters 3 and 4 of this report. The Technical Review also undertaken as part of the ADAS scoping study (Critchley et al., 2005) identified a selection of
external datasets with which links should be considered, though some of these would be more accurately described as programmes. They included:

- Northern Ireland Countryside Survey (NICS)
- Agri-Environment Scheme Monitoring
- Agricultural Change and Environment Observatory Programme
- Land Use/Cover Area Frame Statistical Survey (LUCAS)
- Framework for the Co-ordination of Biodiversity and Habitats (BIOHAB)
- Infrastructure for Spatial Information in Europe
- Water Framework Directive (WFD) Monitoring
- National Inventory of Woodland and Trees (NIWT)
- Environmental Change Network (ECN)
- Co-ordination of Information on the Environment (CORINE)
- National Pond Monitoring Network (NPMN)
- Socio-Economic and Land Management data
- Countryside Quality Counts

Those of relevance here include Agri-Environment Scheme Monitoring (considered later in this chapter), the ACEO Programme, LUCAS, Water Framework Directive, Socio-Economic and Land Management data, and Countryside Quality Counts (also considered later).

5.1.2.1 Agricultural Change and Environment Observatory Programme

At the time of the ADAS scoping study, the ACEO was in the early stages of establishment, and the nature and scope of the programme were not finalised. CS and the Land cover Map were however both identified as important source of information for the Observatory. A further possible application identified by Critchley et al. was modelling potential outcomes of changes in farming patterns, which would require linkage with data on farmer intentions and practices.

5.1.2.2 LUCAS

The LUCAS survey, an EU survey of land cover and land use, has changed its methodology since its potential for linking with CS was considered in an earlier report (McKay et al., 2005) (see section 0). LUCAS has the potential to extend the assessment of change provided by CS, by interpolation between surveys and extrapolation beyond the most recent survey. Critchley et al. (2005) recommended that the potential for data exchange between CS and LUCAS be further examined. However, the future of LUCAS was in some doubt owing to reluctance by member states to provide the necessary funding. Little information has been made available by Eurostat (the sponsoring body) since the call for tenders to undertake a pilot survey using the new methodology in 2006, and the current status of the survey is not clear. Further work on potential links with CS should therefore await the report of the 2006 survey and an indication of the long term future of LUCAS.

5.1.2.3 Water Framework Directive

Critchley et al. (2005) point out that WFD monitoring is focused on large waterbodies at a catchment scale, whereas CS assesses smaller waterbodies at a larger scale. Accordingly, they recommended, in conjunction with the Freshwater Topic Group, that CS should not be used for WFD monitoring, but should provide additional information on smaller water bodies and on links between aquatic organisms and hydromorphology and land cover. To facilitate this, the ADAS review recommended that CS and WFD methods should be reviewed and compared to ensure that he
potential for cross-compatibility could be realised. This task cannot be undertaken however until WFD methods become available.

Because of the diffuse nature of most water pollution arising from agriculture, and the extended area from which it derives, the square kilometre sampling unit of the CS is not well suited to analysing relationships between water chemistry and pollution sources.

5.1.2.4 Socio-Economic and Land Management data

In the report of the CS2007 Scoping Study Business Case (Temple et al., 2005), it was recommended that CS sample squares be linked to external data sources via farm typologies or land classes (see section 3.6.3 for further discussion of possibilities for CS2007 stratification). Critchley et al. (2005) recommended that this approach should be taken instead of collecting additional data during the field survey. The reasoning behind this recommendation appears to be that the standard of records maintained by farmers is variable, and that additional resource would be required to undertake collection of the data. However, although the quality of farm records may be inconsistent, farms are now obliged to keep extensive records of their management to comply with regulations and cross-compliance provisions, and many keep additional records for their own use. The advantage of collecting data directly from the farmers managing the surveyed land is that a direct relationship between management practices and field records is assured. This enables much more detailed analyses of impacts to be carried out than is possible using external datasets. We therefore suggest that consideration be given to collecting farm management data directly, in addition to using external data to scale up the results (Recommendation 2, see also sections 2.5.3.1; 2.5.4)

Data sources identified by Critchley et al (2005) as providing useful potential for interpreting CS results included the Farm Business Survey, June Agricultural Census (Survey), December Agricultural Survey, British Survey of Fertiliser Practice, Pesticide Usage Survey, Farm Practices Survey and Defra’s surveys of specific crops. These have been described in chapter 4 of this report, and some are further considered below in relation to the interpretation of key drivers.

5.2 KEY POLICY DRIVERS AND THE POTENTIAL ROLE OF CS DATA

5.2.1 CAP reform

Whilst agricultural statistics provide information on changes in cropping and numbers of livestock, they do not provide any indication of the condition of agricultural habitats. This is particularly relevant for semi-improved or unimproved grasslands and rough grazing, which can vary considerably in terms of their structure and botanical composition, and hence habitat value, according to their management. Key aspects are nutrient input and grazing intensity. Studies of the likely impacts of CAP reform have suggested that grazing levels in the uplands will decrease (Gaskell et al., 2007). Sheep numbers, derived from the June survey, have already been investigated as drivers of vegetation change, for example by Firbank et al. (2007), and in the ‘GANE’ and ‘Terrestrial Umbrella’ projects (see section 2.7). Linking CS data to livestock data might allow future changes in some aspects of vegetation composition/structure to be imputed on the basis of apparent grazing densities, though care needs to be exercised in the use of June Survey livestock data in this way (see section 4.1.1).
Livestock identification and movement data provide another potential source of information which has only been collected in recent years (section 4.1.5). Accordingly, the potential for its use to estimate grazing pressures has not been fully evaluated, however it is likely to provide a more accurate resource than June Survey estimates (see also section 5.2.8.3) (Recommendation 18).

5.2.2 CAP Healthcheck

5.2.2.1 Summary of policy proposals

The European Commission released proposals for further changes to the Common Agricultural Policy, termed a 'Health Check', in November 2007, for a six month consultation period. The proposals build on the 2003 reforms, improve the way the policy operates based on the experience gathered since 2003 and make further provision for the enlarged EU of 27 Member States. Following the consultation, legislative proposals are planned in spring 2008, which it is hoped will be approved for immediate implementation by the end of 2008. Assessing the impacts of the measures that are adopted will be a priority for the ACE Observatory.

Among the proposals are further movement towards a flat rate payment system across the EU increased decoupling in member states where links between production and subsidy remain, reduced support for large farms and increasing the threshold area for payments, and reviewing cross-compliance provisions. The latter is anticipated to include the removal of unnecessary obligations, but also the addition of new ones to address, for example, improved water management and climate change mitigation.

Among specific proposals for change are changes to the intervention system, the abolition of set-aside, and a gradual reduction in milk quotas. In addition, increased modulation rates are proposed from 5% to 23% by 2013, to fund additional rural development measures to manage risk and preserve biodiversity. The need for retention of the energy crop premium was questioned in the light of new incentives for biofuels and higher prices.

5.2.2.2 Potential role of CS data

Whilst the precise nature of the measures to be adopted is still not finalised at the time of writing, the potential for CS data to provide useful evidence in some areas can already be discerned.

5.2.2.2.1 Set-aside

There already appears to be general agreement that set-aside should be abolished. In anticipation of this, and in response to increased price levels for cereals and other crops, the European Commission set a zero rate for set-aside in the 2007-8 cropping season. This caused some concern that environmental benefits of set-aside would be lost, without sufficient time to assess the implications and put mitigation measures in place should they be justified. Accordingly, a policy strategy group was established under the chairmanship of Sir Don Curry to consider the implications of removing set-aside, and at the same time a programme of environmental monitoring was established, to be carried out by the ACE Observatory.

Unfortunately, because of the immediate nature of the EU action in setting a zero rate, much set-aside had inevitably been lost by the time the monitoring programme commenced (around 50%, but 85% of rotational set-aside; Langton, 2008). Fortuitously however, CS2007 covered the period immediately prior to this policy change. Identification of parcels within CS squares that were designated as set-
aside is possible through reference to field level SPS data, though in some cases confusion has occurred between set-aside and land left uncropped under the GAEC 12 cross-compliance provisions (see section 5.2.4). Furthermore, it is possible in most cases to identify the period for which the land has been out of production, by reference to SPS/IACS data for previous years (Langton, 2008). Thus CS2007 offers an opportunity to retrospectively characterise the vegetation of set-aside fields within CS squares prior to the implementation of the zero set-aside rate. Furthermore, the botanical composition of these set-aside parcels could be analysed in relation to that of adjacent habitats monitored during the survey. Such an exercise would provide valuable additional data to supplement that collected during the Observatory monitoring programme.

Unfortunately, the sample size is likely to be small. For example, 30% of land surveyed in CS2000 was in the arable and horticultural Broad Habitat category. Five ‘X’ plots are surveyed per km square. If 100 of the 300 squares surveyed in England contain arable land, and 10% of the arable fields surveyed were in set-aside, then 50 set-aside fields on arable land might be sampled by ‘X’ plots. However, around 25% of set-aside was in industrial cropping in 2007 (Langton 2008), leaving a sample of only around 35-40 set-aside fields. Nevertheless, the exercise would provide valuable additional evidence to complement that already being collected by the ACEO, including a botanical survey currently being carried out by CSL47. (Recommendation 19).

5.2.2.2 Other uses of CS data

CS records could also provide baseline data for recording the impact of changes in cross-compliance provisions and new rural development measures. However, until the details of these are known it is not possible to judge the value of CS data in this context. The impacts of first generation biofuels are difficult to measure as the crops used are managed in essentially the same way as those grown for food, but CS2007 and LCM2007 could provide a baseline against which the impacts of a large-scale switch to perennial energy crops such as short-rotation coppice and Miscanthus could be measured in future.

Changes in agri-environment schemes are discussed in the following section.

5.2.3 Environmental Stewardship

Environmental Stewardship was first launched in 2005 to replace the former Countryside Stewardship and Environmentally Sensitive Area schemes in England (Radley, 2005; for further information see the Defra website48). For the first time, the new scheme incorporate an Entry Level strand, open to all farmers registered on the RLR, in addition to a Higher Level strand for more targeted agreements. Over the following two years, over 30,000 agreements representing over 4,500,000 hectares, more than 50% of the eligible area, were undertaken.

Some baseline data were collected for ELS agreements as part of the initial evaluation (Boatman et al., 2007), but the number of sample sites was inevitably limited by resources and detailed botanical records were not possible within the constraints of this study.

Critchley et al. (2005) pointed out that in the past, CS data have been too sparse and infrequent to report on detailed outcomes of agri-environment schemes in relation to their objectives and prescriptions. However, the advent of the Entry-Level Stewardship means that a majority of farms will have an agri-environment agreement, a major change in comparison with the previous era. This presents an opportunity to use CS data to evaluate differences between ‘scheme’ and ‘on-scheme’ land, though the establishment of appropriate control areas is not without difficulties (Critchley, 2005). Furthermore, for the most widely adopted options, there may be sufficient examples within CS squares to characterise their vegetation at an early stage in the agreement. For agreements set up shortly before or during 2007, CS data could provide a baseline for comparison with later assessments.

ES uptake data are available for individual options at field level, except for boundary and rotational options, which cannot be allocated to specific land parcels. However, for accurate allocation of quadrats to scheme options, the precise location of each option is required. This can be obtained from agreement maps, but these are scanned from paper originals. The Lowland Farmland Topic group recommended that agreement data in CS sample squares should be digitised, and this recommendation was supported by Critchley et al. (2005). We endorse this approach, and recommend extending it to agreements entered during or shortly after the field survey, for which CS data could provide a baseline assessment (Recommendation 20).

Examples of options for which CS data could provide data are hedgerow management options and field margins.

5.2.4 Cross-compliance

The introduction of the SPS in 2005 was accompanied by the application of cross-compliance conditions to payments for all farms. Cross compliance refers to a requirement for farmers to comply with a set of ‘Statutory Management Requirements’ (SMRs) and ‘Good Agricultural and Environmental Condition’ (GAEC) measures, in order to qualify for the Single Payment and other payments such as those received under Environmental Stewardship agreements. The SMRs relate to legislation at EU level, and cover the areas of public, animal and plant health, environment and animal welfare. GAEC standards are set at national level, and address issues of soil erosion, soil organic matter, soil structure and ensuring a minimum level of maintenance, avoiding the deterioration of habitats. These measures are intended to provide a basic standard of environmental protection for soils, habitats and landscape features, which underpins environmental management supported under agri-environment schemes. Full details are available on the Defra\(^\text{49}\) and Rural Payments Agency (RPA)\(^\text{50}\) websites.

All SMR and most GAEC conditions relate to pre-existing regulatory requirements, that farmers should already be complying with. However, there are a few specific GAEC measures that are not supported by legislation, which apply to the management of soil, habitats and features. Countryside Survey data could therefore potentially be suitable for monitoring the impacts of such measures.

For soil protection, recipients of payments are obliged to prepare and implement a Soil Protection Review (GAEC 1), comply with conditions for the post-harvest management of land (GAEC 2), and avoid operations on waterlogged soil (GAEC 3). The impacts of these measures are probably not suitable for monitoring through CS,

\(^{49}\)http://www.defra.gov.uk/farm/singlepay/furtherinfo/crosscomply/index.htm#2
\(^{50}\)http://www.rpa.gov.uk/rpa/index.nsf/UiMenu/814240C66F10C4C882570C7004248D4?openendocument
as it would be difficult to ascribe any changes in soil structure or composition to compliance with GAEC provisions without additional information on management practices.

Measurements applying to the management of habitats and features include GAEC 12 (agricultural land which is not in agricultural production) and GAEC 14 (Protection of hedgerows and watercourses). Livestock producers must avoid overgrazing and unsuitable supplementary feeding (GAEC 9), stone must not be removed from stone walls (GAEC 13), and hedges must not be cut between 1 March and 31 July (part of GAEC 15).

5.2.4.1 GAEC 12: Agricultural land which is not in agricultural production

Rules for the management of agricultural land which is not in agricultural production under GAEC 12 differ from the set-aside rules to some extent. Essentially, a green cover must normally be established and cut at least once every five years. However, it is also permissible to create a ‘bare fallow’ for up to 15 months, on which cutting, ploughing and graminicide applications are allowed where necessary to control certain weed species. Bare fallows were not permitted on set-aside land; however, an application on non-selective herbicide was allowed after 15 April where the land was to be returned to cropping the following autumn.

CS2007 could potentially provide information on the vegetation of GAEC12 land if it could be identified as such. However, the sample size is likely to be considerably smaller than that calculated above for set-aside (5.2.2.2.1). Langton (2008) estimated that there was about half as much GAEC 12 land in 2007 as unproductive set-aside, indicating a sample size of less than 20 fields calculated on the same basis, which is insufficient to provide representative data.

5.2.4.2 GAEC 14 Protection of hedgerows and watercourses

This measure aims to protect boundary features from agricultural operations. Under GAEC 14, it is forbidden to cultivate or apply fertilisers or pesticides to land within 2 metres of the centre of a hedgerow, watercourse or field ditch; or to cultivate or apply fertilisers or pesticides to land within 1 metre of the top of the bank of a watercourse or field ditch. The provisions do not apply to hedges less than 5 years old, to fields smaller than 2 ha, or those compulsorily set-aside.

CS data could be used to provide information on GAEC 14 field margins in 2007. In most cases, CS boundary (B) vegetation plots will generally equate to GAEC 14 margins, however they are measured from the edge of the boundary rather than the centre, so in the case of a boundary wider than 2m from the centre, the B plot may extend outside the GAEC 14 zone. Most fields greater than 2ha in area which eligible for SPS payments should have a GAEC 14 margin, so sample size should not be a problem. Confirmation that fields are eligible for SPS payments could be obtained from SPS data. It would also be instructive to compare marginal characteristics (e.g. width of uncultivated margin) and vegetation in fields smaller than 2ha, and therefore exempt from the GAEC 14 requirement, with larger fields. This exercise would complement the results of a botanical survey currently being carried out for the ACEO by CSL. (Recommendation 21).

5.2.4.3 GAEC 9 Overgrazing

CS data will provide information on the condition of grazed habitats, however it will not be possible to ascribe any changes specifically to the operation of cross-compliance, as changes in grazing intensity are also occurring as a result of the changes in support regime brought about by the recent CAP reform (Gaskell et al., 2007).
5.2.5 High Nature Value farming

High Nature Value (HNV) Farmland (European Environment agency (EEA), 2004) is a concept developed at European level to describe areas where farming practices are associated with high biodiversity. Andersen (2003) described it as “those areas in Europe where agriculture is a major (usually the dominant) land use and where that agriculture supports, or is associated with, either a high species and habitat diversity of the presence of species of European conservation concern, or both”.

The conservation of HNV farmland is an explicit objective of EU rural development policy. Article 22 of the EU regulation on rural development (1257/99) states that support shall be given to “the conservation of high nature value farmed environments which are under threat”.

EEA (2004) provides a definition and typology of HNV farmland of three types:

Type 1: Farmland with a high proportion of semi-natural vegetation.

Type 2: Farmland dominated by low intensity agriculture or a mosaic of semi-natural and cultivated land and small-scale features.

Type 3: Farmland supporting rare species or a high proportion of European or world populations.

Types 1 and 2 are identified on the basis of CORINE land cover data and Farm Accountancy Data Network (FADN) economic farm system data. Type 3 is based on species distribution data. Further developments of the methodology for mapping HNV farmland areas are described by Paracchini et al. (2006).

Originally, it was intended that HNV areas throughout Europe would be identified by 2006, but this target has only been partially met. A preliminary map of HNV farmland areas was published by the EEA in the Fourth Assessment Report in the Environment for Europe process (EEA, 2007; Figure 5.1). This map is currently being updated, using the latest CORINE land cover data (2000), supplemented by data on Natura 2000 sites, Important Bird Areas (Heath and Evans, 2000), Prime Butterfly Areas (van Swaay and Warren, 2003) and national data sets (EEA, 2007). Paracchini et al (2006) also include Important Plant Areas as a potential dataset for inclusion as an additional measure of biodiversity. The map is intended to support general analyses of environmental trends and policies at European level rather than as a tool for evaluating the effectiveness of national and regional policy.

The mapping approach has received some criticism for relying on the CORINE land cover (CLC), because (a) it does not reflect biodiversity values, and (b) the scale of mapping is relatively coarse, at 25ha. Clearly, the UK LCM could provide more detailed land cover mapping, but the EEA/JRC have resisted offers of national land cover datasets because they consider that it would endanger the consistency of the CLC mapping approach. However, it would still be possible to use LCM data as the basis for a refined UK assessment of HNV farming areas within the UK. Furthermore, more detailed biodiversity datasets available for the UK, such as the forthcoming atlas of bird distribution, could be combined with LCM data in such a mapping exercise.

Some national datasets have been used to refine the CLC-based map however. Among these are data from the Scottish Land Parcel Identification System (LPIS), to distinguish deer forest and grouse moors from areas of extensive livestock grazing (Paracchini et al., 2006). A study for the European Commission Joint Research Centre (JRC) in the Walloon region investigated the use of IACS data to calculate

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51 Letter from EEA/JRC to consultees, 12 May 2007; D. Fernall, pers. comm.
indicators such as crop diversity, grassland cover, percentage of permanent grassland and parcel size.

The use of FADN data is also subject to limitations. Small farms are insufficiently represented, and the reference area is Utilisable Agricultural Area (UAA), not the area actually occupied by the agricultural business. Seasonal lets, common land and grazed fallows are excluded. Finally, FADN data are only available at a coarse (NUTS 2) scale (Paracchini et al., 2006). A study in France used additional survey data to produce a classification of HNV farmland at NUTS 5 level, and EU projects aiming to produce disaggregated data for farm typologies livestock density and nitrogen input (CAPRI, SEAMLESS) could enable an extension of this approach (Paracchini et al., 2006).

Figure 5.1 Preliminary map of High Nature Value Farmland (reproduced from EEA, 2007).

In England, the Rural Land Register and LCM2007 both use OS Mastermap as a base layer. Thus SPS data could be used to supplement the LCM to provide an integrated assessment of land use to underpin a HNV classification. Crop codes for 2007 do not allow separation of most arable crops, but would allow the identification of parcels as arable land, set-aside, fallow land and permanent pasture (Recommendation 22).
5.2.6 Landscape quality and Countryside Quality Counts

The importance of monitoring landscape change for policy purposes has increased with the signature by the UK of the European Landscape Convention in 2006\(^\text{52}\).

The CQC project and indicator are described in section 4.1.11. Among the many datasets used to characterise landscapes, CS2000 data were used (in conjunction with CSS and ESA monitoring data) to provide information for CQC on boundary features, and LCM2000 (in conjunction with CSS and ESA agreements, SSSI condition and EN Habitat Inventory), for semi-natural habitats.

The CQC assessment is carried out at JCA level. Whilst providing a useful source of data at a national scale on stock and change in habitats and features, the CS is not suitable for characterisation at the JCA scale, though stratification into ‘landscape types’ based on aggregated JCAs could provide information at a scale relevant to the CQC (see section 3.6.3.1).

The LCM does not suffer from this limitation, as it provides complete coverage. The use of OS Mastermap as the basis for LCM2007 would enable ready linkage to IACS/SPS data to provide further information on agricultural usage. However, methodological differences mean that LCM2007 cannot be readily compared with earlier LCMs to measure change. (Recommendation 23).

5.2.7 Climate Change

The potential impacts of climate change on the nature of our countryside in the future are complex and a full discussion is outside the scope of this project.

In their review of surveillance and monitoring schemes for detecting the impacts of climate change on biodiversity, Riley et al. (2003) commented that there were sufficient kilometre squares in the CS2000 survey to extract predicted changes in stock and plant species composition for nine habitats\(^\text{53}\), but that the distribution of squares may not be ideal for detecting changes in extent or distribution of these habitats, and that this should be considered in the preparation of the next Countryside Survey. However, this issue does not appear to be referred to in the ADAS scoping study reports (Juppenlatz, 2004; Critchley et al., 2005).

In addition, Riley et al. suggested that the CS would be the most appropriate scheme for the monitoring of lowland raised bogs, lowland dry acid grassland, lowland beech and yew woodland, lowland heathland, and lowland calcareous grassland. They recommended investigation of the potential to increase coverage to provide adequate replication for changes in stock and species composition to be monitored in these habitats.

CS is already linked to the Environmental Change Network, which provided long-term monitoring of a wide range of variables at 12 terrestrial and 42 freshwater sites. Critchley et al. (2005) recommended that these links be maintained, and annual surveys at ECN sites should enable repeat of the vegetation analyses done in Module 10 of CS2000 for freshwater and soil variables.

Assessments of impacts on biodiversity have often been based on climate envelopes projected under forward scenarios such as those generated by the UK Climate Impacts Programme (UKCIP). For example, the MONARCH programme assessed impacts of projected climate change on selected BAP species in Britain and Ireland, but

\(^{52}\) http://www.defra.gov.uk/wildlife-countryside/issues/landscape/index.htm#elc

\(^{53}\) Fen, cereal cropland, horticulture, non-cereal cropland, native pine woods, upland mixed ash woods, upland oak woodland, sub-alpine and alpine mountain habitats.
only in terms of climate space. The report observes that: “There will also be many indirect impacts on biodiversity as land use sectors like agriculture, forestry, planning, water and coastal management respond to accommodate climate change.”

A considerable amount of work has also been carried out on the potential impacts of climate change on agriculture (e.g. as summarised in Defra project CC036\(^5^4\)). Linking land use projections to projections based on climate space is an obvious next step in developing assessments of climate change impacts. CS and LCM data could have a key role in validating the results of such models by testing early predictions and providing baselines for monitoring future impacts. (Recommendation 24).

Connectivity of habitats, allowing dispersal of species to new areas with favourable climatic conditions is one key aspect that will be determined by such factors, and work is already under way by the Forestry Commission and CEH to assess the potential of CS and LCM data to contribute to the production of measures of functional habitat connectivity.

### 5.2.8 Ecosystems services

In order to deliver new Public Service Agreement (PSA) framework announced as part of the Comprehensive Spending Review (CSR) 2007, Defra has adopted an ‘ecosystems approach’ to underpin its policy on the natural environment. A key aspect of this is recognition and evaluation of the ecosystem services that natural environments provide, i.e. the benefits arising for people, either directly or indirectly (Defra, 2007\(^5^5\)).

Module 6 of CS2007 (‘Integrated Assessment’) is intended to provide an assessment of how ecological impacts of different pressures translate into effects on ecosystem services. Reports will be provided on the current state of the potential of natural resources to provide ecosystem services, and the effect of anthropogenic pressures on their provision.

The range of ecosystem services to be considered is derived from Haines-Young & Pochin (2007); these are grouped into four categories: cultural, provisioning, regulating and supporting. CS cannot provide information on all the services included within these categories, and a subset has been identified for further work. First priorities among this subset include:

- **Provisioning**
  - fibre,
  - freshwater,
  - genetic aspects,

- **regulating**
  - air quality,
  - buffering,
  - climate,
  - pests,
  - water flow regulation
  - water quality regulation

- **Supporting**
  - Nutrient cycling
  - Primary productivity

\(^5^4\)http://www2.defra.gov.uk/research/project_data/More.asp?l=CC0366&M=KWS&V=cc03&S UBMIT1=Search&SCOPE=0

The analysis will be set in the context of the conceptual DPSIR\textsuperscript{56} framework originally developed as a classification for indicators. The problem with this classification is that whilst conceptually clear, it is in practice often difficult to allocate a measure to one of the categories, partly because its position is dependent on the context.

Clearly agriculture is a major driver affecting the delivery of ecosystem services, as well as a beneficiary of such services (e.g. pollination, pest control). Pressures identified by CEH for further attention and which are affected by agricultural management include: atmospheric pollution, eutrophication, habitat change, inappropriate grazing, land drainage and management. The report of the stakeholder workshop held by CEH on 30 November 2007 listed the following as key drivers (sic – illustrating the dilemma referred to above!): eutrophication, acidification, nutrient pollution/sediment, habitat degradation, land management.

The potential for linking CS data to other datasets to aid interpretation of these drivers/pressures is briefly considered below.

5.2.8.1 Atmospheric pollution and eutrophication

Key atmospheric pollutants arising from agriculture include methane, ammonia and nitrous oxide; agriculture is responsible for around 40%, 90% and 60-70% of these emissions respectively. Methane and nitrous oxide are of major significance as greenhouse gases, but ammonia is important as an agent of eutrophication and acidification. A considerable amount of work has already been carried out linking CS data to nutrient deposition data (see section 2.7), and this will not be discussed further here.

In more intensively managed agricultural land, both inorganic fertilisers and organic manures fertilisers provide direct sources of nutrients. Firbank et al. (2007) used fertiliser rates along with crop areas and livestock numbers to calculate N surpluses, but do not give details on data sources or methods of calculation. The British Survey of Fertiliser Practice (BSFP) is can provide information on nutrient inputs from these sources (see section 4.1.9), whilst the Farm Practices Survey provides some contextual information on nutrient management. In 2007, questions on nutrient management related to types of nutrient management plan, methods for calculating fertiliser requirements, and methods of assessing the nutrient content of organic manures (Defra/National Statistics 2007). (Recommendation 25).

5.2.8.2 Habitat change

Habitat change is directly influenced by some form of agricultural management over around three quarters of the UK land surface. As well as maintaining biodiversity, habitats are important in supporting a range of ecosystem services such as pollination (by providing nest sites and season-long food resources for bees, food plants for lepidoptera larvae etc.), pest control (by providing over-wintering habitat for beetles, spiders and parasitoids, pollen/nectar for adult hoverflies etc.), buffering and water quality regulation etc. The indicator “Food resources for key species groups” (section 6.4.4) is relevant here.

Analysis of changes in agricultural land use data could be used to help interpret observed changes in land cover of broad habitats. Changes in features such as hedgerows could be set in a broader context by reference to aerial photographs, whilst changes in structure could be analysed in relation to agri-environment scheme data to determine the impact of agreement status on such changes (Recommendations 26, 27).

\textsuperscript{56} Driver, Pressure, State, Impact, Response.
5.2.8.3 Inappropriate grazing

Interpretation of changes in vegetation of grazed habitats, especially in the uplands, would be aided by good data on stocking rates at different times of year. Overgrazing damages habitats and may result in carbon loss through erosion and other processes, but undergrazing may also be detrimental to the maintenance of botanical communities and habitat quality (e.g. for nesting waders). See section 5.2.1 for further discussion of data sources. Natural England also collect data on condition for SSSIs which cover large areas of grazed uplands (Recommendation 18; see sections 4.1.5, 5.2.1).

5.2.8.4 Land drainage

Data on under drainage are not readily available other than by request from individual farmers or agents. For surface drainage, CS data provide a valuable source of information on streams, ditches and ponds (e.g. as used by Brown et al., 2006). Other potential sources with complete land coverage include OS Mastermap and aerial photos. The spatial mapping of CS squares could be used to ‘ground truth’ these datasets and provide a measure of their accuracy in representing watercourses of different types and sizes (Recommendation 28).

5.2.8.5 Management

Data on management practices such as pesticide and fertiliser use stratified by, for example, farm type (using the June survey), could be used to aid interpretation of driving forces behind observed changes in vegetation, and pollution of surface waters. The Farm Practices Survey may also provide useful information (see also section 3.7) (Recommendations 25 (see section 5.2.8.1), 29).
6. THE COUNTRYSIDE SURVEY AS A SOURCE OF DATA FOR POLICY INDICATORS

6.3 INTRODUCTION

The Countryside Survey is well suited as a source of data for policy indicators of plant community and habitat stock and change, though the infrequent nature of the surveys means that they are not suited to short-term monitoring. Instead, they provide ‘snapshots’ at intervals, which can be used to measure change over the previous period. As changes in habitats and plant communities usually occur relatively slowly, measurement at intervals is appropriate. However, occasionally large shifts can occur in managed habitats over a short timescale (e.g. the substantial reduction in area of set-aside at the end of 2007 resulting from an EU policy decision), and the CS is not well suited to monitoring the impacts of such changes (though in this instance fortunate timing means that the CS could provide some baseline data for future monitoring of the impact of set-aside withdrawal; see section 5.2.2.2.1).

Several indicators derived from the CS are used for policy purposes as components of larger indicator sets developed for the ACEO, the Sustainable Food and Farming Strategy (SFFS), England Biodiversity Strategy (EBS). These are listed in Table 6.1.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Indicator set(s)*</th>
<th>Items included</th>
<th>CS years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area of broad habitats in England and Wales</td>
<td>SFFS</td>
<td>Sea, unclassified, boundary &amp; linear, built-up &amp; gardens, sediment rock &amp; montane, rivers &amp; streams, open water &amp; canals, coniferous woodland, mixed woodland, calcareous grassland, bracken, fen marsh &amp; swamp, acid grassland, dwarf shrub heath, bog, neutral grassland, arable &amp; horticulture, improved grassland.</td>
<td>1998</td>
</tr>
<tr>
<td>Trends in plant diversity in fields and field margins</td>
<td>ACEO</td>
<td>arable fields, intensive grassland, fertile/herb rich grassland, hedge bottoms</td>
<td>1978</td>
</tr>
<tr>
<td></td>
<td>SFFS</td>
<td>infertile/herb rich grassland, hedge</td>
<td>1990</td>
</tr>
<tr>
<td></td>
<td>EBS</td>
<td>Therapy against &amp; herb rich streamsides</td>
<td>1998</td>
</tr>
<tr>
<td>Trends in plant diversity in river banks and stream sides in England</td>
<td>EBS</td>
<td>species richness, nutrient score in herb-rich streamsides</td>
<td>1978</td>
</tr>
<tr>
<td></td>
<td>EBS</td>
<td>all plants, ancient woodland indicators, nutrient score</td>
<td>1990</td>
</tr>
<tr>
<td>Trends in woodland plant diversity in England</td>
<td>EBS</td>
<td>hedges, remnant hedges, lines of trees, walls, banks/grass strips, lowland ponds</td>
<td>1990</td>
</tr>
</tbody>
</table>

ACEO = Agricultural Change and Environment Observatory
SFFS = Sustainable Food and Farming Strategy
EBS = England Biodiversity Strategy

However, the comprehensive nature of the habitat data collected in the CS sample squares, in combination with mapping of the habitats themselves, provides the
potential for detailed analysis of landscape patterns and relationships between habitats, and also potentially, signals of drivers of change. Here we consider the potential for development of additional policy indicators which could add to those listed above.

6.4 POTENTIAL NEW INDICATORS FROM CS2007

6.4.1 Habitat connectivity

Habitat connectivity is a key topic of interest in relation to the potential impacts of climate change. As climate envelopes move northward, organisms will need to extend their ranges northward in order to track climatic conditions suited to their ecology. For those organisms with specialised habitat requirements and limited dispersal ability, ‘corridors’ may be needed to allow movement to new habitat patches. An indicator of habitat connectivity is currently under development; the first phase of this work has been undertaken by the Forestry Commission with CEH. The inverse of connectivity could be termed habitat fragmentation.

6.4.2 Habitat diversity

Currently, several measures of plant species diversity are used as policy indicators (Table 6.1). However, for many organisms diversity of habitats at a range of scales, from within field to national and even international levels, is also important (Benton et al., 2003). As part of the intensification of agriculture that is generally cited as the main cause of losses in farmland biodiversity (e.g. Chamberlain et al. 2000; Donald et al., 2001; Stoate et al., 2001; Robinson & Sutherland 2002), specialisation and polarisation of agriculture in response to policy and market signals have resulted in increasing uniformity of habitats. Within farms, simplified rotations, and removal of field boundaries and non-cropped areas contribute to loss of heterogeneity, whilst within fields, mechanization, agrochemical use, drainage and irrigation, crop breeding, grassland improvement and increased duration and intensity of grazing are all important factors (Benton et al., 2003). Many organisms require access to a range of habitats to complete their life cycle, and within habitats, structural diversity may also be important. Diverse landscapes may also be important in maintaining ecosystem services such as pest regulation (e.g. Bianchi et al., 2006) and pollination, for example, bumblebee richness at the 10km² scales was positively correlated with land use heterogeneity, the proportion of grassland and the abundance and diversity of dicotyledonous flowers (Pywell et al., 2006).

Diversity in an agricultural context can be considered at a range of scales, from the increasing dominance of grassland in the west and arable farming in the east of England, to diversity at a regional or landscape scale (different types of farms in an area) through to diversity within farms (e.g. mixed farming). Even within farms, the ‘grain’ of landscape structure, as indicated by field or parcel size, can influence the nature of animal communities. Different organisms respond differently to landscape and management factors operating at different scales (e.g. Burel et al., 2004). The ACEO is currently developing an index of agricultural specialisation (the inverse of diversity) at holding, parish, county and regional levels (Clothier, 2008; see section 3.6.4.2.3). This will be a valuable step forward in understanding and monitoring changes in the agricultural landscape and their ecological implications. However, it is based on enterprise types derived from the June Agricultural Survey, so does not include non-agricultural habitats nor variation within categories (e.g. different agricultural crops, different types of grassland). The CS can provide information on habitats at a much finer scale, including both agricultural and non-agricultural,
intensively managed and semi-natural habitats. Development of one or more indices of habitat diversity would be a valuable addition to the outputs from CS2007, and could be back-casted to include data from the earlier surveys. It would also complement the indicator of connectivity referred to above in analyses of countryside change and their environmental impacts.

Among the issues that would need to be considered in the development of such an indicator might be the following:

- How does the 1km$^2$ scale of CS surveying impact on the development of the indicator and how does this limit what can be achieved?
- At what scales could such an index be reported and what stratification(s) would be appropriate?
- How can features (e.g. field boundaries) and areal habitats be combined in an aggregate index?
- Should a disaggregated series of indices be developed, e.g. parcel size, hedgerow length, crop diversity, semi-natural habitat diversity etc.?

It would also be possible to develop a land cover diversity index from the LCM. This would cover the whole country and would be amenable to stratification at a range of scales, but differences in methodology from previous LCMs mean that analysis of trends would not be possible except in very general terms (Recommendation 30).

### 6.4.3 Additional measures of species diversity

Measures of diversity currently used as indicators are all based on species richness within certain habitats, and are measures of alpha-diversity. Measures of beta diversity (species diversity between habitats/ecosystems); and gamma diversity (overall or pooled diversity for different ecosystems within a region) are also possible and could give additional insights into changes resulting from agricultural and other drivers. For example, beta-diversity could be used to measure changes in the heterogeneity of habitats, as an indicator of the extent to which the vegetation of habitats is becoming more (or less) uniform (Recommendation 31).

Plant diversity in field margins/hedge bottoms is a component of the current indicator “Trends in plant diversity in fields and field margins”. It is suggested that this could usefully be disaggregated into cross-compliance margins (i.e. within 2m of the centre of a hedge or watercourse, or 1m of the top of a watercourse bank), margins managed under Environmental Stewardship or other agri-environment schemes, and others. Ideally, Environmental Stewardship margins would be allocated to option, but this would entail digitising agreement maps, which would be a substantial commitment though achievable given the necessary resources (Recommendation 32).

Currently, plant species diversity indicators are generally related to lowland habitats. Consideration could be given to developing similar indicators for key upland habitats. Large scale changes in upland vegetation are predicted in response to changes in grazing pressure resulting from adjustments to subsidy payments arising from the recent CAP reform (Gaskell et al., 2007), and developing appropriate indicators of such changes could therefore pay dividends over the period between CS2007 and the next Countryside Survey (Recommendation 33).

### 6.4.4 Food resources for key species groups

Changes in the population status of farmland species may be related to changes in habitat availability or quality, or the abundance/accessibility of food resources, or a combination of these factors. There are many examples of relationships between
population change and food availability, for example woodpigeons declined when the area of clover-rich leys reduced, but increased again in response to the growth in the area of oilseed rape (Inglis et al., 1990, 1997).

Smart et al. (2000) reported changes in the abundance of food plants for butterfly larvae and farmland birds between 1978 and 1990. These groups are of conservation interest because of declines exhibited by many species, but also because they are the subjects of policy indicators (e.g. ACEO, EBS) and targets (e.g. the Government’s Public Service Agreement (PSA)). Few significant associations were found between changes in populations and their food plants, but this may reflect differences in the degree of dependence of the species concerned on the range of food plants recorded. A considerable amount of research has been conducted on the ecology of farmland birds in particular since this paper was written, and further analysis in the light of new evidence might allow a more informed section of food plant species to be made.

Changes in abundance of bird, butterfly and bee food plant were also reported for CS2000 and will be reported for CS2007. The FOCUS report for question 3 (Firbank & Smart 2003, see also Firbank & Smart 2002) highlighted the continuing decline in two key food plants of birds: Polygonum aviculare and Stellaria media, though some others had stabilised (e.g. Poa annua) or increased (e.g. Cirsium arvense). Reduced availability of floral resources is widely believed to be the major cause of declines in bumblebee populations. Both bumblebees and butterflies are providers of pollination services.

An indicator based on food plant abundance for one or more of these groups could be a useful indication of the impact of land management changes on key resources, and provide evidence to interpret mechanisms underlying changes in abundance and distribution of these groups. However, if such an indicator were to achieve its full potential, confidence would first need to be established that the plants included were not only consumed, but were important to the reproduction and/or survival of the species concerned, and hence likely to have a limiting effect on their populations (Recommendation 34).

### 6.4.5 Eutrophication

As well as indicators of stock/state and change, indicators of drivers of change are also important, where their roles are sufficiently well established and adequate data are available. Much research using CS data has been carried out on the effects of eutrophication on vegetation of less intensively managed agricultural habitats (see section 2.7). Most of this research has used Ellenberg N values for plant species as a measure of habitat eutrophication, and mean Ellenberg value was used by Firbank et al. (2007) as an indicator of eutrophication. Firbank et al. also attempted to separate direct inputs from agriculture and atmospheric deposition of N from other sources. Attribution of sources is valuable as an aid to interpretation and in order to inform policy options for mitigation. The precise methods used to calculate N surplus from the ELPEN model quoted by Firbank et al. are not elaborated in the documentation available (Wright et al., 1999), but the software is available to download; alternatively another model could be used, or a new one developed, using for example a combination of fertiliser application data (BSFP), crop areas and livestock densities (June Survey/CTS) and organic manure management practices (BSFP/FPS).

The importance of eutrophication as a driver of vegetation change has now been well established, and its adoption as an indicator of agricultural impacts (in conjunction

57 http://www.macaulay.ac.uk/elpen/index1.htm
with measures of agricultural and non-agricultural N outputs) could be a useful indicator (Recommendation 35).

6.4.6 Soil attributes

Soil attributes are important both as measures of environmental health and agricultural fertility. In the ACEO Environmental Monitoring baseline project (Boatman et al., 2006), a suite of indicators for soil was identified as a major gap in the ACEO monitoring framework, but rather than propose interim indicators it was suggested that selection should await the outcome of the UK Soil Indicators Consortium (UKSIC) work programme. It was proposed that organic carbon, total N, extractable P, and heavy metals would be useful indicators for the Observatory as long-term indicators of the state of soils relevant to environmental impact, and as a minimum, organic carbon, total N and extractable P should be included. In addition, bulk density provides a measure of soil compaction and could be useful as one measure of the likelihood of water runoff and erosion.

Soil organic matter for 1978-83 and 1994-2003, and phosphorus in topsoil for 1979 and 1995 are used as indicators by the SFFS (data derived from the National Soil Inventory). Soil phosphate is included in the ACEO indicator list but data are not currently provided.

UKSIC is still developing the soil indicator and monitoring framework, though some interim results have been produced58. Clearly CS is an important source of information on a range of soil attributes and could potentially contribute to such a framework (Recommendation 36).

7. FURTHER RESEARCH AND DEVELOPMENT

Recommendations are given below for further work. The list is numbered in order of appearance in the forgoing text, with cross-references to relevant sections, and includes recommendations for new data collection where appropriate. A priority ranking is also given, but it is emphasized that this is subjective; priorities need to be viewed in relation to evolving policy frameworks, and therefore each proposal should be considered in relation to current requirements.

The priority ranking is as follows:

**Priority 1**: Considered to be of high value and/or urgent. Should be considered immediately. Where a recommendation is awarded priority 1 status, the rationale is stated.

**Priority 2**: A potentially valuable piece of research or research approach but not critical or immediately urgent.

**Priority 3**: Additional useful studies worth considering but of lower priority or urgency, though this may change in the light of evolving policy requirements.

7.1 LIST OF RECOMMENDATIONS

7.1.1 Carried forward from previous research reports

1. Study to determine how well CS samples different aspects of the countryside in relation to socio-economic criteria (sections 2.5.2; 2.5.4). (Priority 3).

2. Repeat survey of farm structures and practices as carried out in “Processes of Countryside Change”, but with greatly refined measures of ‘environmental stock’, and recording of management on a per field basis in much greater detail (e.g. levels of pesticide and fertiliser use) (sections 2.5.3.1; 2.5.4). It should also include the collection of data on management of hedgerows and dwarf upland vegetation (see section 2.6.2.2). Such an exercise would greatly improve the ability to interpret CS data in relation to agricultural management, and would also provide a basis for scaling up using other survey data (see chapter 4). However, if it is to be carried out as an aid to the interpretation of CS2007, it needs to be carried out as soon as possible. Accordingly, this recommendation is given a high priority. (Priority 1).

3. The sampling structure of the Countryside Survey is not well suited to monitoring any but the commonest arable plants. A national arable plant survey to complement the Countryside Survey was recommended by Firbank (1999) and this recommendation was reiterated in the report of FOCUS Question 3 (Barr et al., 2003). The lack of data on weed population trends was also highlighted as a key data gap by Boatman et al. (2006). There is a strong case for developing a national arable plant survey (see Firbank, 1999 and Boatman et al. 2006 for further discussion). A scoping study investigating the potential design of such a survey is currently in progress. (Priority 2).

4. The need for data on deposition of atmospheric pollutants (especially ammonia) at a higher spatial resolution is highlighted in a number of CS reports e.g. FOCUS, see section 2.6.2.2). Consideration should be given to whether and how this might be provided. (Priority 2).
7.1.2 Data linkage, manipulation and stratification

5. Develop an appropriate aggregation of JCAs into ‘landscape types’ for stratifying CS data for analyses relating to agricultural landscapes, possibly based on that of Swanwick et al (2007) (section 3.6.3.1). In view of its potential wide applicability in analysing a range of datasets, this proposal should be given high priority. (Priority 1).

6. Consider the value of the agricultural land classification as a surrogate for intensity of land management (possibly in combination with other datasets indicating components of intensification) for analyses of CS data in relation to agricultural intensification as a determinant of vegetation, soil characteristics and water quality (section 3.6.4.1). (Priority 2).

7. Investigate the potential to develop classifications of agricultural land use based on farm level data, suitable for use in integrated analyses with CS data (section 3.6.4.2.2). Such classifications could also form the basis for an economic stratification, through links to the Farm Business Survey. This approach is central to the concept of integrating CS and agricultural data, and so is accorded high priority. (Priority 1).

8. Analyse CS data in relation to the ACEO specialisation/diversity indices (section 3.6.4.2.3). Investigate relationships with measures of habitat diversity. (Priority 2).

9. Consider the possibility of a repeat of the Processes of Countryside Change study of the motivations of managers of land in CS squares, linked to the repeat survey of farm structures and practices specified under recommendation 2. Investigate the applicability of published farm decision making typologies to interpretation of the results (section 3.6.4.3). (Priority 2).

10. Consider the value of further research on links between behavioural types and farm types, spatial locations etc., to aid interpretation of change data in terms of management practices (section 3.6.4.3). (Priority 2).

11. Investigate the potential value of relating resource use as measured by LCA output data, (such as that produced by Williams et al. (2006)) to CS measures of habitat stock/change and vegetation characteristics, through linkage to agricultural statistics to identify enterprises (section 3.6.4.4). (Priority 2).

12. Investigate the potential for linking CS pond data to the survey data from the National Pond Monitoring Network (section 3.6.4.5). (Priority 2).

13. Consider the need for collection of further data on the characteristics of ditches on agricultural land (section 3.6.4.5). (Priority 3).


15. Investigate the development of web-enabled statistical tools to provide optimal stratifications for specific analyses (section 3.6.4.6) (Priority 2).

16. Consider stratifying CS square data by the following agriculturally orientated classifications for web-based data access provision: Agricultural Land Classification, dominant farm type, index of specialisation, aquatic landscape classification (section 3.6.4.7). This is a high priority in view of the short timescale before data release. (Priority 1).

17. Investigate potential options for stratifying data on farm practices for linking to CS data (section 3.7.3). (Priority 2).
18. Investigate the potential for use of livestock identification and movement data to provide information on grazing pressures (section 4.1.5, 5.2.1). (Priority 2).

7.1.3 Key policy issues

19. Identify set-aside fields in CS squares and analyse botanical composition in relation to soil attributes and (where possible) vegetation in adjacent habitats (section 5.2.2.2.1). This should take high priority in view of the pressing need for evidence on the value of set-aside to inform decision-making on the need for mitigation of any adverse effects arising from its abolition. (Priority 1).

20. Digitise ES agreement data in CS sample squares, including agreements entered during or shortly after the field survey, for which CS data could provide a baseline assessment (section 5.2.3). In order to allow analyses to proceed as soon as possible and provide evidence for the ES evaluation programme, it is suggested that this should be given high priority. (Priority 1).

21. Analyse field boundary herbaceous vegetation plots for farms eligible and not eligible for SPS payments, to determine the effect of cross-compliance condition GAEC 14. Compare fields greater and less than 2ha in size (the threshold above which GAEC 14 provisions are mandatory to SP recipients (section 5.2.4.2). In view of the current government and stakeholder interest in the impacts of cross-compliance, both at national and EU level, and the stated intention of the European Commission to review cross-compliance as part of the CAP Healthcheck, this should be accorded high priority. (Priority 1).

22. Consider the production of a high resolution UK HNV farmland map to complement the European map, as an aid to the implementation of policy at national level (section 5.2.5). This must await agreement on the definition of HNV farmland, which is still under discussion at the time of writing. (Priority 2).

23. Investigate the potential of LCM2007 as a source of information for the next CQC assessment. (Priority 3).


7.1.4 Integrated assessment module (Ecosystems Services)

25. Investigate the value of the BSFP as a source of data on nutrient inputs as contributors to the ecosystem services ‘nutrient cycling’ and ‘primary productivity’, and as sources of pollution/eutrophication, (section 5.2.8.1, see also section 2.6.2.1.2). This could contribute to CS2007 module 6 (integrated assessment), and so it should be given high priority. (Priority 1).

26. Develop methodology for use of aerial photographs to extend estimates of stock and change hedgerows, field margins etc, both spatially and temporally, using CS data to validate estimates in CS sample squares. (Priority 2).

27. Investigate impact of agri-environment schemes in providing habitats and resources for pollinators and natural enemies of pests, and buffering of other habitats, by linking quadrat data to ES agreement maps. This has direct relevance both to the integrated assessment module and evaluation of ES, and so is considered to be a high priority. (Priority 1).
28. Investigate the potential for use of OS Mastermap and aerial photos to estimate location and lengths of surface drainage ditches by comparison with CS mapped squares. (Priority 2).

29. Investigate the potential for using Pesticide Usage Survey data as a source of information for analysis of the impact of herbicide use as an agent of vegetation change, and impacts of pesticide application on surface water pollution (see also related recommendations 17 and 25). Herbicide use is a potentially important influence on vegetation of grasslands and non-crop areas adjacent to arable fields, that could have significant impacts on ecosystem services, but has not hitherto been investigated in studies of CS data, so this is considered to be a high priority. (Priority 1).

7.1.5 Potential new indicators from CS2007.

30. Investigate the potential for development of one or more indicators of habitat diversity from CS data. (Priority 2).

31. Consider developing indicators of beta and gamma diversity for plant species. (Priority 2).

32. Disaggregate indicator for “Trends in plant diversity in fields and field margins” into cross-compliance margins, Environmental Stewardship margins, and others. In view of the high policy interest in the impacts of cross-compliance and ES, this is considered to be a high priority. (Priority 1).

33. Develop plant species diversity indicators for key upland habitats. As significant changes are predicted to occur in upland vegetation as a result of changes in grazing pressure over the next few years, this should be accorded high priority. (Priority 1).

34. Carry out a systematic review of literature on the importance of food plants in limiting populations of birds, butterflies and bumblebees, with the eventual aim of developing one or more indicators based on selected food plants if the evidence justifies it. In view of the importance of birds as indicators of biodiversity, and of butterflies and bumblebees in the provision of pollination services as well as groups of conservation importance, this recommendation should be given high priority. (Priority 1).

35. Develop one or more indicators of eutrophication based on Ellenberg N values for different habitats, supplemented if possible by indicators of the relative contribution of agricultural and non-agricultural sources to eutrophication. This should be given high priority as a platform for wider communication of the large amount of research already carried out on this issue. (Priority 1).

36. Ensure that CS results continue to feed into the work of the UKSIC, and that the potential of CS data as a source of evidence for indicators of soil attributes is fully realised. This should be a high priority, as the CS is a key source of information on soil properties. (Priority 1).
REFERENCES


Wright, I. *et al.* (1999). A protocol for building the ELPEN livestock policy decision support system. MLURI, Scotland, 37pp. available at: [http://www.macaulay.ac.uk/elpen/index1.htm](http://www.macaulay.ac.uk/elpen/index1.htm)
### APPENDIX 1: LIST OF ABBREVIATIONS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
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<tbody>
<tr>
<td>ACEO</td>
<td>Agricultural Change and Environment Observatory</td>
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<td>BAP</td>
<td>Biodiversity Action Plan</td>
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<tr>
<td>BCMS</td>
<td>British Cattle Movement Service</td>
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<td>BRC</td>
<td>Biological Records Centre</td>
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<tr>
<td>BSFP</td>
<td>British Survey of Fertiliser Practice</td>
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<tr>
<td>CAP</td>
<td>Common Agricultural Policy</td>
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<tr>
<td>CEH</td>
<td>Centre for Ecology and Hydrology</td>
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<tr>
<td>CQC</td>
<td>Countryside Quality Counts</td>
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<tr>
<td>CS</td>
<td>Countryside Survey</td>
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<tr>
<td>CS1990</td>
<td>Countryside Survey 1990</td>
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<tr>
<td>CS2000</td>
<td>Countryside Survey 2000 (field work conducted in 1998)</td>
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<td>CS2007</td>
<td>Countryside Survey 2007</td>
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<tr>
<td>CSEZ</td>
<td>Countryside Survey Environmental Zone</td>
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<tr>
<td>CSS</td>
<td>Countryside Stewardship Scheme</td>
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<tr>
<td>CTS</td>
<td>Cattle Tracing Scheme</td>
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<tr>
<td>CVS</td>
<td>Countryside Vegetation System</td>
</tr>
<tr>
<td>DETR</td>
<td>(the former) Department of the Environment, Transport and the Regions</td>
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<tr>
<td>EBS</td>
<td>England Biodiversity Strategy</td>
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<tr>
<td>EEA</td>
<td>European Environment Agency</td>
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<tr>
<td>ELS</td>
<td>Entry Level Stewardship</td>
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<tr>
<td>EO</td>
<td>Earth Observation</td>
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<tr>
<td>ES</td>
<td>Environmental Stewardship</td>
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<tr>
<td>ESDS</td>
<td>Economic and Social Data Service</td>
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<tr>
<td>EU</td>
<td>European Union</td>
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<tr>
<td>ESA</td>
<td>Environmentally Sensitive Area</td>
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<tr>
<td>FADN</td>
<td>Farm Accountancy Data Network</td>
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<tr>
<td>FBS</td>
<td>Farm Business Survey</td>
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<tr>
<td>FC</td>
<td>Forestry Commission</td>
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<tr>
<td>FOCUS</td>
<td>Finding Out Causes and Understanding Significance</td>
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<td>FPS</td>
<td>Farm Practices Survey</td>
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<tr>
<td>GA</td>
<td>Genetic Algorithm</td>
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<tr>
<td>GAEC</td>
<td>Good Agricultural and Environmental Condition</td>
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<tr>
<td>GIS</td>
<td>Geographical Information System</td>
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<tr>
<td>GLUD</td>
<td>Generalised Land Use Database</td>
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<tr>
<td>HAP</td>
<td>Habitat Action Plan</td>
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<tr>
<td>HLS</td>
<td>Higher Level Stewardship</td>
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<tr>
<td>HNV</td>
<td>High Nature Value (farmland)</td>
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<tr>
<td>IACS</td>
<td>Integrated Administration and Control System</td>
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<tr>
<td>IBD</td>
<td>Indicator of Botanical Diversity</td>
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<tr>
<td>ITE</td>
<td>Institute of Terrestrial Ecology (forerunner of CEH)</td>
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<tr>
<td>JRC</td>
<td>European Commission Joint Research Centre</td>
</tr>
<tr>
<td>LCM</td>
<td>Land Cover Map</td>
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<tr>
<td>LFA</td>
<td>Less Favoured Area</td>
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<tr>
<td>LUCAS</td>
<td>Land Use/Cover Area frame Survey</td>
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<tr>
<td>NBN</td>
<td>National Biodiversity Network</td>
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<tr>
<td>OELS</td>
<td>Organic Entry Level Stewardship</td>
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<td>ONS</td>
<td>Office of National Statistics</td>
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<tr>
<td>OS</td>
<td>Ordnance Survey</td>
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<tr>
<td>PCC</td>
<td>Processes of Countryside Change</td>
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<td>PSA</td>
<td>Public Service Agreement</td>
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<tr>
<td>PUS</td>
<td>Pesticides Usage Survey</td>
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<td>RELU</td>
<td>Rural Economy and Land Use</td>
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<tr>
<td>RLR</td>
<td>Rural Land Register</td>
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<tr>
<td>RPA</td>
<td>Rural Payments Agency</td>
</tr>
<tr>
<td>SFFS</td>
<td>Sustainable Food &amp; Farming Strategy</td>
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<tr>
<td>SGM</td>
<td>Standard Gross Margin</td>
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<tr>
<td>SLA</td>
<td>Specific Leaf Area</td>
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<tr>
<td>Acronym</td>
<td>Description</td>
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<tr>
<td>SMR</td>
<td>Statutory Management Requirements</td>
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<tr>
<td>SPIRE</td>
<td>Shared Spatial Information Repository</td>
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<tr>
<td>SPS</td>
<td>Single Payment Scheme</td>
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<tr>
<td>SSR</td>
<td>Standard Statistical Region</td>
</tr>
<tr>
<td>UAA</td>
<td>Utilisable Agricultural Area</td>
</tr>
<tr>
<td>UKCIP</td>
<td>UK Climate Impacts Programme</td>
</tr>
<tr>
<td>UKSIC</td>
<td>UK Soil Indicators Consortium</td>
</tr>
<tr>
<td>VML</td>
<td>Virtual Microdata Laboratory</td>
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</table>
APPENDIX 2: INDICATORS OF BOTANICAL DIVERSITY AND DRIVING FORCES ANALYSED IN “CAUSES OF CHANGE IN BRITISH VEGETATION” (Firbank et al., 2000)

Indicators of Botanical Diversity
(for full description, see Firbank et al., 2000, box 11, pp. 61-62)

1. Aggregate classes
2. CVS classes
3. Change in representation of functional attributes
4. CVS classes unique to 1 plot type per 1 km square
5. Species richness per plot
6. Ellenberg scores by plot
7. Frequency of species groups
8. Frequency of aggregate class preferential species
10. Frequency of food plants for animal groups
11. Frequency of scarce species and NVC categories
12. CVS classes per 1 km square

Driving Forces
These are listed in Table A2.1 below.
Table A2.1 Description of driving forces acting upon botanical diversity (from Firbank et al. 2000). Drivers less related to agriculture are in grey.

<table>
<thead>
<tr>
<th>Driving Force</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Eutrophication</strong></td>
<td>The increased inputs of nitrogen and other nutrients</td>
</tr>
<tr>
<td>Atmospheric deposition</td>
<td>Areal deposition, especially from power stations and road transport emissions</td>
</tr>
<tr>
<td>Agricultural fertilisers</td>
<td>Use of fertilisers on agricultural land, especially nitrogen</td>
</tr>
<tr>
<td>Waterside eutrophication</td>
<td>Increased trophic status of catchment waters and watersides</td>
</tr>
<tr>
<td><strong>2. Acidification</strong></td>
<td>Deposition of sulphur dioxide and nitrous oxides</td>
</tr>
<tr>
<td><strong>3. Urbanisation and transport</strong></td>
<td>The loss and fragmentation of land parcels to urban and infrastructure land covers</td>
</tr>
<tr>
<td>Road verge management</td>
<td>Impacts on transport routes; lack of management, increased disturbance, eutrophication</td>
</tr>
<tr>
<td><strong>4. Leisure</strong></td>
<td>Trampling, disturbance, changes in land use associated with leisure</td>
</tr>
<tr>
<td>Trampling, disturbance</td>
<td>Disturbance linked to walking and leisure activities largely in upland GB</td>
</tr>
<tr>
<td>Heather management</td>
<td>Moorland management for grouse shooting</td>
</tr>
<tr>
<td><strong>5. Agricultural intensification</strong></td>
<td>The increase in the level of inputs per unit area</td>
</tr>
<tr>
<td>Crop management &amp; pesticide use</td>
<td>Cropping systems, cultivation practices and use of agrochemicals</td>
</tr>
<tr>
<td>Grassland cultivation</td>
<td>The conversion of grasslands and other semi-natural habitats to arable crops</td>
</tr>
<tr>
<td>Grassland management</td>
<td>Changes in fodder production, grazing regime and use of agrochemicals</td>
</tr>
<tr>
<td>Upland sheep grazing</td>
<td>Changes in stocking density</td>
</tr>
<tr>
<td><strong>6. Drainage</strong></td>
<td>Ditches, tile drains / plastic drains in vegetation associated with wet soils</td>
</tr>
<tr>
<td>Waterside management</td>
<td>Disturbance and dereliction of watersides, water abstraction</td>
</tr>
<tr>
<td><strong>7. Agricultural extensification</strong></td>
<td>Transfers from intensive to less intensive agriculture</td>
</tr>
<tr>
<td>Lack of cultivation</td>
<td>Including set-aside and former arable land managed for environmental benefit</td>
</tr>
<tr>
<td>Biodiversity enhancement</td>
<td>Use of practices designed to encourage wildlife, (eg habitat restoration, conservation headlands, managed productivity reductions)</td>
</tr>
<tr>
<td><strong>8. Land abandonment</strong></td>
<td>Transfers from agricultural to scrub, excludes afforestation</td>
</tr>
<tr>
<td><strong>9. Forest management</strong></td>
<td>Changes in the cover of forest land and management of its canopy including hedgerows</td>
</tr>
<tr>
<td>Broadleaved planting</td>
<td>Changes in land use and canopy closure</td>
</tr>
<tr>
<td>Broadleaved management</td>
<td>Thinning, clearfelling, coppicing, ride management, grazing, neglect</td>
</tr>
<tr>
<td>Conifer planting</td>
<td>Changes in land use and canopy closure</td>
</tr>
<tr>
<td>Conifer management</td>
<td>Thinning and clearfelling</td>
</tr>
<tr>
<td>Hedgerow management</td>
<td>Trimming, removal, lack of management leading to change of feature into line of trees/scrub</td>
</tr>
<tr>
<td><strong>10. Climate change</strong></td>
<td>A modelled effect of increasing levels of certain gases due to human activity</td>
</tr>
</tbody>
</table>
### APPENDIX 3: SUMMARY OF RECOMMENDATIONS FOR FURTHER WORK ON ANALYSIS OF AGRICULTURAL DRIVERS USING CS2000 DATA (reproduced from ‘Drivers of Countryside Change’ final report)

<table>
<thead>
<tr>
<th>Process or Driver</th>
<th>Recommended Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Consolidation:</strong> What effects does the trend towards fewer, larger farms have for the environment?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Extend analysis of district level June Census data (1988-97) for holding number, size and mean size to Wales and Scotland.</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Polarisation &amp; Specialisation:</strong> To what extent are the regional/zonal patterns in farming observed during the 1980s being maintained and what are the environmental consequences?</td>
<td>The analysis in the shifts between major agricultural cover types and changes in diversity of cover and vegetation types within the farmed landscape by SSR and CSEZ using CS1990 and CS2000. Is the structure of the farmed landscape becoming more or less similar between regions and CSEZ post 1990? How does environmental stock change by 1993 PCC typology?</td>
</tr>
</tbody>
</table>

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| **Diversification** | Analysis of recent census data on diversification by SSR and CSEZ. Extend analysis of ‘local economy’ by using data such as *EC Farm Structures Survey*, *Annual Employment Survey*, *Labour Force Survey*, and *ONS classification of local authority districts*. | Use follow-up to PCC to determine extent of off-farm diversification by PCC typology and EU Farm Type.  
How have different types of enterprise responded to changed economic circumstances via diversification? What role does off-farm income have in triggering/preventing land cover change? What is the impact of part-time working on levels of ‘environmental management’? |
<p>| <strong>Management Intensity</strong> | Extend FBS analysis of <em>fertiliser and pesticide</em> inputs using other data sources (e.g. Survey of Fertiliser Use). Attempt regional disaggregation and use levels by farm type | Expectation: little change in impacts of fertiliser and pesticide use. Analysis of the relationship between changes in relevant IBDs within the farmed landscape by SSR and CSEZ. Extend CS2000 IBD system to formally include measures of biological condition of freshwaters. Disaggregate by SSR and CSEZ to examine response in relation to character of farmed landscape. Use follow-up to PCC to determine changing use of fertilisers and pesticides. |
| <strong>Grazing intensity</strong> | Expectation: Little overall change, but developing regional contrasts. Analysis of the relationship between changes in relevant IBD scores by SSR, CSEZ and especially LFA/non-LFA areas. | Use follow-up to PCC to examine changes in intensity of pasture management |
| <strong>Other aspects of farm management</strong> | There are other aspects of farm management not captured by JC and FBS – direct analysis using CS2000? | Extend CS2000 system of IBDs to develop composite agricultural intensification index; disaggregate by SSR and CSEZ. Index should include information on level and quality of environmental stock. Use PCC follow-up to assess how farm types have responded generally to economic changes via intensification of on-farm operations. |</p>
<table>
<thead>
<tr>
<th>Environmental practice/policy</th>
<th>Extend regional analysis of JC data for LFA/non-LFA districts to include ESA/non-ESA districts.</th>
<th>Comparison of stock and quality change in ‘policy-on’ vs ‘policy off’ situations. Will require access to MAFF Countryside Stewardship and ESA monitoring data. Exploitation of CS2000 as contextual data for agri-environmental monitoring</th>
<th>Use PCC follow-up to look at take up of environmental advice/information, levels of environmental awareness and response agri-environmental schemes by farm types.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Use CS2000 results to define environmental potential and/or targets for farmed landscape.</td>
<td>Use PCC follow-up to develop ‘sustainability profiles’ of farm managers and farm enterprises and relationships between profiles and 1993 PCC farm typology and change 1990-98.</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX 4 METHODS FOR DATA MANIPULATION

Interpolation and statistical estimation of gaps

Interpolation is defined in the ESRI GIS dictionary online\(^{59}\) as “The estimation of surface values at un-sampled points based on known surface values of surrounding points”. The output is usually a raster surface, thus a variety of interpolation methods exist that may be suitable to output an interpolation of point data to a raster surface that matches the CS2007 1km grid (Table A.1).

It is not possible to use interpolation to map CS2007 data across a broader area, as the data are influenced by other factors and do not vary according to space alone. The limited coverage of the UK means that data points are not close enough to one another to assume that there is a smooth spatial gradient between them. For example, the number of trees surveyed is likely to be due to land use. Therefore, even though the number of trees from CS2007 data could be interpolated across the landscape, the result is not likely to be accurate, as there is unlikely to be a smooth spatial gradient in reality but sharp transitions as land use changes. There are not enough data points in the CS2007 dataset to give enough information at the scale at which transitions are likely to occur for interpolation to be accurate.

Interpolation is therefore only likely to be useful if there are datasets that may correspond to CS2007 that have complete UK coverage as point data (i.e. a data point for at least every 1km). An example may be the LUCAS dataset. Formerly this consisted of 774 primary sampling units (PSUs) in the UK, each comprising ten secondary sampling units (SSUs) in a grid covering 1.5km x 0.6km (0.9 km\(^2\)). The methodology has been revised to operate from a 1km grid, from which a master sample on a 2m grid will be used for the survey. Points on the 2m grid will be stratified using photo-interpretation, and 25% will be surveyed in the field, corresponding to a sample of approximately 19,500 survey points within the UK.

A variant of the interpolation approach is to use modelling approaches to predict occurrence/amounts of habitats or features in unsampled areas. For example, establishing a correlation between hedgerows and total boundary length could allow hedgerow length to be predicted from unsampled squares using, for example, Mastermap.

Matching up datasets and stratification

Some points or grid cells from a dataset may directly match CS2007 data. This would mean it is straightforward to compare the two datasets.

Another possibility would be to either stratify other datasets by an intermediary dataset (such as land cover or land use) so that it may correspond with CS2007 cells, or to stratify CS2007 itself by such an intermediary dataset.

It may also be possible for a few datasets to match up an attribute so that a point dataset may be converted to a polygon/raster. An example is work done at CSL with the IACS and RLR datasets (see also section 4.3.1.2). The area of each crop group for each land parcel from IACS was linked to the matching RLR polygon, using the unique land parcel identifier in both datasets.

\(^{59}\) http://support.esri.com
Table A.1: Interpolation methods available in ArcGIS (information taken from ESRI documentation).

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Topo to Raster</td>
<td>Interpolates a hydrologically correct surface from point, line, and polygon data.</td>
</tr>
<tr>
<td>Trend</td>
<td>Fits a polynomial surface by linear or logistic regression through sample data points. This method results in a surface that minimizes the variance of the surface in relation to the input values. The resulting surface rarely goes through the sample data points. This is the simplest method for describing large variations, but the trend surface is susceptible to outliers in the data. Trend surface analysis is used to find general tendencies of the sample data, rather than to model a surface precisely. Uses either (1) linear regression: polynomial regression to fit a least-squares surface to the set of input points for continuous data or (2) logistic regression: a trend surface analysis that generates a continuous probability surface for binary, or dichotomous, types of data.</td>
</tr>
<tr>
<td>Minimum Curvature</td>
<td>Raster cell values are estimated using a mathematical function that minimizes overall surface curvature, resulting in a smooth surface that passes exactly through the input points. Spline types may be (1) regularized: yields a smooth surface and smooth first derivatives or (2) tension: tunes the stiffness of the interpolant according to the character of the modelled phenomenon. This includes weighting options and ability to set the number of nearest input sample points to be used to perform interpolation.</td>
</tr>
<tr>
<td>Spline technique</td>
<td></td>
</tr>
<tr>
<td>Natural Neighbour</td>
<td>An interpolation method for multivariate data in a Delaunay triangulation. The value for an interpolation point is estimated using weighted values of the closest surrounding points in the triangulation. These points, the natural neighbours, are the ones the interpolation point would connect to if inserted into the triangulation.</td>
</tr>
<tr>
<td>Kriging</td>
<td>The surrounding measured values are weighted to derive a predicted value for an unmeasured location. Weights are based on the distance between the measured points, the prediction locations, and the overall spatial arrangement among the measured points. Kriging is unique among the interpolation methods in that it provides an easy method for characterizing the variance, or the precision, of predictions. Kriging is based on regionalized variable theory, which assumes that the spatial variation in the data being modelled is homogeneous across the surface. Kriging methods in ArcGIS have the option of Ordinary or Universal. If the Ordinary method is selected, Semivariogram properties for the model may be spherical, circular, exponential, gaussian or linear. If the Universal method is selected, Semivariogram properties for the selected model may be linear with linear drift, or linear with quadratic drift. The search radius (defines which surrounding points will be used to control the raster) may be variable or fixed. If variable, options are available to set the number and maximum distance of input points to perform the interpolation. Thus, an integer value may be specified to set the number of nearest input sample points to be used to perform interpolation and a distance in map units is used by which to limit the search for the nearest input sample points. If the search radius is fixed, a distance is specified where all points within that distance are used to perform the interpolation and a minimum number of points is specified with which to perform the interpolation. If the required number of points is not found then the radius is increased.</td>
</tr>
<tr>
<td>Inverse distance</td>
<td>Sample points are weighted so that the farther a sampled point is from the raster cell being evaluated, the less weight it has in the calculation of the cell's value. The exponent of distance may be set, which controls the significance of surrounding points on the interpolated value. A higher power results in less influence from distant points. It can be any real number greater than zero, but is usually values between 0.5 and 3 (default is 2). As with Kriging, the search radius may be variable or fixed. In addition, a barrier polyline feature may be used as a break or limit in searching for the input sample points.</td>
</tr>
<tr>
<td>weighted (IDW)</td>
<td></td>
</tr>
</tbody>
</table>
Cropping maps were generated based on 1km OS grid squares. Therefore, the RLR land parcels were intersected with, and summarised by, the OS 1km grid as illustrated in Figure A.1. Before intersection of a single field, each crop-group was assumed to be uniformly distributed across the field, and a crop-group density value was calculated on the basis of the relative area of each crop within the field. After intersection, the area of each field segment was then multiplied by the crop-group density for that field to get the area of crop-group within that field segment. The area of each crop-group was then summed by OS 1km square. This is simply a form of categorical disaggregation (see 60).

**Figure A.1** Summarising crop areas by OS 1km square (Boatman *et al*, 200660).

(a) Field segmentation

![Field segmentation diagram]

(b) Data Processing

<table>
<thead>
<tr>
<th>Field</th>
<th>Field Area</th>
<th>Crop</th>
<th>Crop Area</th>
<th>Field Segment</th>
<th>Field Segment Area</th>
<th>Crop Area in Field Segment as Proportion of Field Area</th>
<th>Map Square</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3</td>
<td>BA1</td>
<td>2</td>
<td>1a</td>
<td>0.5</td>
<td>BA1 0.33 SK4622</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>WH1</td>
<td>1</td>
<td>1b</td>
<td>0.5</td>
<td>BA1 0.33 SK4722</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1c</td>
<td>1</td>
<td>BA1 0.66 SK4621</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1d</td>
<td>1</td>
<td>BA1 0.66 SK4721</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1a</td>
<td>0.5</td>
<td>WH1 0.17 SK4622</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1b</td>
<td>0.5</td>
<td>WH1 0.17 SK4722</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1c</td>
<td>1</td>
<td>WH1 0.33 SK4621</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1d</td>
<td>1</td>
<td>WH1 0.33 SK4721</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>WH1</td>
<td>1</td>
<td>2a</td>
<td>1</td>
<td>WH1 0.5 SK4821</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2b</td>
<td>1</td>
<td>WH1 0.5 SK4721</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>2.5</td>
<td>PO1</td>
<td>2.5</td>
<td>3a</td>
<td>2</td>
<td>PO1 2 SK4922</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3b</td>
<td>0.5</td>
<td>PO1 0.5 SK4921</td>
<td></td>
</tr>
</tbody>
</table>

(c) Crop totals by 1km square

<table>
<thead>
<tr>
<th>Map Square</th>
<th>SK4622</th>
<th>SK4722</th>
<th>SK4822</th>
<th>SK4922</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.33 BA1 0.17 WH1</td>
<td>0.33 BA1 0.17 WH1</td>
<td>No Data</td>
<td>2 PO1</td>
</tr>
<tr>
<td></td>
<td>0.66 BA1 0.33 WH1</td>
<td>0.66 BA1 0.83 WH1</td>
<td>0.5 WH1</td>
<td>0.5 PO1</td>
</tr>
</tbody>
</table>

Aggregation and Disaggregation

Density information per unit area (e.g. per m$^2$) may be converted to the scale of CS2007 by simply aggregating the data, either by taking the mean value or the sum of the smaller units within the CS2007 1km grid square. This is straightforward unless the smaller area does not align with the boundaries of the CS2007 raster.

**Weighted: Area weighted average technique**

**Figure A.2: Count data in larger grid squares intersected by CS2007 grid square**

A\_area = 1 km$^2$
A\_1\_area = 0.4 km$^2$
A\_2\_area = 0.6 km$^2$
B\_1\_area \text{ and } B\_2\_area = 10 km$^2$
B\_1\_value = 150
B\_2\_value = 200

Data may exist as a count within a 10 km$^2$ (B1 and B2), where the boundaries of these squares do not align with CS2007 (Figure A.2). In order to compare this to the values in the CS2007 survey, the data must first be disaggregated so that a value can be attributed to each of A1 and A2, derived from B1 and B2 values respectively.

Assuming these counts are evenly distributed across the 10 km$^2$ area, the count value for A is found thus:

A\_1\_value = (B\_1\_value \times A\_1\_area) \div B\_1\_area
= (150 \times 0.4) \div 10
= 6

A\_2\_value = (B\_2\_value \times A\_2\_area) \div B\_2\_area
= (200 \times 0.6) \div 10
= 12

A\_value = 18

This works equally with polygon data and with units that are smaller than grid cell A. It will also work with some other forms of data rather than values, such as percentages.
This method will not work with categorical data (see below).

It is also necessary to consider the nature of the data when assigning values to cells in this way. For example, if the data (B1 and B2) that are being manipulated were pollution values, it may be such that the highest value, rather than the weighted average, would be used because average values mask pollution ‘hotspots’.

**Categorical**

**Figure A.3: Categorical data in larger grid squares intersected by CS2007 grid square**

Data may exist as a discrete category for a polygon, such as RLR data. Two (or more) categories may be intersected by a CS2007 grid cell (A), as in Figure A.3. Options to assign a category to A are:

1. To assign the category that the greatest proportion of the area of A overlaps. Thus if A1 is 0.4 km$^2$ and A2 is 0.6 km$^2$, A would be assigned to urban.

2. To assign A with a probability of being either category, where the probability is based upon the proportion of the area that A overlaps. Therefore the probability A would be woodland if A1 is 0.4 km$^2$ would be 40% and thus 60% probability it would be urban.

3. Rather than assign a unique category for the CS2007 grid area, assign the proportions of each category to the cell. Thus information in the database for the grid would indicate that cell A is 40% woodland and 60% urban.

When cell A is comprised of smaller cells or polygons, option 3 may be preferable as there is likely to be a greater range of categories.

Similar methods may be used when disaggregating larger cells that do not align with the boundaries of CS2007.
APPENDIX 5. LIST OF POLICY DRIVER IDENTIFIED IN THE POLICY REVIEW
UNDERTAKEN AS PART OF THE SCOPE STUDY FOR CS2007

- **International policy drivers:**
  - Convention on Biological Diversity (CBD)
  - Ramsar Convention
  - Bern Convention
  - OSPAR Convention
  - World Heritage Convention (WHC)
  - Aarhus Convention

- **EU environmental obligations:**
  - Habitats Directive
  - Birds Directive
  - Water Framework Directive
  - Common Agricultural Policy
  - Strategic Environmental Assessment (SEA) Directive
  - Renewable Energy Directive
  - Environmental Impact Assessment (EIA) Directive

- **Environment strategies:**
  - World Summit on Sustainable Development
  - Environment for Europe UNECE Ministerial Conference
  - OECD Ministerial Round table on Sustainable Development
  - EU Environment Action Plans
  - Global Forest Resources Assessment
  - Pan European Biodiversity & Landscape Diversity Strategy
  - UK Sustainable Development Strategy
  - Soil Protection
  - Strategy for Sustainable Farming & Food

- **Other policy drivers:**
  - Climate Change
    - UNFCCC & Kyoto Protocol
    - Inter-governmental Panel on Climate Change (IPCC)
    - European Climate Menu
    - UK Climate Impacts Programme (UKCIP)
    - UK Climate Change Programme February 2001
    - ESPACE Programme
    - Tyndall Centre for Climate Change Research
    - Monarch
    - Environmental Change Network
  - Land Use Planning
    - SEA and Planning Reform
  - Access to Information
APPENDIX 6 WORKSHOP

A workshop was held on Wednesday 3rd October 2007, hosted by Defra at Nobel House, London, to inform stakeholders about the project, allow them the opportunity to comment on the initial findings, identify any gaps and propose solutions. Invitees were from the policy decision-making, data provider and data user communities. A list of attendees is given below.

In the morning, presentations were given on the Countryside Survey 2007 by Lindsay Maskell and Simon Smart (CEH), on the Defra Agricultural Change and Environment Observatory by Steve Langton (Defra Observatory team), and on the aims of the scoping study and findings to date, by Nigel Boatman (CSL). In the afternoon, participants were divided into two breakout groups, Group 1 to discuss issues associated with CAP reform (e.g. cross-compliance, Environmental Stewardship), and Group 2 to discuss other changes in the regulatory/institutional landscape affecting agriculture (e.g. Water Framework Directive; Nitrates Directive, Integrated Pollution Prevention and Control Directive, Waste Framework Directive etc.). Both groups were also asked to consider the cross-cutting issue of adaptation to climate change.

Questions posed to the breakout groups were:

- What are the key policy issues?
- What CS & other datasets would be relevant?
- Are there confidentiality issues involved and how might they be addressed?
- What are the key methodological issues involved in linking and analysing the data to address the policy issues?
- Are there any other new ACEO indicators based on CS data that would be useful?

In fact, only the first two questions were addressed in any depth because of time constraints.
<table>
<thead>
<tr>
<th>Name</th>
<th>Group 1</th>
<th>Group 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nigel Boatman</td>
<td>CSL</td>
<td>Alistair Murray</td>
</tr>
<tr>
<td>Hazel Parry</td>
<td>CSL</td>
<td>Lindsay Maskell</td>
</tr>
<tr>
<td>Jim Harris</td>
<td>Cranfield</td>
<td>Marian Jenner</td>
</tr>
<tr>
<td>Steve Chaplin</td>
<td>Natural England</td>
<td>Sarah Moon</td>
</tr>
<tr>
<td>Nadeem Raja</td>
<td>Defra ELM Uplands &amp; Commons Policy</td>
<td>Zoe Davies</td>
</tr>
<tr>
<td>Lindsey Clothier</td>
<td>Defra ACEO</td>
<td>Steve Langton</td>
</tr>
<tr>
<td>Dave Cawley</td>
<td>Defra ACEO</td>
<td>Barbara Norton</td>
</tr>
<tr>
<td>Dave Fernall</td>
<td>Defra Sustainable Farming Statistics</td>
<td>Nina Pritchard</td>
</tr>
<tr>
<td>Mark Baylis</td>
<td>Defra ELM</td>
<td>Paul Scholefield</td>
</tr>
<tr>
<td>Lisa Norton</td>
<td>CEH</td>
<td>Bridget Emmett</td>
</tr>
<tr>
<td>Simon Smart</td>
<td>CEH</td>
<td>Philip Earl</td>
</tr>
<tr>
<td>Peter Costigan</td>
<td>Defra NESD</td>
<td>Andrew Baker</td>
</tr>
<tr>
<td>Helen Pontier</td>
<td>Defra NESD</td>
<td></td>
</tr>
</tbody>
</table>

1 Facilitator
2 Recorder
3 Natural Environmental Science Division
### Summary of outputs: Group 1

<table>
<thead>
<tr>
<th>Policy questions</th>
<th>CS data</th>
<th>Other data</th>
</tr>
</thead>
</table>
| Bracken in uplands:  
  - Increased distribution?  
  - Increased control? | CEH have already mapped broad habitat for bracken. Information at the plot scale (including sufficient upland data) | Pesticide usage survey. HLS data + classic schemes |
| Pesticides and biodiversity action plan, voluntary initiative, environmental stewardship etc.  
Aquatic environment? | Biodiversity (in field plots, margins etc) | Pesticide usage survey. May be limited at crop level (bit crude) so could stratify by soil types? Subset data? Compare crop protection management plans? Agri stats could be used to generate rotations. Information from farmers would help here. |
| Green belts – can we distinguish quality of green belt land in comparison with non-green belt?  
Urban fringe – how urban areas influence land management. Perhaps better to investigate how rural areas are becoming more urbanised? | Data from CS is limited around urban areas. 16 sample squares relevant across UK. CEH have made some broad statements with the data on this. | Urban/rural definition used as baseline for previous analysis. Farmers attitude survey Farmers voice Farm practices survey. Overall probably still too little data. |
| Landscape management – prediction of integrated policy effects on landscape & adaptation to change for biodiversity. Connectivity and corridors in changing landscape context (e.g. energy crop plantation). ‘High Nature Value farmland’. | Too big a question for CS data? Requires models to answer such questions. CS may give context (perhaps even pick up baseline changes). Niche models already exist (Simon Smart) | CQC. Farmer attitude survey. Woodland - Forestry Commission. HLS, Local Authority incentives? LCM. |
| Regional/local soil nutrient balance: in particular use to ground truth models and other datasets. | Vegetation data  
Stratify by land class?  
Stratify by river basins?  
P Currently relies on modelling | June survey BSFP Farm Practices Survey Historic data. Needs fine spatial scale |
<p>| Agri-environment schemes (ELS) and the impacts they have on biodiversity/ecosystem services and value. | Biodiversity data. | ES data OK for comparison. Classic scheme data more difficult to match. Need to consider when agreement started. RLR/June survey may link to ELS points to make it spatial. |</p>
<table>
<thead>
<tr>
<th>Policy questions</th>
<th>CS data</th>
<th>Other data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cross-compliance – narrow margins, fallow.</td>
<td>Boundary plots may give comparisons btw CS2000 &amp; CS 2007. Crop margin width data only started to be collected in 2007. Few non-cross-compliance for comparison.</td>
<td>GAEC12 data from SPS can be identified</td>
</tr>
<tr>
<td>Regionalisation of payments: putting farm practices in context of local landscape and environmental limitations? EU thinkpiece paper on linking Pillar 1 payments to environmental health.</td>
<td>Headwater data (sensitive points in the landscape) Unlikely to be taken up – easier to pay on farm practices than env. outcome.</td>
<td></td>
</tr>
<tr>
<td>Farm business evolution in global context – international issues of higher prices, climate change etc.</td>
<td>Economic stratification of CS data?</td>
<td></td>
</tr>
</tbody>
</table>
**Summary of outputs: Group 2**

First the group discussed the breadth of the question and whether the correct policies had been chosen for discussion. In addition to the specified Directives, it was also decided that the Soils Framework Directive, climate mitigation-carbon, Environmental Liability directive, air quality- emissions, wild birds, PSA targets, SSSI targets, and net benefit of agriculture should be considered.

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<tr>
<td><strong>Water framework directive</strong></td>
<td>Upland streams quality data</td>
<td>Better linkage to other data</td>
</tr>
<tr>
<td>• requirement to provide ecological quality in every water body</td>
<td>Land use- habitat survey</td>
<td>Definition of catchment</td>
</tr>
<tr>
<td>• reporting at the catchment scale</td>
<td>CS pond data- whole new data set which may have implications for WFD as it says every water body and policy not currently focused on ponds</td>
<td>Need good biophysical model</td>
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<td></td>
<td>CS soils- currently reporting by habitat- is that the best way to report?</td>
<td>Link to intelligent river network (think CS is proposing to do this)</td>
</tr>
<tr>
<td><strong>Nitrates directive/pollution</strong></td>
<td>Ellenberg N from vegetation</td>
<td>Farm Practices Survey</td>
</tr>
<tr>
<td>• How are people doing what they’re doing?</td>
<td>Soils N and P</td>
<td>Pick out 1km squares more subject to pollution than expected by the N dep map and study them in more detail</td>
</tr>
<tr>
<td>• What % measuring nutrients?</td>
<td>Water quality</td>
<td>If in Nitrate Vulnerable Zones should have records- is it possible to get hold of these?</td>
</tr>
<tr>
<td>• Timing of inputs</td>
<td>Catchment sensitive farming</td>
<td>Need help from other spatial and temporal datasets to interpret Olsen P, CS biased towards semi-natural rather than crop types</td>
</tr>
<tr>
<td>• Level of take up of mitigation measures</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Interpreting Olsen P</td>
<td></td>
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<tr>
<td><strong>Pollution/waste framework directive (slurry not a waste)</strong></td>
<td>Soils metals- need indicators and thresholds on soils. CS should be able to do state and function, once response function understood can be scaled up by other methods, datasets</td>
<td>Air deposition</td>
</tr>
<tr>
<td>• Impact of heavy metals</td>
<td></td>
<td>National soil inventory</td>
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<tr>
<td></td>
<td></td>
<td>Cadmium in wheat</td>
</tr>
<tr>
<td><strong>Effects of agri-environment policy</strong></td>
<td></td>
<td>Land ownership- holding information-does farm size effect responses</td>
</tr>
<tr>
<td><strong>Climate change- mitigation, soil C</strong></td>
<td>CS habitats and veg- use of habitats, linear features data</td>
<td>Reading University’s farm typologies</td>
</tr>
<tr>
<td>Can we predict effects of climate change?</td>
<td>Soil C and bulk density</td>
<td></td>
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<td>Area under concrete?</td>
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<td>Intensity of management</td>
<td></td>
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<tr>
<td><strong>Intentions of housebuilding</strong></td>
<td>Use data to determine impacts on WFD e.g. water quality, Soil sealing in square</td>
<td>Development in catchments</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CPRE tranquillity map</td>
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</table>