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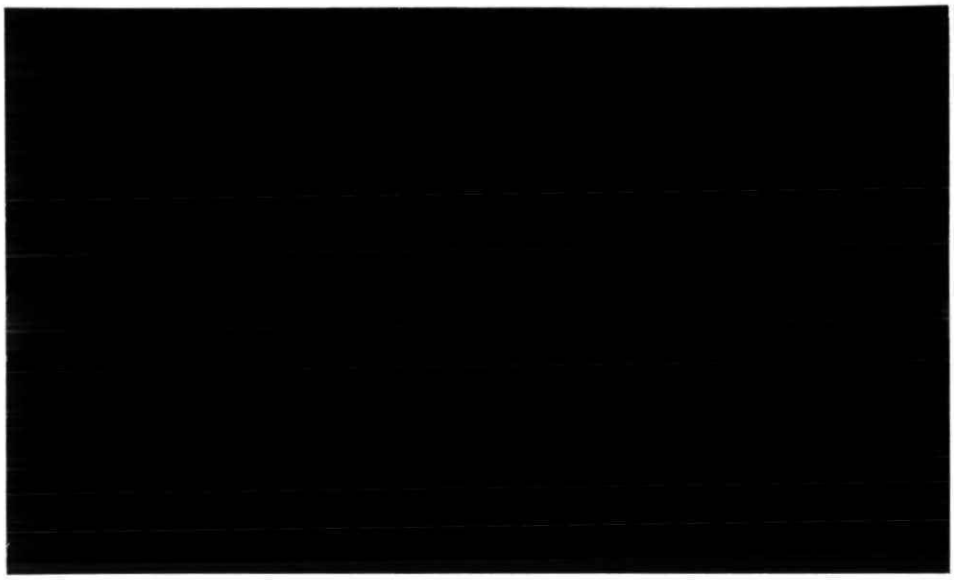

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- To advance the sciences of ecology, environmental microbiology (including virology) and hydrology through high-quality and internationally recognised research leading to a better understanding and quantification of the physical, chemical and biological processes relating to land and freshwater and living organisms within these environments.

- To investigate, through monitoring and modelling, natural changes in the ecological, microbiological and hydrological environments, to assess both past and future changes and to predict man's impact on these environments.

- To secure, expand and provide ecologically and hydrologically relevant data to further scientific research and provide the basis for advice on environmental conservation and sustainable development to governments and industry.

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CENTRE FOR ECOLOGY AND HYDROLOGY

CONTRACT REF: CR0264

Countryside Survey 2000

Module 17 - FINDING OUT CAUSES AND UNDERSTANDING SIGNIFICANCE (CS2000 FOCUS)

DRAFT

Second Progress Report

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and also including:
Countryside Council for Wales
Department for Environment, Food & Rural Affairs (Science Directorate)
English Nature
Forestry Commission
Joint Nature Conservation Committee
Scottish Natural Heritage

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MODULE 17:
FINDING OUT CAUSES AND UNDERSTANDING SIGNIFICANCE (FOCUS)

BACKGROUND

Objectives

1 The objectives of the work programme (as defined in the project specification) are:

1. to undertake further critical analysis of the data arising from CS2000 to answer a series of specific questions concerning interpretation and understanding of the results in terms of ecological processes and land management effects;
2. to acquire and use other contextual data to assist in the analysis, interpretation and assessment;
3. to recommend improvements to survey protocols;
4. to establish and consult a steering group and organise workshops as necessary to ensure that user requirements are defined, clearly understood and addressed;
5. to publish the results in technical reports and concise non-technical summaries and to present the results at a seminar; and
6. to maintain the CS2000 website following completion of the current Module 16 and to facilitate internet publication of the results of ongoing CS2000 projects.

Task, Topics & Questions

2 The Module 17 objectives are being met through three main areas of work (**tasks**):

1. Answering specific research **questions** arising from published results.
2. Recommending improvements to survey protocols.
3. Maintaining the CS2000 Website.

3 Other stated objectives are being met as part of carrying out and completing these three areas of work.

4 It has been agreed that the specific research questions should be aggregated under seven distinct **topics**. Each topic relates to one of the Broad Habitat groups (Chapters) in the CS2000 main report (Accounting for nature), with the exception of one which is of a more over-arching nature. **It should be noted that funding is not currently available for work in Topic 6.**

5 The aggregation of FOCUS questions as shown in Table 1.

Table 1. Aggregation of 17 specific research questions under 7 topic headings.

Topic no.	**Topic heading**	Qu. no.*	Question
T1	Enclosed farmland	1 (1) 2 (2) 3	Decline in semi-natural grasslands? Newly cultivated land in CS2000? Conservation value of weed species?
T2	Boundary & linear features	4 (10) 5 (8) 6 (9) 7 (7) 8	Change in hedges 1990, 1993 and 1998? Plant diversity, hedge characteristics, land use? Value of hedges for birds? Hedges that are being gained/lost? Condition of ancient and/or species-rich hedgerows?
T3	Woodlands	9 (13)	Differences in estimates of woodland cover? Correspondence with AWI sites? Woodland changes - where and how?
T4	Mountain, moor, heath & down	10 (6) 11 (4) 12 (5)	Changes in dwarf shrub heath? Increases in fen, marsh & swamp? Bracken invasion?
T5	Rivers, streams & standing waters	13 (3) 14 (11)	Causes of overgrown streamside vegetation? What and where are the new ponds?
T6	Developed land in rural areas	15 (15) 16 (16)	Habitat creation on developed land? Countryside around towns?
T7	Agri-environment schemes	17 (12)	Agri-environment schemes?

* (#) = number in original project specification

6 A number of general points apply to the way this suite of questions is being addressed:

1. Where possible, work is making use of external (ie to CS2000) research and survey results, including information and expertise held by the funding consortium.
2. Although this programme of work has been initiated to clarify or expand on some of the results from CS2000, it will still be necessary to include an assessment of uncertainty of these further, second-stage results. Statistical significance is being handled in the same way as in the earlier analyses but, in addition, discussion will be held with interested sponsors and other experts about the policy significance and relevance of any results and conclusions.
3. The work will adopt a flexible approach to the use of geographical frameworks according to customer requirements; ie Environmental Zones, countries, including separate reporting of England and Wales and will investigate the appropriateness of using other possible geographical breakdowns – regions, catchments and natural areas.
4. Given the timescales involved, some of the vegetation analysis is relatively simple (compared with earlier EcoFact work, for example). It is sufficient to undertake simple analyses, look at changes in individual squares and then apply expert judgement to the interpretation of the results. We will use expertise within the

sponsoring organisations. An iterative approach of data exploration, consultation with experts and further analysis may be productive.

5. Where there is uncertainty about the feasibility of undertaking an analysis and generating useful results then the work programme for the topic will include a review stage. This should allow for unpromising lines of enquiry to be halted and new lines of enquiry instigated within the overall scope and timing of the project.

Timetable, Milestones & Reports

7 The proposed programme of work (Table 3) has been devised with two guiding principles in mind: (a) the priority attached to the different tasks as indicated by DEFRA and (b) ensuring optimal use of staff and other resources throughout the course of the contract period.

8 Table 3 shows a work programme that meets these requirements. It shows modifications from earlier schedules as above in light of slippage in the contract establishment procedure (as approved at the FOCUS Steering Group Meeting in May 2002).

9 Progress reports summarising work in individual research topics will be produced at intervals according to the schedule proposed in Table 2. The dates of delivery of interim and final reports are based on discussions of priorities held with DEFRA and modified from earlier schedules.

Table 2. Due dates of interim and final reports for each work task.

Task		Interim report	Final report
M	Overall management and liaison	15th Mar 2002	n/a
T1	Enclosed farmland	30th Sep 2002	15th Feb 2003
T2	Boundary & linear features	30th Sep 2002	15th Feb 2003
T3	Woodlands	30th Sep 2002	15th Feb 2003
T4	Mountain, moor, heath & down	30th Sep 2002	15th Feb 2003
T5	Rivers, streams & standing waters	30th Sep 2002	15th Feb 2003
T6	Developed land in rural areas	n/a	n/a
T7	Agri-environment schemes	n/a	30th Sep 2002
P	Survey protocols	n/a	15th Feb 2003
W	Maintaining web site	n/a	n/a

Table 3 Detailed work programme (and milestones)

	Priority	2002 Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	2003 Jan	Feb	Mar	Apr	May	Jun
Topic 1 Enclosed farmland																	
Q1 Decline in semi-natural grasslands.	H							FR									
Q2 Newly cultivated land in CS2000.	H							FR									
Q3 Conservation value of weed species.	L							IR					FR				
Topic 2 Boundary & linear features																	
Q4 Change in hedges 1990, 1993 and 1998.	H							FR									
Q5 Plant diversity, hedge characteristics, land use.	M							IR					FR				
Q6 Value of hedges for birds.	M							IR					FR				
Q7 Hedges that are being gained/lost.	M												FR				
Q8 Ancient and/or species-rich hedgerows.	L												FR				
T3 Woodlands																	
Q9 Differences in estimates. Changes - where and how.	M/H							IR					FR				
Topic 4 Mountain, moor, heath & down																	
Q10 Changes in dwarf shrub heath.	H							FR									
Q11 Increases in fen, marsh & swamp.	M/H							IR					FR				
Q12 Bracken invasion.	M/H							IR					FR				
Topic 5 Rivers, streams & standing waters																	
Q 13 Causes of overgrown streamside vegetation.	L							IR					FR				
Q 14 What and where are the new ponds.	L										IR		FR				
Topic 6 Developed land in rural areas																	
Q15 Habitat creation on developed land.	L																
Q16 Countryside around towns.	L																
Topic 7 Agri-environment schemes																	
Q17 Agri-environment schemes.	H							FR									
Module 17 report														R			FR

IR = Interim report / FR = Final report

10 No delivery dates are given for Topic 6 given the absence of funding for work at this stage. If further funding becomes available, then appropriate reporting dates will be agreed.

11 A **Final report** will be produced in draft by 15.12.2002 and in final draft by 15.03.2003, and results will be prepared for inclusion in an **internet website**.

12 Depending on the outcome of individual research initiatives, opportunities will be sought to publish results in refereed science journals.

Project team

13 The project is led by Colin Barr who has overall responsibility of the completion of research, to time and to budget

14 Each work task is led by a member of the Land Use Section at CEH Merlewood, as indicated in Table 4.

Table 4 Work Task Leaders

	Work Task	*Leader*
M	Overall management and liaison	Colin Barr
T1	Enclosed farmland	Dr Sandrine Petit
T2	Boundary & linear features	Colin Barr/Rick Stuart
T3	Woodlands	Dr David Howard
T4	Mountain, moor, heath & down	Simon Smart
T5	Rivers, streams & standing waters	John Watkins
T6	Developed land in rural areas	n/a
T7	Agri-environment schemes	Lindsay Maskell/Lisa Norton
P	Survey protocols	John Watkins
W	Website	Dr Andrew Sier/Colin Barr

15 As well as Topic Leaders identified above (all of whom are based at CEH Merlewood) a number of other CEH staff are involved in the work, including:

Dr Les Firbank (CEH Merlewood)

Geoff Smith (CEH Monks Wood)

Dr Mike Furse (CEH Dorset)

PROGRESS

Management

16 The Merlewood-based members of the project team meet formally at fortnightly intervals and minutes are produced; there have been fourteen such meetings so far. Other members of the team are kept in touch through meeting minutes, e-mails and personal visits.

17 A FOCUS workshop was held on May 17th. There were 32 participants and minutes are available. The workshop reviewed work to date and discussed future work programmes; it was very helpful to the researchers, giving fresh ideas to the project team and encouraging interaction and discussion with other experts and interested parties. A 'contact group' has been established which includes over 90 people who were either at the workshop, invited to it, or are known to have an interest in the work

Task 1: Answering specific questions

Generic work

18 Some generic work has taken place to revisit the results of automated allocation procedures used in the analysis of CS2000 data to further investigate particular data records and rules used to allocate change. This has informed categorisation of changes under several different FOCUS topics.

Research approach

19 The research approach used to address each question is included in the original tender document.

Individual questions

20 There follow reports on progress made on each of the fifteen questions. Under 'Science outputs', work is reported according to the structure given under 'Approach' in the original project tender document and repeated here in italics (where appropriate).

Question 1: What are the likely causes of the decline in extent and condition of semi-natural grasslands (acid, neutral and calcareous)? Why was there a high turnover with improved grassland types? To what extent do gains compensate for losses? What are the implications for conservation of biodiversity and agri-environment management prescriptions?

DRAFT FINAL REPORT - *Simon Smart & Dr Sandrine Petit*

DUE START DATE:

- March 2002

DUE FINISH DATE:

- June 2002

OVERALL PROGRESS

21 Work has been completed and the question has been fully addressed in this draft final report presented here.

DEFINITIONS

- Semi-natural grasslands includes three Broad Habitats defined in Jackson (2000) – see policy context statement below for these definitions. It also includes 'permanent' grasslands as defined for the EIA directive (see report for question 2).
- 'Botanical characteristics' includes several plot level and parcel level attributes. We include condition measures as analysed in the CS2000 Module 1 report (Haines-Young et al 2000) and species cover codes used for describing mapped parcels of Broad Habitat. In addition plot level botanical data recorded in 1990 and 1998 can be assigned to community units of the National Vegetation Classification and hence, to the three Priority Habitats included in the Broad Habitat.
- 'Extent' refers to estimated area of Broad Habitat. 'Condition' refers to the status of Broad Habitat parcels measured in terms of their botanical characteristics.
- This report focuses on assessing the robustness of mapped change and avoids generating an additional set of national estimates. We therefore concentrate on evidence for change on 'surveyed land'. This means mapped parcels that were assigned to Broad Habitats in CS survey squares.

POLICY CONTEXT STATEMENT

Current policy context

DEFRA Public Service Agreement (PSA)1

22 The PSA set out the aims and objectives of individual government departments. With the formation of DEFRA in 2001 a new set of PSA statements and targets were drawn up by the ministerial team. The PSA targets are coined as specific actions some of which form relevant policy background to this question. These are:

- PSA Target 6: Bring into favourable condition by 2010 95% of all nationally important wildlife sites compared to 60% of sites currently estimated to be in such condition.
- Remaining CSR 1998 target: Contribute to a more attractive and accessible countryside by increasing the area protected and enhanced under the major agri-environment schemes.

Quality Of Life Counts Indicators2

23 The government publishes 147 separate indicators which together help track progress towards national sustainable development. One of these indicators (S3) is based on CS field survey data and measures changes in plant diversity (mean plant species richness) between each survey. The indicator is arranged by aggregate class not Broad Habitat. The semi-natural grasslands included in this topic question will fall within the Infertile Grassland class.

24 The indicator has been recently updated using the latest results from CS2000.

Environmental Impact Assessment

25 In 2002 the existing government regulations that required EIA to precede planned development and forestry were extended to cover "..the use of uncultivated land or semi-natural areas for intensive agricultural purposes."[3] These extended measures complete the implementation of the European EIA Directive but also contribute to the wider aims of promoting sustainable agriculture. See policy context for T1 – Q2 for further information on the policy background.

Grassland Priority Habitats under the UK BAP

26 The three BHs considered in this FOCUS question incorporate five Priority Habitats (PHs) – Lowland meadows, Upland hay meadows, Lowland calcareous grassland, Upland calcareous grassland and Lowland dry acid grassland. Unenclosed upland grazings are excluded from the five, so that the increases in area of upland acid grassland that may have resulted from overgrazing of Bog and Dwarf Shrub Heath will not offset any loss or degradation across the constituent PHs.

27 Table 1.1 summarises the main threats by the five constituent PHs. For more detail see the respective action plans for each PH.

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[1] See www.defra.gov.uk/corporate/busplan/01psa.htm

[2] See www.sustainable-development.gov.uk/sustainable/quality99/chap4/04s03.htm for the 1978 to 1990 figures.

[3] See guidelines at http://www.defra.gov.uk/environ/eia/

Table 1.1 Main threats to five Priority Habitats.

	Neutral Grassland		Calcareous Grassland		
THREAT	Lowland meadows	Upland hay meadows	Lowland calcareous grassland	Upland calcareous grassland	Lowland dry acid grassland
Agricultural improvement including	✓	✓	✓		✓
Switch from hay to silage	✓	✓			
Abandonment	✓	✓	✓		✓
Supplementary stock feeding	✓	✓	✓		✓
Herbicide applications	✓	✓			
Atmospheric pollution	✓	✓	✓		✓
Over-grazing	✓	✓			✓
Reduced inundation of water meadows	✓				
Shift from meadow to rough grazing		✓			
Afforestation			✓		✓
Local invasion of non-native species			✓		
Development, including mineral extraction, road building and urbanisation			✓		✓

Selected key actions from each Priority Habitat Action Plan[4]

Lowland calcareous grassland

- Arrest the depletion of unimproved lowland calcareous grassland throughout the UK.
- Within SSSIs, initiate rehabilitation management for all significant stands of unimproved lowland calcareous grassland in unfavourable conservation by 2005, with the aim of achieving favourable status wherever feasible by 2010.
- For stands at other localities, secure favourable condition over 30% of the resource by 2005, and as near to 100% as is practicable by 2015.
- Attempt to re-establish 1000 ha of lowland calcareous grassland of wildlife value at carefully targeted sites by 2010.

Upland calcareous grassland

- Maintain the current distribution and extent (*ca* 22,000-25,000 ha) of upland calcareous grassland in the UK.
- Achieve favourable condition for at least 75% of upland calcareous grassland (7,000 ha in England, 7,000-9,750 ha in Scotland, 500 ha in Wales and 500 ha in Northern Ireland) through sympathetic management by 2005 or as soon as biologically practical thereafter.
- Review and modify livestock support mechanisms in the Less Favoured Areas (LFAs) through further lobbying for reform of the Common Agricultural Policy (CAP) to promote sustainable agricultural management of upland calcareous grassland. Promote a more

[4] Actions taken from each plan at www.ukbap.org.uk/species.htm

integrated approach to environmental, agricultural and socio-economic policy through CAP reform. Continue to reduce overgrazing by implementing the environmental cross-compliance conditions.

- By 2002 review and consider common land legislation with a view to improving the sympathetic management of upland commons.

Lowland dry acid grassland

- Arrest the depletion of unimproved lowland acid grassland throughout the UK.
- For stands at other localities, secure favourable condition over 30% of the resource by 2005, and as near to 100% as is practicable by 2015.
- Attempt to re-establish 500 ha of lowland acid grassland of wildlife value at carefully targeted sites by 2010.
- Develop and implement strategies to restore and expand the cover of unimproved acid grassland, taking into account the need to ameliorate the negative effects of small patch size, fragmentation, isolation and scrub encroachment.
- Support initiatives to conserve unimproved acid grassland within local government development plans and related policy, in forest management and planting schemes and by special projects.
- Consider mechanisms by which lowland acid grassland within areas designated as common land can be brought under sympathetic management.

Lowland meadows

- Arrest the depletion of unimproved lowland hay meadow throughout the UK.
- Within SSSIs and ASSIs, initiate rehabilitation management for all significant stands of unimproved lowland hay meadow in unfavourable condition by 2005, with the aim of achieving favourable status wherever feasible by 2010.
- For stands at other localities, secure favourable condition over 30% of the resource by 2005, and as near to 100% as is practicable by 2015.
- Attempt to re-establish 500 ha of lowland hay meadow of wildlife value at carefully targeted sites by 2010.
- Ensure the conservation requirements of lowland meadows are taken into account in the development and adjustment of agri-environment schemes; design measures to suit local needs and in particular target local concentrations of remnant semi-natural neutral grasslands.
- Develop and implement strategies to restore and expand the cover of unimproved neutral grassland, taking into account the need to ameliorate the negative effects of small patch size, fragmentation and isolation.

Upland hay meadows

- Arrest the depletion of unimproved upland hay meadow throughout its UK distribution.
- Within SSSIs, initiate rehabilitation management for all significant stands of unimproved upland hay meadow in unfavourable condition by 2005, with the aim of achieving favourable status wherever feasible by 2010.

- For stands at other localities, secure favourable condition over 30% of the resource by 2005, and as near to 100% coverage as is practicable by 2015.
- Attempt to re-establish 50 ha of upland hay meadow of wildlife value at carefully targeted sites by 2010.

Agri-environment schemes[5]

28 The main agri-environment schemes include the Countryside Stewardship Scheme in England, Rural Stewardship in Scotland, Tir Gofal in Wales and the Environmentally Sensitive Area schemes in all countries. Uptake of land and its subsidised management within these schemes constitutes the major mechanism for delivering BAP objectives outside of SSSI. Scheme objectives differ somewhat to reflect the particular character of the local area or ESA. Note that Welsh and Scottish ESA schemes are currently closed to new entrants.

Historical change in extent of lowland semi-natural grasslands

29 Permanent grasslands in Britain are largely managed for livestock production so that changes in their extent and condition have been associated with shifts in the economic viability and intensity of agricultural management over time (Hopkins & Hopkins 1994). Unimproved grasslands, particularly in lowland Britain and including in-bye on upland farms, have declined in extent at least since the plough-up campaign of WWII (Hopkins et al 2000) during which about 35% of permanent grassland was converted to sown ley or crops (North 2000). Since then there has been a gradual decline in extent and condition of the remaining unimproved grasslands with loss rates of unimproved lowland grasslands that were still estimated at between 2-10% pa in parts of England in the 80s and 90s (Jefferson & Robertson 1996).

30 The post war period of intensification was driven by a strategic desire for self-sufficiency (eg. HMSO 1975) and assisted by the increasing mechanisation of agriculture and the availability of cheap mineral fertiliser (Hopkins et al 2000). It was only from the 80s onwards that the threat that agriculture posed to the countryside at large was realised via the Wildlife & Countryside Act (1981) and the Agriculture Act (1986). The latter imposed a statutory duty to balance the needs of crop and livestock production with conservation and also led to the establishment of the first tranche of ESA in 1987.

Results from CS2000

Neutral grassland6

Change in extent

31 CS2000 results showed statistically significant reductions in area in Northern Ireland and in the marginal upland and north western lowland Environmental Zone 5 in Scotland. Relatively large gains were seen in Environmental Zones 1 and 2 in lowland England & Wales although these were not significant. High turnover probably contributed to lack of statistical significance in places.

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[5]See detailed ESA objectives and prescriptions at http://www.defra.gov.uk/erdp/docs/national/annexes/annexx/contents.htm and the England Rural Development Programme links at www.defra.gov.uk.

[6] "..vegetation dominated by grasses and herbs on a range of neutral soils usually with a Ph between 4.5 and 6.5. It includes dry hay meadows and pastures, together with a range of grasslands which are periodically inundated or permanently moist."

32 Patterns of flow from and to other BH between 1990 and 1998 highlight possible drivers of change. At the GB level, high turnover was seen for Neutral Grassland with 48% of the 1990 stock lost to other BH and 47% gained over the eight year period. BH that increased in area at the expense of Neutral Grassland were largely Improved Grassland (implying agricultural improvement), Arable & Horticultural (set-aside re-cultivated rather than ploughing of old grassland?), Acid Grassland and Broadleaved Woodland. BH that lost stock to Neutral Grassland in 1998 were mainly Improved Grassland (extensification?), Fen, Marsh & Swamp and Arable & Horticultural (non-rotational set-aside?). These patterns of loss and gain were not evenly distributed across GB with losses tending to occur in Scotland and NI and gains in England & Wales. The plausibility of the highlighted processes being responsible for observed flows will be assessed as part of this FOCUS topic.

Change in condition

33 An increase in mean Ellenberg fertility score across the GB plot sample was seen for Y plots only indicating the vulnerability of smaller fragments of Neutral Grassland to elevated fertility. However, a significantly decreasing light score in the same sample suggests that lack of disturbance also affected the population of less improved grassland fragments. This process can amplify the effects of increased fertility on terrestrial vegetation hence, small grassland fragments seem doubly susceptible to processes that can reduce the richness of characteristics species. Not surprisingly, the proportion of competitive plants went up and the proportion of stress-tolerators decreased in the same GB-wide, Y plot sample (CS2000 web-tables; Haines-Young et al 2000). Where Neutral Grassland was sampled by the X plots in fields and usually larger parcels, no change in light score was observed while Ellenberg fertility score only increased in the England & Wales sample suggesting relative stability may characterise larger Scottish stands of the BH (McGowan et al 2001).

Acid grassland[7]

Change in extent

34 The total area of Acid Grassland was estimated to have declined throughout GB and NI between 1990 and 1998, however the only statistically significant changes were a 17% decline in England & Wales, which was largely a function of a statistically significant decline in upland Environmental Zone 3, and a 15% decline in the lowland Environmental Zone 4 in Scotland.

35 Patterns of turnover indicated gains to Acid Grassland largely at the expense of DSH and Bog perhaps indicative of the ongoing effects of elevated grazing intensity in upland Britain, especially England & Wales. The loss of 24% of the 1990 stock mainly to Improved Grassland suggests agricultural improvement.

Change in condition

36 Analyses of change in vegetation condition measures saw GB-wide reductions in proportion of stress-tolerators and increased average proportions of weedier and more competitive species (CS2000 web-tables). Increases in Ellenberg fertility score also imply changes in species composition towards vegetation more typical of heightened fertility. Interestingly though, these changes accompany an increase in mean species richness at the GB-level.

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[7] "..vegetation dominated by grasses and herbs on a range of lime-deficient soils which have been derived from acidic bedrock or from superficial deposits such as sands and gravels. Such soils usually have a pH of less than 5."

37 Candidate drivers of these changes include increased grazing pressure and atmospheric N deposition.

Calcareous grassland[8]

Change in extent

38 Between 1990 and 1998 significant reductions in extent of calcareous grassland were seen in England & Wales and in Scotland. These losses were estimated as 9,000ha (95% CI 200ha – 21,800ha) and 5,000ha (95% CI >0 – 14,400ha) respectively (CS2000 web tables). Gains to calcareous grassland were relatively small over the eight year period as would be expected given the long time scales needed for development and species packing in the best examples (eg. Rodwell 1992; Gibson & Brown 1991). A gain amounting to 5% of the 1990 stock was seen at the expense of Arable & Horticultural implying restoration management and re-seeding, while 23% of the 1990 stock of Calcareous Grassland was lost mainly to Improved and Neutral Grassland (agricultural improvement?) and to Arable & Horticultural (ploughing up?). The circumstances of all these changes will be fully investigated as part of this FOCUS question and evaluated against action plan objectives for the priority habitats concerned. The first step will therefore involve assessing the probable representation of each PH across the CS sample. This will be achieved by matching CS plot data against relevant units of the NVC (Rodwell 1991; Jackson 2000).

Change in condition

39 The number of CS vegetation plots that fell in Calcareous Grassland in either 1990 or 1998 was too small for meaningful analyses of change in vegetation condition. However, movement between the plant community types of the Countryside Vegetation System (Bunce et al 1999) showed local losses to more improved grassland and to less disturbed scrub. Hence, the signals in this very small dataset are consistent with lack of appropriate management and eutrophication.

40 The high frequency of *Ammophila areneria* in the few available Scottish plots indicates sampling on base-rich machair and dune rather than upland limestone (McGowan et al 2001).

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[8] "..vegetation dominated by grasses and herbs on shallow, well-drained soils formed from the weathering of chalk and other types of limestone or base-rich rock

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SCIENCE OUTPUTS

41 The science outputs follow, organised in relation to stated approach in the CEH tender document.

Part 1: Analyses of change in extent and condition

Approach

42 In accordance with the CEH tender document, plot and parcel level information was used firstly to assess the reliability of the change in extent of semi-natural grassland Broad Habitats. The question focuses on loss of Broad Habitat as well as turnover with improved grassland and so we specifically target parcel level changes within CS squares involving transfers of surveyed land between the Broad Habitats outlined in Table 1.2. The consistency of directional change in the following pairs of Broad Habitats was examined by a comparison of expected patterns of mapping codes with those actually observed in changing parcels (Table 1.2). Primary codes refer to the main category of land-cover type that was mapped in 1990 and, in enclosed land, in 1998. They usually carried the most weight in the automated process of allocating parcels to Broad Habitats. Hence, consistent change in primary codes is considered strong evidence for the reliability of the Broad Habitat change. Species codes were often used in the field survey to qualify each primary code. These could also exert a critical effect on the Broad Habitat allocation procedure. Clearly, certain patterns of species change would be expected given a particular change in Broad Habitat.

Table 1.2 Expected patterns of change in primary and species codes given a particular change in Broad Habitat between 1990 and 1998.

	Expected patterns given Broad Habitat change		
Broad Habitat grassland change; 90 to 98	**Primary codes in 1990**	**Primary code change 1990 to 1998**	**Species code changes 1990 to 1998**
Acid to Improved	Acid grassland (102) and Moorland grassland (103)	102 and 103 to Fertile agric. grassland (101)	Decrease in species such as *Nardus stricta* (106), *Deschampsia flexuosa* (159) and *Festuca ovina* (155) and gain to *Lolium perenne* (147) and *Trifolium repens* (148) among others.
Calcareous to Neutral	Calcareous grassland (105)	105 to 101 or to Unmanaged grassland (133), Tall-herb vegetation (134), Abandoned land (142) or Neglected land (141) – both can include set-aside. Shifts to Herb-rich grassland (171) would suggest Priority Habitat vegetation.	Decreases in calcicoles and increase in mesophytes such as *Agrostis capillaris* (154), *Cynosurus cristatus* (152) and *Holcus lanatus* (153)
Calcareous to Improved	Calcareous grassland (105)	105 to 101	Decreases in calcicoles and increase in *Lolium perenne* (147) and *Trifolium repens* (148) among others.
Calcareous to Arable	Calcareous grassland (105)	105 to crops eg. 117-131 or to Ley (137) or Ploughed (143)	Decreases in calcicoles. Crop species not recorded as included in the primary code.
Neutral to Improved	133, 134, 142, 141 and 171	133, 134, 142, 141 and 171 replaced by 101	Decrease in mesophytes such as *Agrostis capillaris* (154), *Cynosurus cristatus* (152) and *Anthoxanthum odoratum* (150) and increase in *Lolium perenne* (147) and *Trifolium repens* (148) among others.
Improved to Neutral	Opposite of above	Opposite of above	Opposite of above
Neutral to Arable	133, 134, 142, 141 and 171	133, 134, 142, 141 and 171 replaced by crops eg. 117-131 or to Ley (137) or Ploughed (143)	Decrease in mesophytes such as *Agrostis capillaris* (154), *Cynosurus cristatus* (152) and *Anthoxanthum odoratum* (150)

43 In addition, we compared the consistency of change in botanical characteristics measured from vegetation sample plots recorded from mapped parcels (Table 1.3). The approach here was to compare change in selected condition measures in parcels that saw a change in Broad Habitat allocation with plots in parcels that did not change Broad Habitat. There are however, limits on the extent to which vegetation plot data can be assumed to track mapped changed in the total surveyed area. Firstly, plots sample only a subset of the total number of parcels and secondly, mapped parcels can be heterogeneous so that changes in the botanical character of a plot may not represent the overall change in character of the parcel.

Table 1.3. Expected changes in vegetation condition measures in plots within parcels that changed Broad Habitat allocation between 1990 and 1998.

Broad Habitat grassland change; 90 to 98	Number of repeat plots	Aggregate class change	Light score	Fertility score	pH score
Acid to Improved	31	IV & VII to III	n/a	up	up
Calcareous to Neutral			Too few		
Calcareous to Improved	5	IV to III	n/a	up	down
Calcareous to Arable			Too few		
Neutral to Improved	44	IV to III	n/a	up	n/a
Improved to Neutral	46	III to IV	n/a	down	n/a
Neutral to Arable	6	IV to I	up	up	n/a

Acid grassland to Improved grassland

Results – change in mapping codes

44 82% of the surveyed area that changed Broad Habitat allocation from acid to improved grassland did so based on change in species codes only (Figure 1.1). Of the remaining 18%, the majority showed a consistent pattern of primary code changes with Acid grassland (102) predominant in 1990 moving to unknown or Fertile agricultural grassland (101) in 1998 (Figure 1.1).

Figure 1.1 Proportion of surveyed area that changed Primary code or only changed in terms of species and minor codes

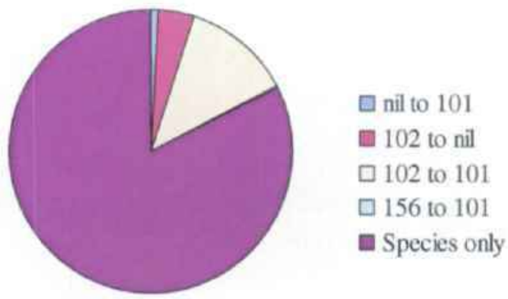
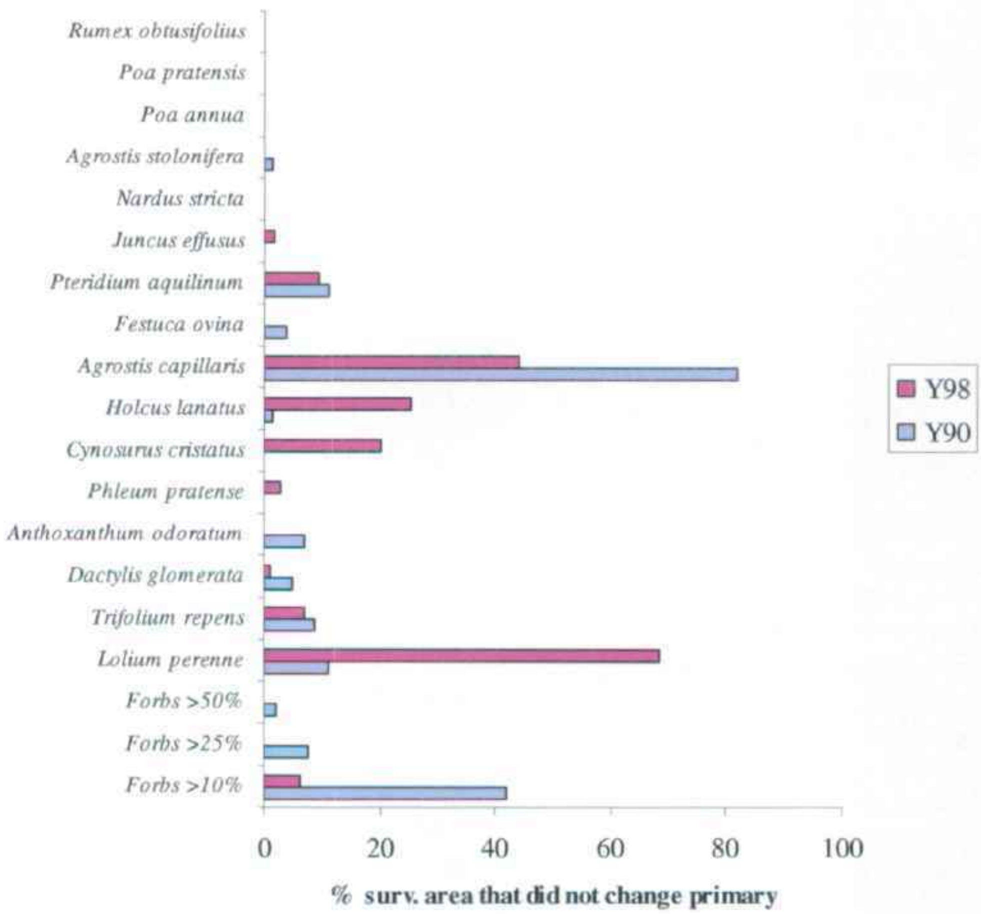


Figure 1.2 Contribution of change in species and other minor codes to the change in Broad Habitat. Proportions based on the surveyed area that did not see a change in Primary code.

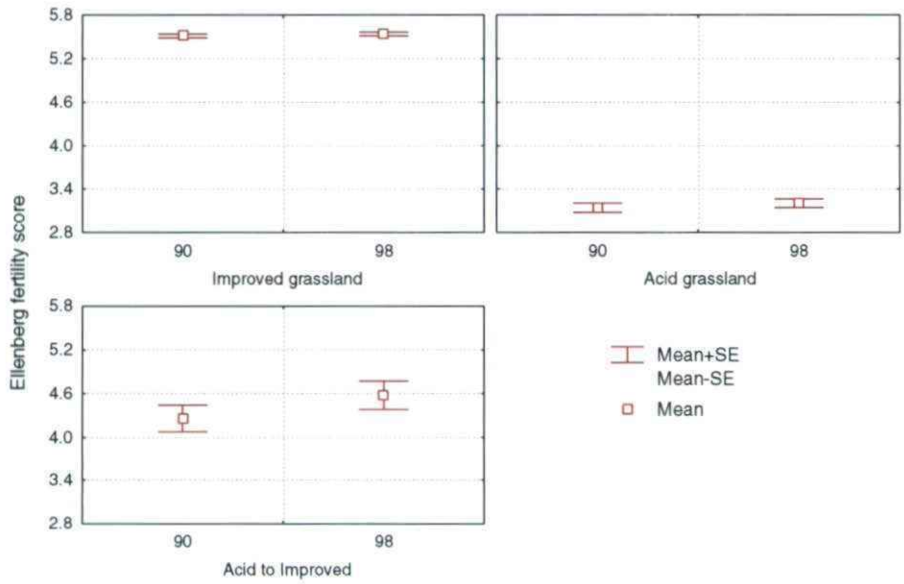


45 Changes in species codes were also largely consistent with the shift from acid to improved grassland with increases in recording of *Lolium perenne* suggesting sward improvement (Figure 1.2). However the decreases in *Anthoxanthum odoratum*, *Festuca ovina* and *Agrostis capillaris* but absence of decreases in more strict acid grassland dominants such as *Deschampsia flexuosa* and *Nardus stricta* suggest that the acid grasslands to have been affected do not include the least fertile and most acidic swards.

Results – change in condition measures

46 Change from acid to improved grassland would be expected to result in increased Ellenberg fertility and pH scores between 1990 and 1998. Moreover, mean scores in 1990 should be similar to the overall mean for stable acid grassland plots while scores in 1998 should be closer or at least be moving toward the mean typical of stable improved grassland in 1998.

Figure 1.3 Mean Ellenberg fertility score for vegetation plots in mapped parcels that either remained in Acid or Improved grassland Broad Habitat between surveys or moved from Acid to Improved grassland.



47 In fact both condition measures place the mean fertility and pH scores for plots in changing parcels, at the mid-point between the overall means for stable acid and improved grassland (Figs 1.3 & 1.5). Taken together with the modest increase in fertility score between 1990 and 1998, the results are consistent with the parcel change assessment in suggesting firstly, that the parcels concerned started out as semi-improved in 1990 and were therefore rather different from the core acid grassland represented in the CS vegetation data, and secondly that some continuing improvement did occur in the eight year interval but this still left parcels somewhat less improved than the bulk of improved grassland in 1998. The small magnitude of the floristic changes to have taken place is supported by the fact that only minor shifts in aggregate class occurred (Figure 1.4).

Figure 1.4 Aggregate class membership of plots in 1990 and '98 from parcels that moved from acid to improved grassland Broad Habitats.

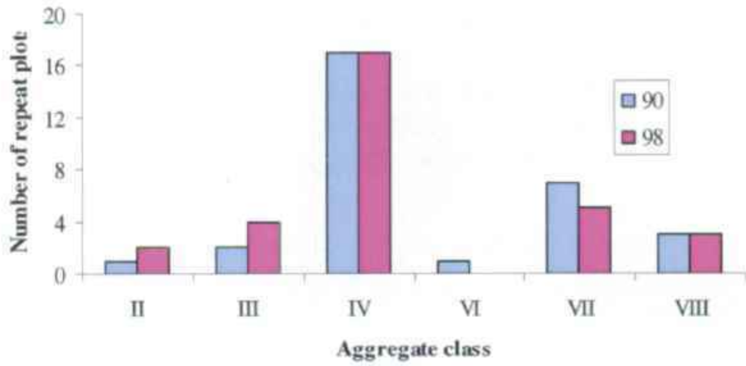
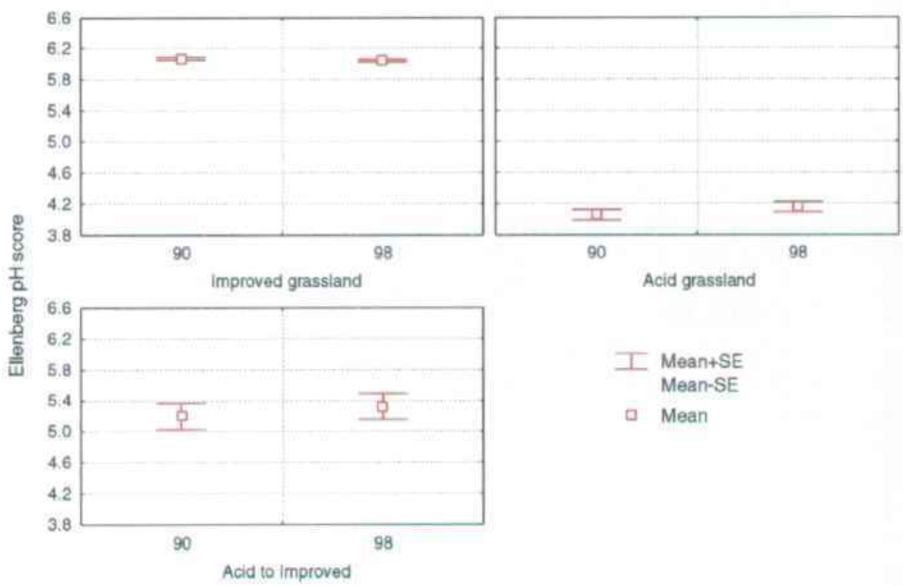


Figure 1.5 Mean Ellenberg pH score for vegetation plots in mapped parcels that either remained in Acid or Improved grassland Broad Habitat between surveys or moved from Acid to Improved grassland.



Conclusions

48 Changes in both mapping codes and plot condition measures are largely consistent with the change in area of Acid to Improved grassland. However, these data also suggest that the change has affected swards that were already partly improved by 1990, hence floristic change between surveys was relatively slight.

49 It therefore follows that the core of unimproved acid grassland was not involved in this change in Broad Habitat.

Calcareous to Neutral grassland

Results – change in mapping codes

50 The change involved only 2.3ha of surveyed land within one sample square in Environmental Zone 5 made up of a complex mosaic of cultivated, fallow and undisturbed machair. The square included the total amount of surveyed land in CS98 that shifted from calcareous to arable (see below). 65% of the change in Broad Habitat was based on parcels that changed primary code, most of which saw a consistent change from the calcareous grassland code (105) to tall-herb (134) although 18% of the total surveyed area had no primary code in 1990 and was tall-herb in 1998.

51 34% of the surveyed area did not change primary code or species code.

Results – change in condition measures

52 No plots were available for analyses of condition.

Conclusions

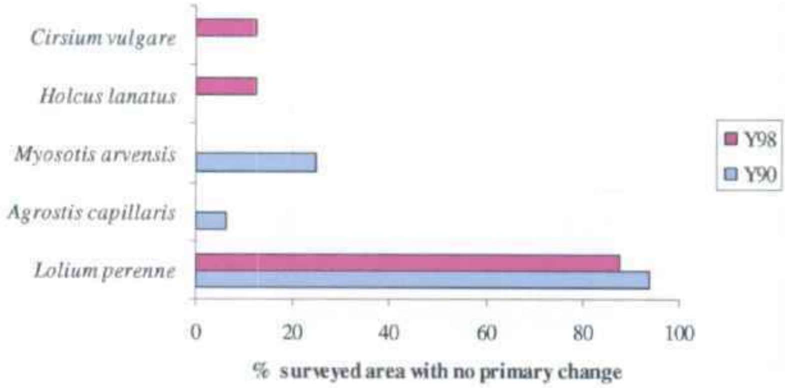
- Change was confined to one sample square.
- Although about half of the changing area remains unsupported by available mapping code data, there has been consistent primary code change in other parts of the square.
- The vegetation involved was restricted to calcareous, dune grassland.

Calcareous to Improved grassland

Results – change in mapping codes

53 A total of 9.7ha of surveyed area changed from calcareous to improved grassland Broad Habitat of which 45% involved a consistent change in primary code from calcareous grassland (105) to Fertile agricultural grass (101). Of the remaining surveyed area the primary code was 101 in both years of survey while the species data also showed no indication of an expected shift away from calcicolous vegetation rather appearing to be *Lolium* dominated in both 1990 and 1998 (Figure 1.6). These apparently inconsistent patterns of change were confined to the two squares in Environmental Zone 2. Changes in Environmental Zones 1 and 5 all appeared to be based on consistent change in primary code.

Figure 1.6 Changes in species code for surveyed land that did not show a change in primary code.



Results – change in condition measures

54 Because of the small area of surveyed land involved there were only 5 plots available, hence comparison of means with plots in stable parcels was not useful. However all of these repeat plots remained in aggregate class IV in both 90 and 98, hence any improvement that occurred in this subset of changing parcels, was not sufficient to shift the species composition into the semi-improved and improved swards of aggregate class III.

Conclusions

- Half of the mapped change is supported by primary code information.
- The small amount of available plot condition data does not suggest marked improvement rather overall stability at the aggregate class level.

Calcareous to Arable

Results – change in mapping codes

55 Here the change involved 25ha of surveyed land all confined to one survey square comprising a complex mosaic of cultivated, fallow and uncultivated machair grasslands in Environmental Zone 5. Mapped change in primary codes indicated a shift from calcareous grassland (105) to Barley (118) and Turnips/Swedes (121). Hence, primary code changes were consistent with the Broad Habitat change. No changes in species code were involved.

Results – change in condition measures

56 Change in parcel allocation was represented by one plot only, hence condition analyses were not possible.

Conclusions

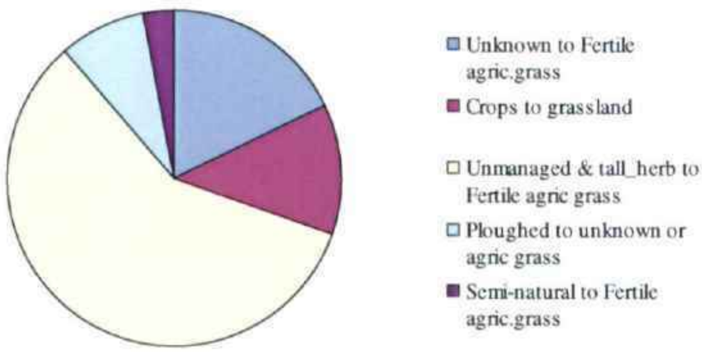
- Although very limited in extent the change in Broad Habitat is entirely consistent with mapping code data.

Neutral to Improved

Results – change in mapping codes

57 The change involved 314ha of surveyed land, 70% of which saw no change in primary code. 55% of the area that did change primary code saw consistent change largely from Unmanaged grass (133) and Tall-herb (134) to Fertile agricultural grass (101). A proportion (31%) of this area had inconsistent primary changes however. This was mainly due to primary codes being absent in 1990 or recorded in crop categories 1990 (Figure 1.7).

Figure 1.7 Primary code changes for parcels that moved from Neutral to Improved grassland Broad Habitat.



58 Parcel changes attributable to shifts in recorded species would be expected to show increases in *Lolium perenne* and *Trifolium repens* and this was indeed the case (Figure 1.8). Also consistent with an increase in the intensity of grassland management was the reduction in records for species such as *Anthoxanthum odoratum*, *Cynosurus cristatus*, *Festuca rubra* and *Agrostis capillaris*.

Results – change in condition measures

59 Interestingly, the sample of plots located in parcels that changed from neutral to improved grassland Broad Habitats started in 1990 with a lower fertility score than the overall mean for stable neutral grassland (Figure 1.10). Fertility score subsequently increased to 1998 but to a similar extent as the increase seen in the plots from stable parcels. The consequence is that plots in parcels newly recruited to the improved grassland Broad Habitat from neutral grassland have a mean fertility score that is still well below that typical of the majority of stable improved as well as stable neutral grasslands in the CS vegetation data.

60 Changes in aggregate class membership (Figure 1.9) were not dramatic but the increase in ACII (tall-herb/grass) and ACIII (Fertile grassland) at the expense of ACIV (Infertile grassland) are consistent with local improvement. Most plots however, remained stable.

Figure 1.8 Species code changes for parcels that changed from Neutral to Improved Broad Habitat but saw no change in primary code.

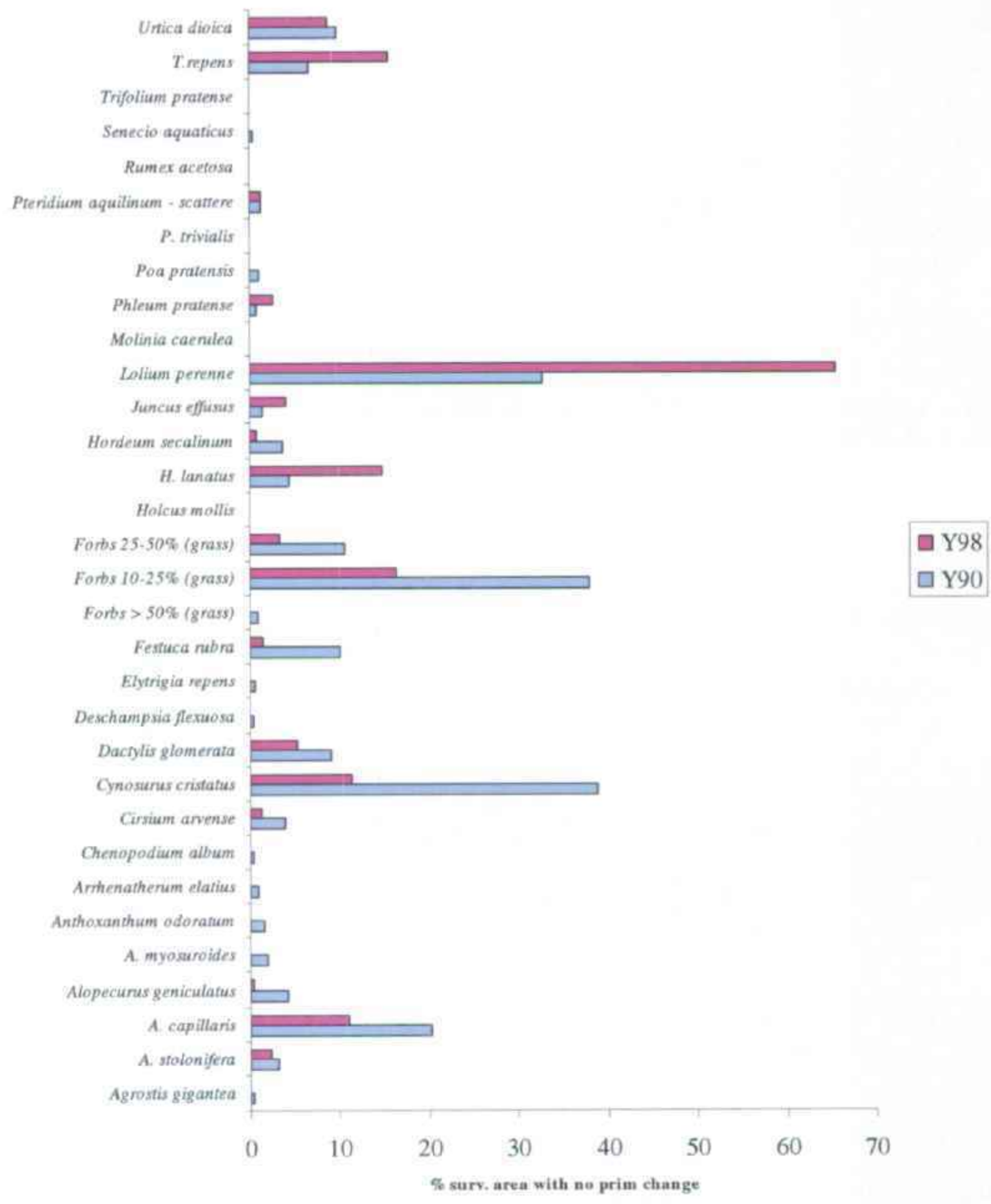


Figure 1.9 Aggregate class membership of plots in 1990 and '98 from parcels that moved from neutral to improved grassland Broad Habitats.

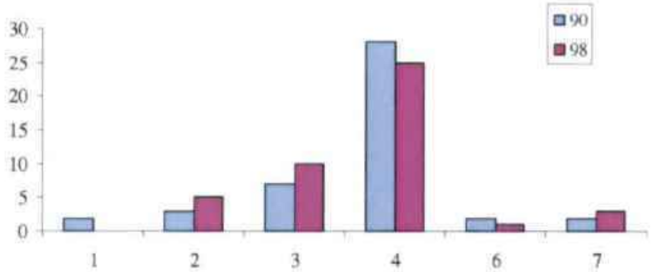
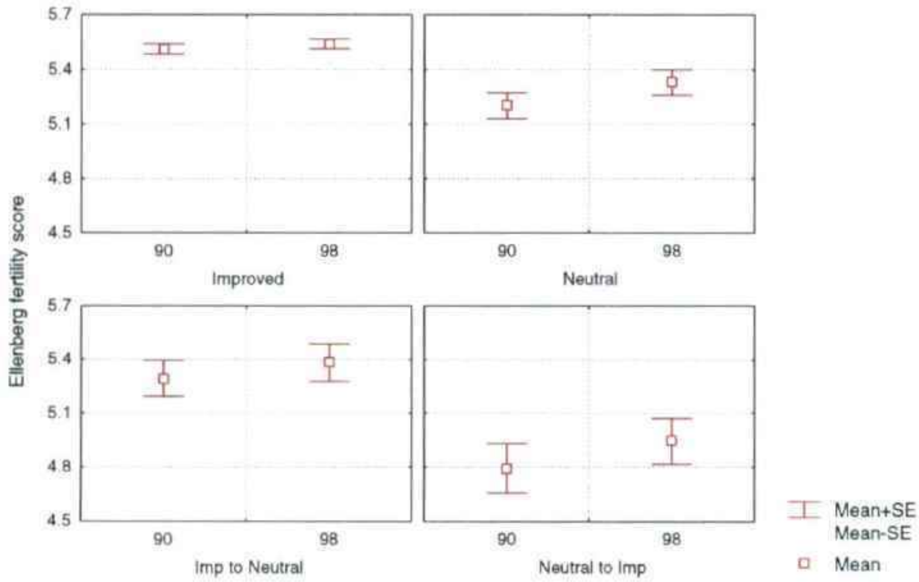


Figure 1.10 Mean Ellenberg fertility score for vegetation plots in mapped parcels that either remained in Neutral or Improved grassland Broad Habitat between surveys or moved between the two.



Conclusions

- Mapping code data generally support the shift from Neutral to Improved grassland for the majority of the surveyed land involved.
- Plot condition data was equivocal and suggested that floristic change had been slight.
- In spite of evidence for modest improvement, plot data from a subset of parcels that changed still had a much lower fertility score than the stable core of neutral grassland.
- A small proportion of semi-natural habitat (Fen & Acid grassland) was lost to Improved grassland but the majority started as unmanaged and tall-herb in 1990. These swards are likely to have had more in common with set-aside than established unimproved or semi-improved grasslands.

Neutral to Arable

Results – change in mapping codes

61 172ha of surveyed land changed from neutral grassland to the arable Broad Habitat between 1990 and 1998 of which 54% involved parcels that shifted primary code (Figure 1.11). About half these changes were consistent with expectation while half indicated that parcels were allocated to neutral grassland in 1990 even though their primary code indicated crops or ploughed land.

Figure 1.11 Proportion of surveyed land that saw primary code changes between 1990 and 1998.

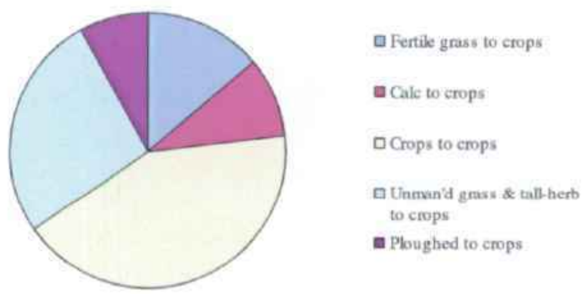
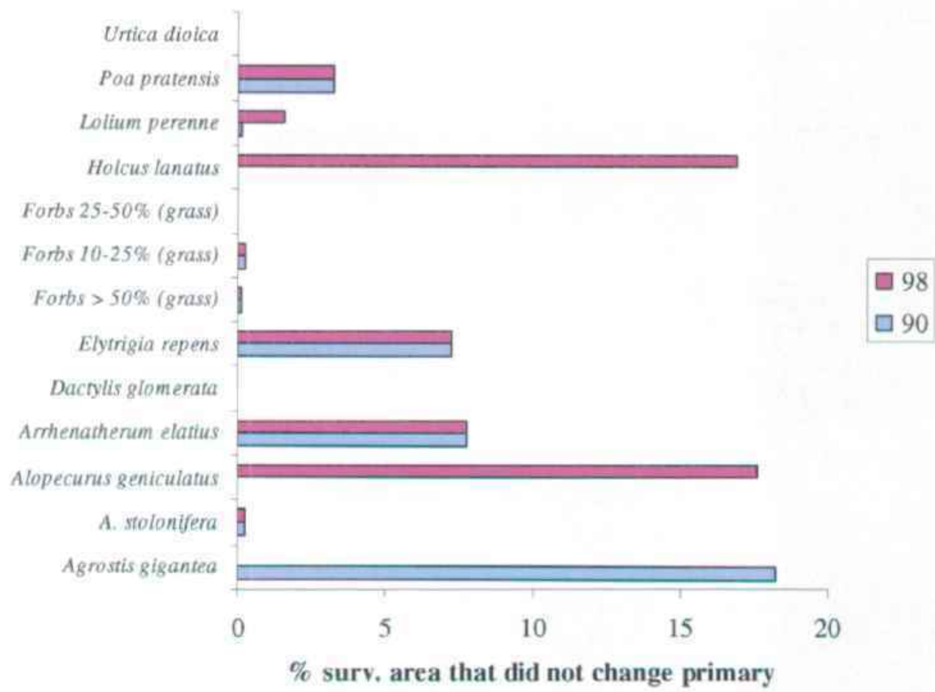


Figure 1.12 Species occurrences as a proportion of surveyed land that did not change primary code between 1990 and 1998.



62 Species changes also seemed to be inconsistent with an expected decline in mesophytic perennials. In fact both *Holcus lanatus* and *Alopecurus geniculatus* saw a marked increase in recorded occurrence while the arable weed *Agrostis gigantea* declined markedly (Figure 1.12). In any event, the vegetation starting point in 1990 seems far removed from unimproved, mesotrophic grassland.

Results – change in condition measures

63 Because of the small area of surveyed land involved there were only 6 plots available hence comparison of means with plots in stable parcels was not useful. Of these 6, all remained in the same aggregate classes between years with AC I (Crops/weeds) only represented by a single plot.

Conclusions

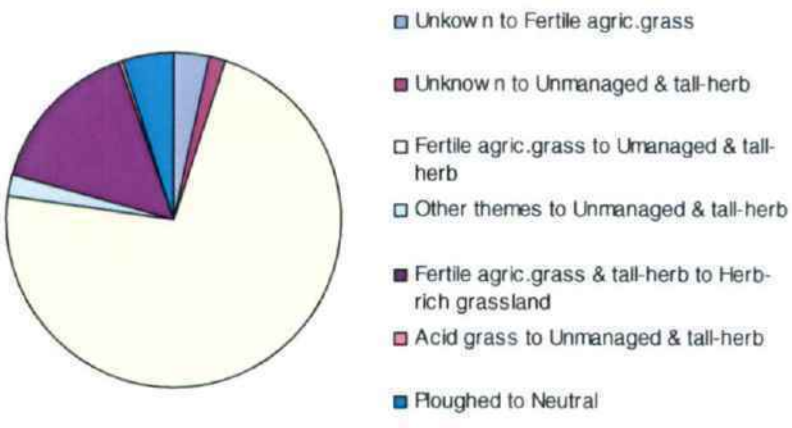
- The change on surveyed land from Neutral to Arable is not generally supported by available mapping code data for parcels that changed.
- Plot condition data was very limited. What little there was indicated floristic stability at the aggregate class level.

Improved to Neutral

Results – change in mapping codes

64 364ha of surveyed land changed from improved to neutral grassland between 1990 and 1998 of which 48% involved parcels that shifted primary code (Figure 1.13). The majority of this area saw consistent changes mainly involving Fertile agricultural grass to Unmanaged (133) and tall-herb (134). In addition, a significant fraction saw a net gain to Herb-rich grassland (171), a rare category that targets neutral grassland characterised by the presence of indicator species for the Lowland Meadows Priority Habitat (NVC=MG3, 4 & 5).

Figure 1.13 Proportion of surveyed land that saw primary code changes between 1990 and 1998.



65 Overall, species changes appeared to be consistent with the change in Broad Habitat with a marked decrease in records for *Lolium perenne* and *Trifolium repens* and increases in the

mesophytic grasses *Cynosurus cristatus*, *Anthoxanthum odoratum*, *Agrostis capillaris* and *Festuca rubra* (Figure 1.14).

Results – change in condition measures

66 Despite the consistency of the parcel mapping data with the direction of Broad Habitat change, the comparison of mean Ellenberg fertility scores for plots in parcels that changed from improved to neutral grassland showed a minor increase rather than an expected decrease (Figure 1.10). In fact the local shifts towards less improved grassland indicated by the mapping data, may not be well represented by available plot data. This is because only 20% of the total surveyed area that changed Broad Habitat comprised parcels with vegetation plots.

67 Of the 46 plots located in parcels that changed Broad Habitat, most remained stable in aggregate classes III and IV (Figure 1.15).

Figure 1.14. Species occurrences as a proportion of surveyed land that did not change primary code between 1990 and 1998.

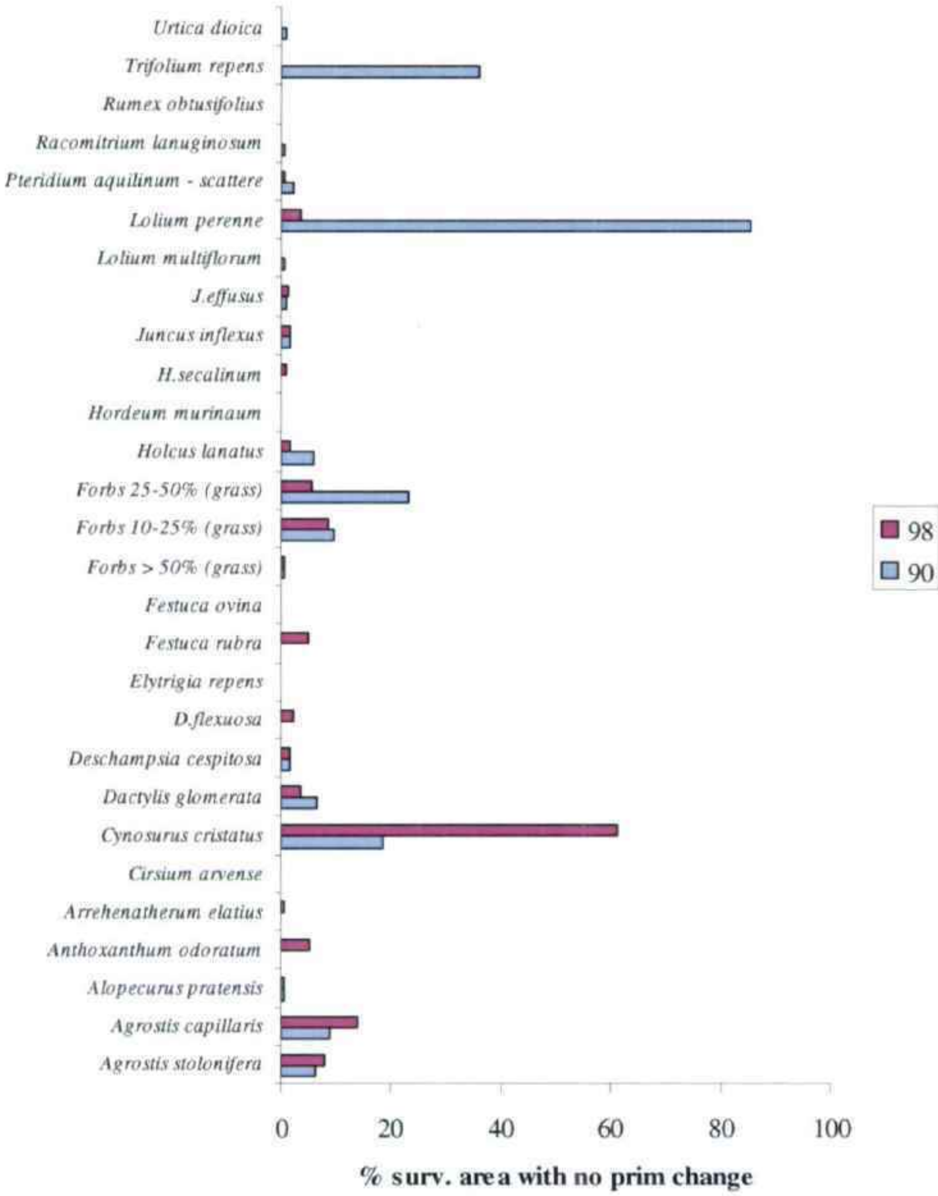
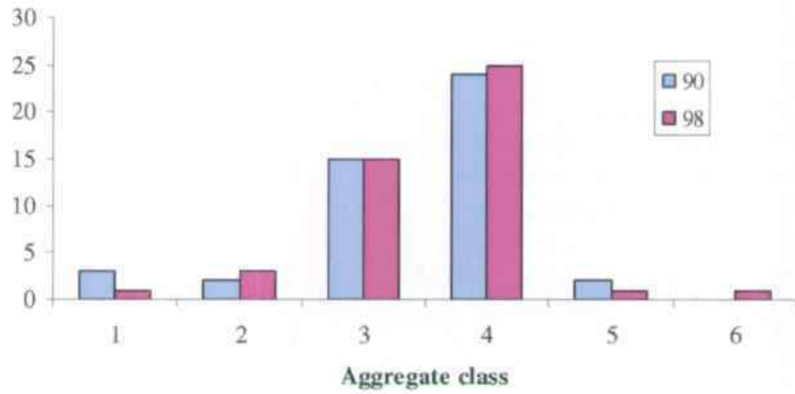


Figure 1.15. Aggregate class membership of plots in 1990 and '98 from parcels that moved from improved to neutral grassland Broad Habitats. N=46.



<u>Conclusions</u>

Changes in primary and species code data from the mapped parcels were consistent with the change in Broad Habitat area.

- Plot-based condition measures and mapping codes do however suggest that the newly recruited neutral grassland is likely to be more similar to fertile, non-rotational set-aside rather than unimproved, species rich meadow.

Part 2: Implications of change in extent and condition for biodiversity and management

Approach

68 Considerable net change and turnover in grassland Broad Habitats occurred between the 1990 and 1998 surveys. A key question is therefore to what extent these fluxes have involved 'high quality' grassland communities. Haines-Young et al (2000) showed that the improved and neutral Broad Habitats mapped during 1998 displayed much variation in terms of their constituent plant communities. It is therefore possible that losses of neutral grassland could have impacted swards relatively rich in characteristic species that would have been classified as lowland meadow priority habitat. Alternatively, losses and gains may comprise semi-improved swards of less significance in terms of BAP and HAP objectives.

69 In addition to the insights provided by the previous analyses of change in extent and condition, two further approaches were adopted to assess the likely quality of the semi-natural grassland Broad Habitats in 1990 and 1998. These were firstly, comparison of grassland vegetation plot data against ESA reference data of established botanical 'quality' and secondly, an NVC-based assessment of the likely representation of grassland priority habitats in CS plot data.

Comparison of CS vegetation plots against reference data of known quality

70 The rationale here is that aspects of the condition and hence, botanical quality of surveillance or monitoring data can be quantified and evaluated by comparison with plot data from plant

communities recognised to be of high conservation value given their status within designated sites such as SSSI or under agri-environment scheme agreements (eg. Critchley et al. 1999; Carey et al 2002; Smart 2000). Our goal was to compare the species composition and Ellenberg scores of plot data from semi-natural grassland Broad Habitats with reference data taken from the AEMA Archive of monitoring data for English agri-environment schemes. Reference data was selected from the Validation and ADAS Plot Method monitoring schemes for ESA. Criteria for selection were that each plot should have been assigned to any of the NVC communities included in the priority habitats; lowland calcareous grassland, lowland dry acid grassland, lowland meadows and upland hay meadows (see Annex 1.1). These data were then compared with CS plots sampled in the acid grassland, calcareous grassland and neutral grassland Broad Habitats in 1990 and '98. Assessments of differences in species composition were carried out using an index that measures compositional similarity between two or more groups of samples but takes into account the existing strength of the similarity between plots within each reference and target group (see Phillipi et al 1998; Clarke, 1993). Differences in mean condition measures (Ellenberg scores for fertility, light and species richness) were also assessed.

Results – ESA versus CS neutral grassland Broad Habitat

71 A total of 38 plots were selected from the ESA archive (Table 1.4a). Such a low number reflected efforts to avoid artificially inflating similarity between ESA plots that would have resulted from selecting plots sampled from within the same field. CS plots located in the neutral grassland Broad Habitat were more numerous (Table 1.4b). All eight aggregate classes of the Countryside Vegetation System (Bunce et al 1999) were represented in the CS data illustrating the heterogeneity that typified mapped Broad Habitat parcels in the countryside surveys. For the purposes of the calibration exercise and reflecting small sample numbers among the other aggregate classes, only II (Tall-herb/grassland), III (Fertile grassland) and IV (Infertile grassland) were analysed.

Table 1.4 Numbers of plots sampled in parcels assigned a) to the neutral grassland Broad Habitat in CS90 and CS98 and b), to community units of the National Vegetation Classification in English ESA monitoring data.

a)

Aggregate class	90	98
I	6	8
II	**62**	**98**
III	**44**	**54**
IV	**161**	**180**
V	2	4
VI	17	17
VII	15	16
VIII	2	6
Total plots	309	383

b)

NVC community	N
MG3	19
MG8	12
MG5	4
MG4	3
Total plots	38

72 Two analyses of differences in species composition were carried out (Table 1.5). Firstly, similarity was tested between ESA reference data and all CS plots in the richer, unimproved grassland communities of aggregate class IV. Results showed that the mean similarity between ESA and CS plots was significantly greater than the mean similarity within each group. However both between and within-group similarities were very low (0.07 and 0.13

respectively[9]) indicating marked floristic differences between ESA and CS data but a also a great deal of heterogeneity largely within the CS dataset. To some extent, this was not surprising since aggregate class IV is known to include a diverse range of wet to dry and basic to circum-neutral herbaceous communities.

73 Secondly, ESA reference data for neutral grassland priority habitats was also compared with a dataset combining CS plots from neutral grassland parcels that were referable to the more fertile aggregate classes II and III. Unsurprisingly, ESA data was significantly dissimilar to this subset of improved and semi-improved, neutral grassland plots. These results show that over a third of the neutral grassland plots in '90 and '98 were floristically quite different to priority habitat neutral grasslands while the majority of ACIV plots clearly include some that are comparable.

Table 1.5 Results of testing for differences in mean similarity coefficient between ESA reference data for neutral grassland priority habitats and plots sampled in the CS neutral grassland Broad Habitat in 1998. Similarity based on central 2x2m nest of CS X plots only.

Comparison	Test statistic (Clarke's R)	Significance level
II & III v. ESA	-0.12	0.001
IV v. ESA	0.31	0.001

74 Comparison of condition measures between all CS neutral grassland plots and the ESA reference data showed a clear pattern. ESA plots were more species rich and likely to have a greater abundance of shade-intolerant plant species more often found under less fertile conditions (Figure 1.16). Moreover, changes in mean condition measures for the CS neutral grassland plots between 1990 and 1998 translated into a move further away from the average for the ESA reference for all three condition scores (Figure 1.16).

[9] The similarity coefficient ranges between 0 and 1 where 1 indicates that every species in plot A was also in plot B and *vice versa*.

Figure 1.16 A comparison of three condition measures between CS plots in the neutral grassland Broad Habitat and 38 ESA reference plots for neutral grassland priority habitats.

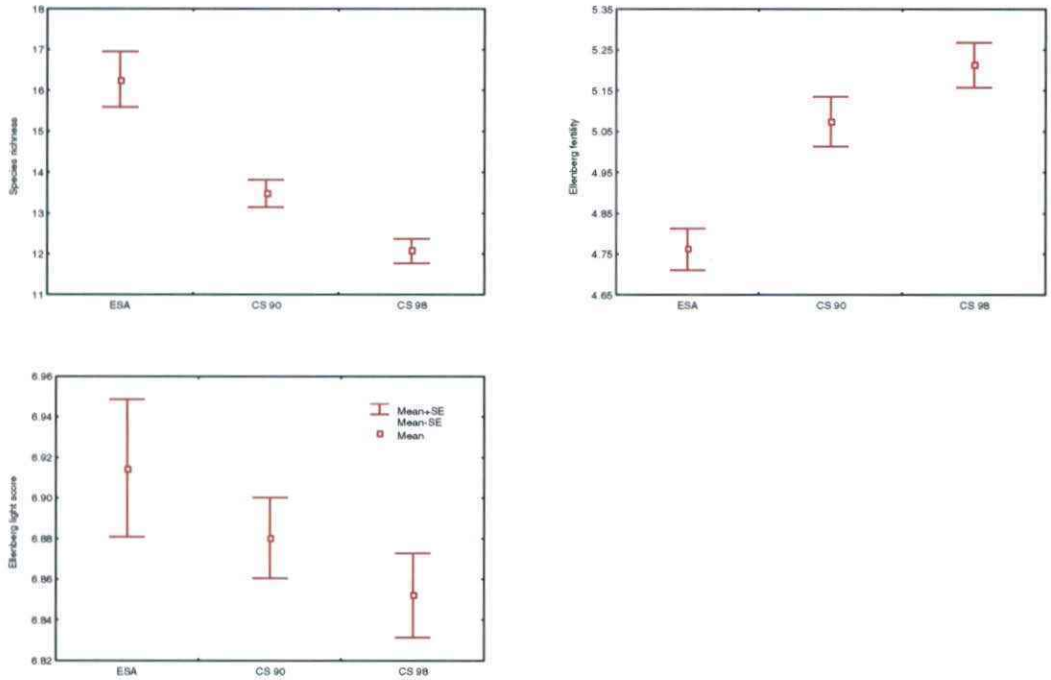


Figure 1.17 A comparison of Ellenberg fertility scores between CS plots in the neutral grassland Broad Habitat and ESA reference plots for neutral grassland priority habitats plus 52 ESA plots sampled in semi-improved MG6. CS plots have been broken down by aggregate classes II, III or IV.

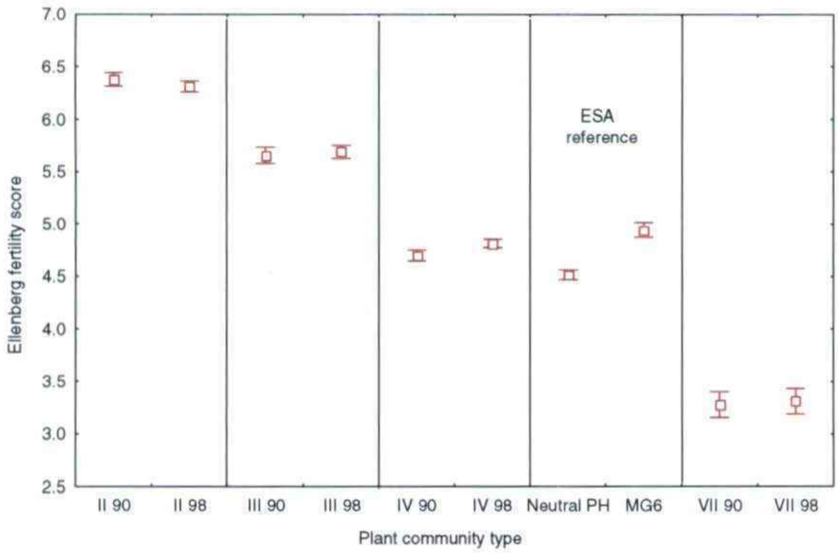
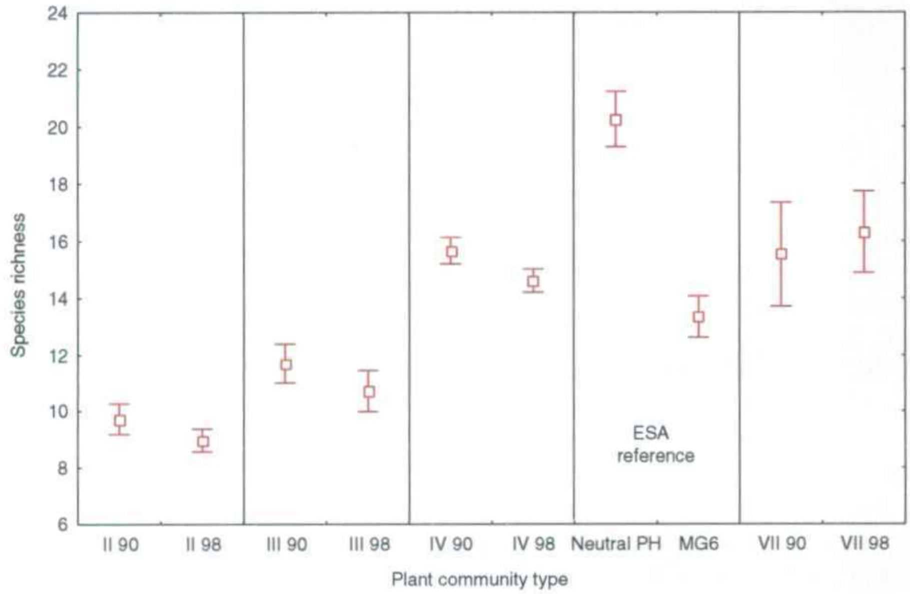


Figure 1.18 A comparison of species richness values between CS plots in the neutral grassland Broad Habitat and ESA reference plots for neutral grassland priority habitats plus 52 ESA plots sampled in semi-improved MG6. CS plots have been broken down by aggregate classes II, III and IV.



75 When broken down by plant community type the aggregate class IV CS plots were closest in terms of mean Ellenberg fertility to the ESA priority habitat plots although also relatively close to the ESA reference data for the semi-improved MG6 *Lolium perenne-Cynosurus cristatus* grassland (Figure 1.17). The small number of moorland grass/mosaic (VII) CS plots showed the lowest fertility score while the typically productive swards of ACII and III showed the highest scores. Comparison of mean species richness also revealed marked differences between ESA reference data and CS neutral grassland plots (Figure 1.18). ESA quadrats representing the neutral grassland priority habitats were, on average, 25% richer than ACIV plots for the CS90 data. However, despite the reduction in mean richness between 1990 and 1998, the ACIV plots still had a higher mean richness than the 'good quality' MG6 from the ESA database.

Results – ESA versus CS calcareous grassland Broad Habitat

76 Comparisons between CS plots located in the calcareous grassland Broad Habitat parcels and ESA reference data were based on 50 plots from English ESA all on chalk in southern England and referable to the CG2 *Festuca ovina-Avenula pratensis* plant community (Table 1.6). Because of the absence of machair grassland and communities on northern limestone in the ESA archive, matching was based only on CS plots from the lowland Environmental Zones 1 and 2 in England & Wales.

77 A test of difference in species compositional similarity showed that the ESA and CS plot data were significantly different (Table 1.7). Further cross-calibration should be based on additional reference data from other CG plant communities included in the priority habitat.

78 Comparisons of mean condition measures showed that species richness differed markedly between the ESA and CS plots. In fact CG2 is typically, highly species dense and, in this respect, it is perhaps not surprising to see such a high degree of difference (Rodwell 1992).

Table 1.6 Numbers of plots sampled in parcels assigned a) to the calcareous grassland Broad Habitat in CS90 and CS98 and b), to community units of the National Vegetation Classification in English ESA monitoring data.

a)

Aggregate class	90	98
III	0	1
IV	31	25
V	0	1
VII	5	3
Total plots	36	30

b)

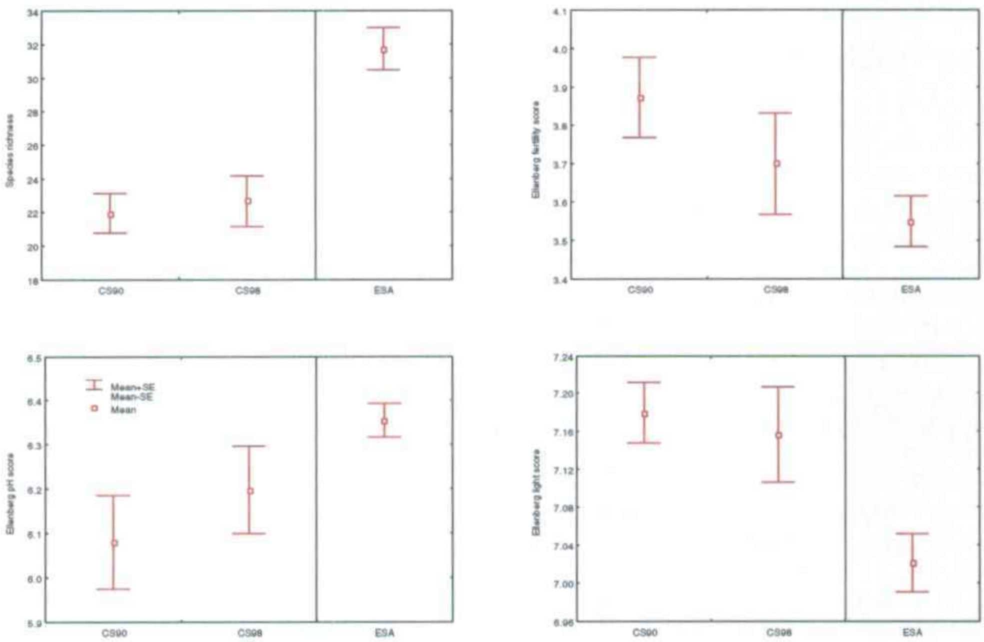
NVC community	N
CG2	50

Table 1.7 Results of testing for differences in mean similarity coefficient between ESA reference data for neutral grassland priority habitats and plots sampled in the CS neutral grassland Broad Habitat in 1998. Similarity based on central 2x2m nest of CS X plots only.

Comparison	Test statistic (Clarke's R)	Significance level
CS v. ESA	0.55	0.001

79 In addition, CS plots tended to have higher mean light and fertility scores and lower pH scores. The change between 1990 and 1998 however brought the mean values for all three Ellenberg scores for CS plots closer to the mean for the ESA reference (Figure 1.19).

Figure 1.19 A comparison of three condition measures between CS plots recorded in the calcareous grassland Broad Habitat and 50 ESA reference plots for the lowland calcareous grassland priority habitat (CG2 only).



Results – ESA versus CS acid grassland Broad Habitat

80 Too few plots representative of lowland dry acid grassland were available in the ESA archive to allow meaningful comparison.

Conclusions

- Comparison of ESA and CS data were limited in scope because not all semi-natural grassland priority habitats were adequately represented in the ESA archive.
- The comparisons between CS plots from neutral grassland Broad Habitat parcels and plots from neutral grassland priority habitats in English ESA showed that neutral grassland priority habitats may be represented in the CS data but floristic similarity is on average extremely low because of the high variation in species composition associated with the infertile grassland of aggregate class IV. Also, about a third of the CS neutral grassland Broad Habitat plots are from semi-improved or improved communities and are floristically very dissimilar to the ESA reference data.
- CS neutral grassland plots also had species compositions associated with higher fertility and more shade compared to ESA data. Species richness was also markedly lower than ESA data.
- Change in CS neutral grassland plots between 1990 and 1998 moved mean condition measures even further from the ESA reference.

- Comparison of CS plots from calcareous grassland Broad Habitat parcels and ESA calcareous grassland was limited to CS plots in lowland England and Wales and to the CG2 community as represented in ESA data from the South Downs and South Wessex Downs.
- CS plots were highly dissimilar to the ESA plots although change between '90 and '98 moved mean condition measures closer to the ESA values.

Representation of Priority Habitats in CS plot data from semi-natural grassland Broad Habitats

81 Repeat plots that were located in the three semi-natural grassland Broad Habitats in either 1990 or 1998 were selected. Only area plots (X and Y) were selected consistent with the exclusion of the linear Broad Habitats. Only data from the central 4m2 nest of each X plot was used so as to match dimensions between X and Y plots.

82 Botanical data were allocated to the units of the NVC (Rodwell 1992) using the MAVIS software. Although widely and justifiably recognised as a poor substitute for expert judgement (eg. Palmer 1991), we implemented an objective and hence repeatable rule for selecting a single best-fitting community unit. Each plot was assigned to the community unit that appeared most often in the list of top ten coefficients. If tied, then the top coefficient was chosen.

83 Links between priority habitats and NVC communities were based on published information from the relevant Habitat Action Plans (see Annex 1.1). In addition, NVC units other than those within each priority habitat were treated as groups of communities or kept separate (Table 1.8).

Table 1.8 NVC community groups and key to figure 20.

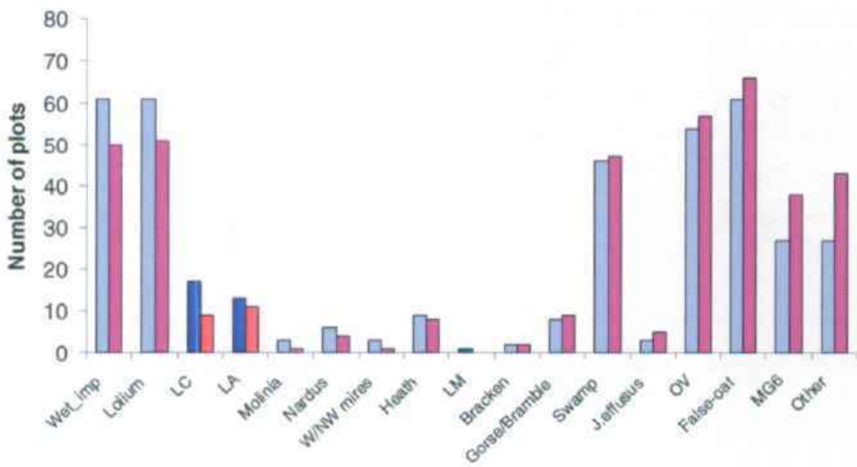
Group name	**NVC communities and priority habitats**
J. effusus	M23 *Juncus effusus-Cirsium palustre* rush pasture
Molinia	M25 *Molinia caerulea-Potentilla erecta* mire
Swamp	All swamp communities
Heath	All heath communities
Wet_imp	*Seasonally wet, mesotrophic grasslands: MG9 Holcus lanatus-Deschampsia cespitosa grassland, MG10 Holcus lanatus-Juncus effusus rush-pasture, MG11 Festuca rubra-Agrostis stolonifera-Potentilla anserina grassland*
Lolium	*MG7 Lolium perenne leys and related grassland*
False-oat	MG1 *Arrhenatherum elatius* grassland
Gorse/Bramble	W23 *Ulex europaeus-Rubus fruticosus* scrub
Bracken	U20 *Pteridium aquilinum-Galium saxatile* community
Nardus	U5 *Nardus stricta-Galium saxatile* grassland
W/NW mires	M15 *Trichophorum cespitosum-Erica tetralix* wet heath, M17 *Trichophorum cespitosum-Eriophorum vaginatum* blanket mire
OV	Other Vegetation plus a small number of sand-dune and maritime cliff communities
LA	Lowland dry acid grassland priority habitat
LC	Lowland calcareous grassland priority habitat
UC	Upland calcareous grassland priority habitat
LM	Lowland hay meadow priority habitat

Results

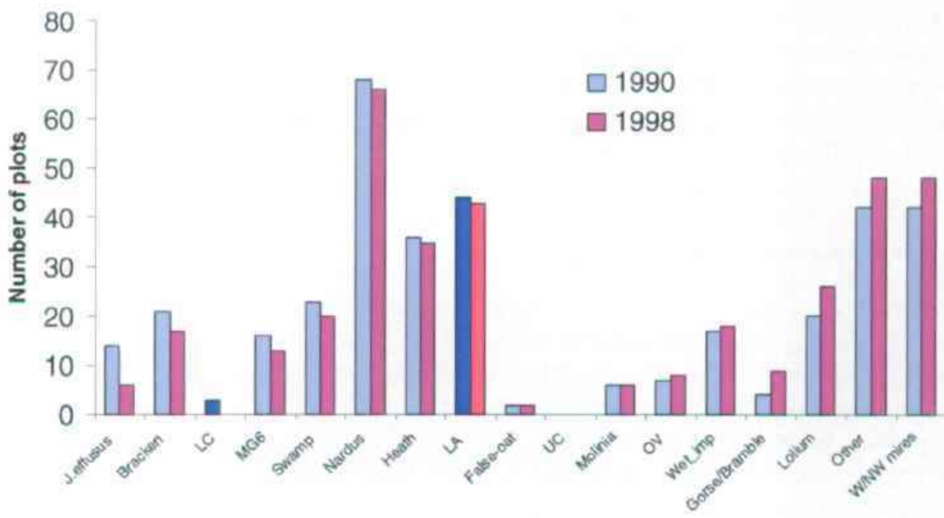
84 All the grassland priority habitats are extremely scarce in CS plot data that coincide with the semi-natural grassland Broad Habitats. Lowland meadow plots were the scarcest of the priority habitats in the lowland subset (Figure 1.20a) while upland calcareous grassland and upland hay meadow were both absent from the upland subset (Figure 1.20b). Predictably, the uplands supported a far greater extent of communities referable to lowland acid grassland than the lowland Environmental Zones. This merely highlights the difference in applying geographical location rather than just species composition, as a criterion in defining the priority habitats.

Figure 1.20 Representation of priority semi-natural grassland habitats and other NVC communities in plots that were located in either acid, neutral or calcareous grassland Broad Habitats in 1990 or 1998. Bright red and blue bars denote priority habitats.

a) Lowlands – Environmental Zones 1,2 and 4



b) Uplands(Environmental Zones 3, 5 and 6)



85 Inferring the importance of processes of Broad Habitat change from these data must be done cautiously given the partial sampling of parcels of land-cover by vegetation plots. However, the patterns of change in allocation of plots between 1990 and 1998 seem to suggest that there has been little net gain to late-successional bracken, scrub or woodland vegetation. Also, the small losses of lowland acid and calcareous grassland in the lowland Environmental Zones are consistent with net loss in area of the respective Broad Habitats in lowland GB (Haines-Young et al 2000).

Conclusions

- The results should be treated cautiously given known problems with relying on matching software to determine the 'correct' match.
- However, the results are consistent with the ESA cross-comparison in that, with the exception of lowland dry acid grassland in the uplands, plots that matched with the semi-natural grassland priority habitats were very rare in CS data.
- In lowland CS plots from semi-natural grassland Broad Habitats, the most common matches were for the wetter semi-improved grasslands MG9, 10 and 11 plus the improved grassland of MG7 and the less intensively managed but often fertile MG1.
- In upland plots the highest matches were for U5, a range of Heath communities and the group of NVC units that make up the lowland dry acid grassland priority habitat.

Lowland linear plots as refuges for the building blocks of neutral grassland priority habitats

86 The final part of this assessment of the causes and significance of ecological change in semi-natural grasslands focuses on the potential role of the linear network as a refuge for plant species most characteristic of the grassland priority habitats. This issue is important because earlier work comparing the 78 to 90 data (Bunce et al 1999; Smart et al. 2002) showed that linear features were much more likely to support occurrences of acidic, mesotrophic and calcareous grassland indicators than adjacent fields. This polarisation of diversity was also most marked in the marginal uplands and the grassland dominated pastural lowlands of Britain (Bunce et al 1999). The potential refuge function of the linear network is important to revisit because the signals of both eutrophication and succession have continued to be detected on linear features, hence the differences between linear and area features seen in 1990 may have been lessened by the impact of these processes on the linear network. Reductions in species richness per se have already been quantified for linear plots between 1990 and 1998 (Haines-Young et al 2000; Smart et al in press) but here we target indicator species just for the lowland and upland meadow priority habitats and ask whether recent changes have reduced the proportion of different types of plots in different Environmental Zones that could be expected to support a significant number of indicators.

87 The approach used was the same as that carried out in the EcoFact program where the goal was to determine for a group of indicator species, the location in the landscape where the highest number of plots were likely to support the highest number of indicator species. This work was exploratory in nature. While hopefully producing meaningful results that would help quantify the restoration potential of linear features, the work was also a further development of the EcoFact approach, with no guarantee that it would ultimately be the best approach to adopt in addressing the science and policy issues involved.

Methods

88 Indicator species for the lowland and upland meadow priority habitats were included as follows:

a) All species present in published tables for the NVC units MG3,4,5 and 8 that had a constancy value of 3 or greater.

b) Species that satisfied a) but that were also frequent in semi-improved and improved grasslands were manually deleted.

c) All species were included that were listed as strict mesotrophic grassland indicators in the unpublished England Field Unit list (see Bunce et al 1999).

89 The richness of this final pool of species was measured for each CS repeat plot in 1990 and 1998 data including linear and area plots but taking only records from the second nested (5x5m) quadrat in each X plot.

90 A 'desirable' richness value was then selected. This value had to be high enough to include residual plant assemblages of sufficient richness to be of some practical significance either as a resource to be potentially exploited for propagules, or as a resource to be valued in its own right. Two further requirements were that the target richness value should be taken from similar size quadrats as the CS linear plots, and that it should realistically reflect the maximum richness of these indicators that could be expected in linear plots. As a result, we selected the mean richness of indicators in the boundary plots used in the study reported in Smart et al (2002). This mean was calculated using only boundary plots next to fields containing MG3 and MG5. The target mean richness was 22 indicators per CS plot.

91 The percentage of plots that should contain at least 22 indicators was estimated for each plot type and Environmental Zone combination. Environmental Zones 5 and 6 in Scotland were excluded because of known biases in the EFU indicator list and the absence of a Scottish indicator list.

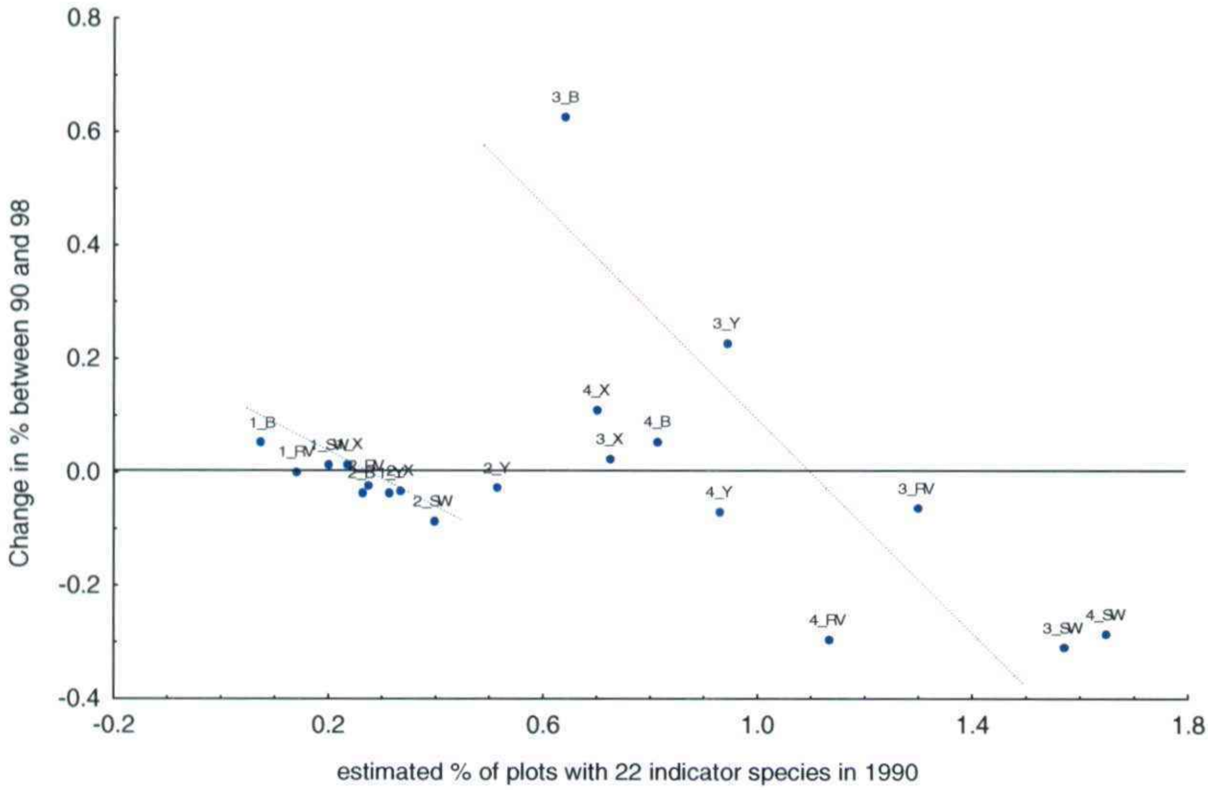
92 Estimation was carried out by firstly generating a linear regression equation of $\log_{10}$ (% of plots in the plot Environmental Zone combination) onto $\log_{10}$ (richness of indicator species per plot) for each plot Environmental Zone combination. This equation was then used to derive the proportion of plots with at least 22 indicator species.

93 The estimation exercise was carried out separately for 1990 and 1998 and the results compared.

Results

94 Very low percentages of CS plots are estimated to support the target richness value of 22 neutral grassland indicators. The greater likelihood of finding indicator-rich assemblages on linear features rather than fields and small patches (Y plots) is clearly shown although there is a large influence of Environmental Zone. The highest expected percentages of indicator-rich plots in 1990 were associated with streamsides and road verges in the Scottish lowland Environmental Zone 4 and the upland Environmental Zone 3 in England & Wales (Figure 1.21). Plot locations in Environmental Zones 1 and 2 were all lower than Environmental Zones 3 and 4 with field plots in Environmental Zones 3 and 4 still exceeding all linear locations in Environmental Zones 1 and 2.

Figure 1.21 Change in the refuge function of linear versus area features between 1990 and 1998. The x-axis indicates the percentage of plots in each stratum that were estimated to support 22 indicator species for the lowland and upland meadow priority habitats. Two lines of best fit have been added by hand – see text.



95 Between 1990 and 1998, change in the expected percentage of indicator-rich plots affected Environmental Zones 3 and 4 much more than Environmental Zones 1 and 2. However the pattern of these shifts is suspect as well as intriguing (Figure 1.21). Known changes in condition measures for these plot and Environmental Zone locations do not help explain either the differences in direction of change or the fact that Environmental Zones 1 and 2 seem to show less change than Environmental Zones 3 and 4. Decreases in mean species richness, increases in fertility score and decreases in light score are known to have occurred across the majority of lowland linear plot types but with most stability in fact associated with Environmental Zones 3 and 4. Therefore the different trajectories between Environmental Zones and plot types within Environmental Zones 3 and 4 remains hard to explain. In practice however, the magnitude of changes made little difference to the overall ranking so that in 1998, streamsides and road verges in Environmental Zones 3 and 4 were still the locations estimated to have the highest proportion of indicator-rich patches.

Conclusions

- This approach to assessment of the refuge potential of linear features has some promise but requires further work in particular to examine change in estimated proportions of indicator-rich plots.

- Plots with at least 22 indicator species were rare in all Environmental Zones and linear features but the richest patches are likely to be most common on streamsides and road verges in the uplands of England & Wales and the Scottish lowlands. Zones 5 and 6 were omitted.

SUMMARY

Change in extent and condition

- Published changes in national extent of the semi-natural grassland Broad Habitats were derived from an automated allocation of parcels of surveyed land in sample squares. These changes were revisited by examining field mapping code data for the 1990 and 1998 surveys.
- The majority of the change to and from grassland Broad Habitats appeared to reflect real change in land-cover, however condition measure data from plots within subsets of changing parcels showed that actual changes in species composition were often slight although mainly consistent with expectation given the type of Broad Habitat change.
- In particular, losses of acid grassland appeared to involve vegetation already showing floristic signs of improvement in 1990 and therefore unrepresentative of core, unimproved acid grassland
- Losses from neutral grassland included a reduction in infertile, unimproved grassland. This amounted to 5% of the surveyed area of land that changed from neutral to improved. However, the majority of the loss from neutral to improved and arable seemed to be from vegetation more similar to fallow, non-rotational set-aside in 1990.
- Gains to neutral from improved grassland also reflected the reverse of the above, with replacement of intensive *Lolium* dominated grassland in 1990 by swards more similar to fallow, arable land in 1998. However, about 15% of the surveyed area that was gained to neutral from improved, was mapped as herb-rich grassland, a rarely used mapping code that targeted grassland rich in indicator species for the lowland meadow priority habitat. Further investigation of these locations is desirable. Overall the majority of the change from improved to neutral did seem to reflect a shift from improved to less-improved grassland.
- The reasons for turnover and loss of calcareous grassland were difficult to ascertain for Environmental Zones 1 and 2. However, the reduction in extent recorded in Environmental Zone 5 was clearly attributable to cultivation of machair, dune grassland. Hence, there was no evidence that plant communities referable to the upland calcareous grassland priority habitat had been affected.

Implications of change in extent and condition for biodiversity and management

- Two methods were used to assess the representation of high conservation value grassland within the semi-natural grassland Broad Habitat sampled by CS squares in 1990 and 1998.
- A comparison was made with reference data from English ESA that represented the lowland meadow, upland hay meadow and lowland calcareous grassland priority habitats. CS calcareous grassland was highly dissimilar to ESA reference data in terms of floristic similarity and condition measures including Ellenberg fertility and species richness. However, the comparison was only based on CS plots from England compared with the CG2 community type based on plots from ESA on the southern English chalk. This reflected the limitation of available ESA data.

- Mean condition values for CS plots in calcareous grassland moved closer to means for the ESA reference between 1990 and 1998.
- Comparisons of CS neutral grassland plots with ESA reference data showed that a small number of CS plots in the infertile grassland aggregate class were floristically similar to the ESA reference data but the majority were highly dissimilar to ESA plots.
- CS neutral grassland plots also had species compositions associated with higher fertility and greater shade compared to ESA data. Species richness was also markedly lower than ESA data.
- Change in CS neutral grassland plots between 1990 and 1998 moved mean condition measures even further from the ESA reference dataset.
- An NVC matching exercise also highlighted the scarcity of priority habitat plant communities in CS plots. In upland CS plots in semi-natural grassland Broad Habitats, no matches were found with either upland hay meadow or upland calcareous grassland communities.
- In lowland CS plots, lowland meadow, lowland acid grassland and lowland calcareous grassland were all extremely rare.
- Following previous work on the issue of linear features as potential refuges of characteristic grassland species, an assessment was carried out to determine whether characteristic species for the lowland meadow priority habitat were more abundant in linear plots than in adjacent fields.
- Results showed that road verges and streamside plots in upland England & Wales and in the Scottish lowlands were the richest locations for indicator species. In lowland England & Wales, streamsides and small semi-natural habitat fragments were the richest locations. Changes between 1990 and 1998 require further investigation.

FURTHER WORK AND RECOMMENDED CHANGES TO CS METHODS

96 The significance of change: Large scale agri-env schemes rely for success on responsive starting points ie. some residual biota being present to respond to managed amelioration of intensive land management. If 'broad-shallow' schemes are expected to roll-out across the wider countryside then a more realistic appraisal of their performance in generating biodiversity gains would come from an assessment of the abundance of residual fragments of priority habitat assemblages. Hence, it would be worth revisiting proposals for locating patches of vegetation in a subset of squares referrable to a list of named and regionally specific NVC plant communities drawn up by local EN/SNH/CCW staff.

97 In light of the new agri-env scheme, ongoing commitments to BAP objectives and the new waters directive it might also be worth considering revisting some or all key habitat squares in parallel with the next Countryside Survey

98 Causes of change: 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. Advances are needed on the methodological frontier rather than new data gathering, since to a large extent these other datasets already exist.

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ANNEX 1.1

Representation of Priority Habitats and corresponding NVC units in the semi-natural grassland Broad Habitats.

NVC community lists for each Priority Habitat taken from the respective Habitat Action Plan[10]

	Neutral Grassland		Calcareous Grassland		
NVC unit	Lowland meadows	Upland hay meadows	Lowland calcareous grassland	Upland calcareous grassland	Lowland dry acid grassland
CG1			✓		
CG2			✓		
CG3			✓		
CG4			✓		
CG5			✓		
CG6			✓		
CG7			✓		
CG8			✓		
CG9			✓	✓	
CG10				✓	
CG11				✓	
CG12				✓	
CG13				✓	
CG14				✓	
U1					✓
U2					✓
U3					✓
U4					✓
MG3		✓			
MG4	✓				
MG5	✓				
MG8	✓				

[10] See action plan text at http://www.ukbap.org.uk/species.htm

Question 2: What was the amount and character, in terms of Broad Habitat, parcel size and location of land that was recorded as newly cultivated in CS2000?

DRAFT FINAL REPORT - ***Dr Sandrine Petit & Simon Smart***

DUE START DATE:

- March 2002

DUE FINISH DATE:

- June 2002

OVERALL PROGRESS

99 This is the final report.

DEFINITIONS

100 One important point is that users were not just concerned about conversion to arable land but, rather, about loss of uncultivated land due to agricultural improvements generally and this can include conversion to improved grassland. Cultivated land is therefore defined as the two Broad Habitat types Arable & horticultural (BH4) and Improved grassland (BH5) of the Biodiversity Action Plan

101 In this report, we often grouped uncultivated Broad Habitat types according to the definition of the Environmental Impact Assessment[11] for projects involving the conversion of uncultivated land and semi-natural areas into cultivated land.

- The Permanent grassland category corresponds to the Broad Habitats types Neutral grassland (BH6), Calcareous grassland (BH7) and Acid grassland (BH8) of the Biodiversity Action Plan.
- The Heathland & moorlands category corresponds to the Broad Habitats types Bracken (BH9), Dwarf shrub heath (BH10), Fen, marsh and swamp (BH11) and Bog (BH12) of the Biodiversity Action Plan. .

POLICY CONTEXT STATEMENT

102 The following policy context statement has been presented and approved at the May 2002 workshop.

103 The 1990s have been characterised by important modifications in the policy context of agriculture, notably the implementation of the MacSharry reforms (1992) and the development of Agenda 2000 (for a review see Winter and Smith, 2001). Market trends have fluctuated widely, with an increase in farming income in the early 1990s followed by a fall in the

[11] *Regulations 2001 (England) – Statutory Instrument 2001 – No 3966.coming into force 1 February 2002 - http://www.hmso.gov.uk/si/si2001/20013966.htm#n*

economic returns to agriculture from 1996 onwards. In response to this context, Haines-Young and McNally (2001) suggest in their review on drivers of countryside change that the British agriculture in the 1990s experienced three different processes: consolidation, specialisation and diversification. One trend of specialisation is for example the increase in cereals farm numbers observed in some areas of Britain (Kiddle, 2001) suggesting that, although the overall area agricultural land decreased, farmers have not halted expansion of arable area. The loss of permanent grasslands to cereals and other crops is a trend noted in several other studies (see Haines-Young and McNally, 2001, p29).

104 In parallel, governments have recently had to implement the Environmental Impact Assessment[12] for projects involving the conversion of uncultivated land and semi-natural areas into intensive agricultural production (part of Directive 85/337/EEC as amended by Directive 97/11/EC, or 'uncultivated land provisions' in the UK). Consultation exercises were carried out in 2001[13] and highlighted a number of questions related to i) the identification of projects where EIA will be required and the need for "a short list of illustrative projects updated in the light of experience" or "a comprehensive list of probable projects" and also ii) a definition of what might constitute "significant environmental effects".

105 Uncultivated lands identified in the consultation exercises were:

106 Permanent grassland, defined as grassland which has been in grassland since at least 1991 and has not been reseeded or improved to an extent that plant characteristic of unimproved grassland constitute less than 20% of the sward by area. This definition corresponds to the Broad Habitats types Neutral grassland, Acid grassland and Calcareous grassland of the Biodiversity Action Plan.

107 Heathland & moorlands: this category corresponds to the Broad Habitats types Dwarf shrub heath, Bracken, Fen, marsh and swamp and Bog.

108 Estimates of the amount of newly cultivated land in the UK, and in countries within the UK, have been derived from successive Countryside Surveys and related projects since 1984 (see http://www.cs2000.org.uk/). However, there is a lack of information as to the characteristics of parcels that were converted into cultivated land in term of use and ecological condition.

109 This piece of work will examine aspects of the CS databases where uncultivated land and semi-natural areas have been converted into intensive agricultural production between 1990 and 1998. It will quantify for each Broad Habitat type the amount of land that was converted into cultivated land and describe the condition of habitats that have been converted. Finally, this project will document the spatial characteristics of parcels of land converted in term of adjacency and overall composition of the 1km square.

References

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Kiddle (2001) http://www.cs2000.org.uk/Final_reports/M14_final_report_App6.pdf

Winter and Smith (2001) http://www.cs2000.org.uk/Final_reports/M14_final_report_App4.pdf

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[12] *Regulations 2001 (England) – Statutory Instrument 2001 – No 3966.coming into force 1 February 2002 - http://www.hmso.gov.uk/si/si2001/20013966.htm#n*

[13] *The Ministry of Agriculture, Fisheries and Food and The Scottish Executive Rural Affairs Department have issued a consultation paper on implementing the uncultivated land and semi-natural areas provisions of the Environment Impact Assessment directive - closed on 31/08/01 - http://www.scotland.gov.uk/consultations/agriculture/eia/eia.pdf*.

SCIENCE OUTPUTS

Quantify for each Broad Habitat the amount of land that was converted to newly cultivated between 1990 and 1998. Statistical confidence will be given at the country and Environmental Zone levels and, where possible, by designated areas (eg ESAs)

The broad context

110 Cultivated land, that is Arable & horticultural and Improved grassland, covered 10.7 millions hectares in 1998, i.e. 46% of the area of GB. One important result of CS2000 was the differences in the patterns of net gains and losses observed between 1990 and 1998 across the different Environmental Zones (Table 2.1). There were significant increases in the area of Arable & horticultural in the pastoral Westerly lowlands of England & Wales (Environmental Zone 2) and Scottish lowlands (Environmental Zone 4) while it tended to decline in the Easterly lowlands of England & Wales (Environmental Zone 1). There was a significant loss of Improved grassland in the Westerly lowlands (Environmental Zone 2) but a significant increase in the Uplands of England & Wales (Environmental Zone 3).

Table 2.1: Stock 1998 and net change between 1990 and 1998 of Arable & horticultural and Improved grassland (in '000 ha) per Environmental Zone and country. * = significant change (p <0.05).

	Arable & horticultural		Improved grassland	
	Stock 98	Change 90-98	Stock 98	Change 90-98
Zone 1	3278	-35	1322	-25
Zone 2	1277	86*	2379	-119*
Zone 3	54	-2	730	43*
E&W	4609	49	4431	-102
Zone 4	536	15	660	-20
Zone 5	100	24*	299	+
Zone 6	4	-	92	18
Sc.	639	38	1051	-1

Conversion to Arable & horticultural (BH4)

111 Analysis of the CS databases showed that newly Arable & horticultural parcels came from the conversion of a diverse array of Broad Habitat types (Table 2.2). A large proportion of newly Arable & horticultural came from the conversion of the Permanent grassland category of the EIA (BH6,7 and 8). For the least represented Broad Habitat types (Calcareous grassland and the Heathland & moorlands category of the EIA), the 95% confidence interval of the estimates does not exclude the fact that these conversions did not occur significantly.

112 It should be noted that we also found some cases of conversion from woodlands (BH1 and 2), boundaries (BH3) and built-up areas (BH17) which we checked manually in a systematic way. In a majority of cases, conversions from woodlands (BH1 and 2) did not correspond to real changes; it appeared that, for a number of different reasons, some parcels were allocated to woodland in 1990 while they should have been allocated to Arable & horticultural. The results of the validation exercise were fed back to the central allocation table. In the case of boundaries (BH3), changes often corresponded to the conversion of tracks to arable land as a result of the disappearance of a linear feature between 1990 and 1998. This is related to the definition of tracks, which were allocated track if bordered by two linear features and allocated to the adjacent Broad Habitat type if not bordered by a linear feature on at least one side. The validation of conversions from built up areas (BH17) was not seen as a priority given the

resources available. Conversions from those 3 types of Broad Habitat were not included in the following analyses.

Table 2.2: Confidence limits 95% after 1000 bootstraps of the amount of Broad Habitat converted into Arable & horticultural in GB between 1990 and 1998 expressed as area in '000 ha and as a percentage of the 1998 stock of Arable & horticultural.

	Area converted ('000 ha)	As % of 1998 stock
Improved grassland (BH5)	**540 – 741**	**10 – 14**
Neutral grassland (BH6)	***12 – 49***	***0.2 – 0.9***
Calcareous grassland (BH7)	***0 – 7***	***0 – 0.1***
Acid grassland (BH8)	***2 – 21***	***0.04 – 0.4***
Total Permanent grassland	**14-77**	**0.03 – 1.4**
Heathland & moorlands (BH9, BH10, BH11, BH12)	**0 – 6**	**0 – 0.1**

113 Table 2.3 presents the amount of area that was converted to Arable & horticultural per Environmental Zone and per country. As in Table 2.2, the only conversions for which we had significant estimates relate to conversions from Improved and Neutral grasslands.

114 Conversion from Improved grassland varied greatly according to Environmental Zone, especially in the Easterly lowlands of England & Wales (Environmental Zone 1), where the percentage of 1998 Arable & horticultural' coming from Improved grassland was much lower than elsewhere. A likely explanation is that in Environmental Zone 1, the proportion of intensively cultivated land which was Improved grassland was only 30%, a much lower proportion than elsewhere in GB. There was therefore less opportunities for turnover between Arable & horticultural and Improved grassland.

115 In contrast, the proportion of Arable & horticultural coming from Improved grassland was very high in the Westerly lowlands of England & Wales (Environmental Zone 2), which might partly explain the significant net gain of Arable & horticultural and net loss of Improved grassland observed in Environmental Zone 2 between 1990 and 1998 (see Table 2.1). However, because most of the Arable & horticultural was located in Environmental Zone 1 and because turnover was low in this Environmental Zone, the overall proportion of new Arable & horticultural coming from Improved grassland was almost twice lower in England & Wales than in Scotland. The proportion of Arable & horticultural parcels coming from Neutral grassland also tended to be less important in England & Wales than in Scotland.

Table 2.3: Confidence limits 95% after a 1000 bootstraps of the amount of Broad Habitat converted into Arable & horticultural per Environmental Zone and country between 1990 and 1998 expressed as area in '000 ha and, when relevant, within brackets, as a percentage of the 1998 stock of Arable & horticultural.

	From Improved grassland	From Permanent grassland			From Heathland & moorlands
		Neutral	Calcareous	Acid	
1	129-267 (4-8)	2-11 (0.1-0.3)	*0-1*	*0-0.1*	*0-1*
2	225-344 (18-27)	2-34 (0.2-3)	*0*	0-5 (0-0.4)	*0-0.3*
3	3-28 (6-52)	*0*	*0*	0-4 (0-7)	0-4 (0-7)
E&W	406-590 (9-13)	7-40 (0.2-0.9)	0-1	0-8	0.1-4
4	60-142 (11-26)	1-14 (0.2-3)	*0*	*0-1*	*0-1*
5	9-60 (9-60)	0.1- 3 (0.1-3)	0-7 (0-7)	0-16 (0-16)	*0*
6	0.1-8 (0-100)	*0*	*0*	*0- 2*	*0*
Sc.	86-183 (13-27)	2-15 (0.3-2)	0-7 (0-1)	1-17 (0.2-3)	0-1 (0-0.2)

Conversion to Improved grassland (BH5)

[This work was initiated after feedback from DEFRA on the policy context statement but is additional to work costed in the original CEH tender.]

116 New Improved grassland came from a broad array of Broad Habitat types (Table 2.4). The area of new Improved grassland resulting from the conversion of Arable & horticultural was the most important, between 8 and 11% of the 1998 stock of Improved. A large amount of converted area also came from the Permanent grassland category, mainly Neutral and Acid grassland (BH6 and 8). It also appears that up to 1% of Improved grassland came from the conversion of the Heathland & moorlands category, mostly Bracken (BH9) and Fen, Marsh, Swamps (BH11).

Table 2.4: Confidence limits 95% after 1000 bootstraps of the amount of Broad Habitat converted into Improved grassland in GB between 1990 and 1998 expressed as area (in '000 ha) and as a percentage of the 1998 stock of Improved grassland.

	Area converted ('000 ha)	As % of 1998 stock
Arable & horticultural (BH4)	**428 - 607**	**8 – 11**
Neutral grassland (BH6)	*93 - 161*	*2 – 3*
Calcareous grassland (BH7)	*1 – 24*	*0 – 0.4*
Acid grassland (BH8)	*86 - 164*	*1.5 – 3*
Total Permanent grassland	**180 - 349**	**3 – 6**
Heathland & moorlands (BH9, BH10, BH11, BH12)	**14 - 55**	**0.3 – 1**

117 When analysing these figures at the Environmental Zone and country levels (Table 2.5), one can see a difference in trends between the lowland Environmental Zones (1, 2 and 4) and the upland ones (3,5 and 6). In the lowland Environmental Zones, new Improved grassland came mainly from Arable & horticultural and, only to a much lesser extent, from Permanent grassland. Because most of the Improved grassland was located in lowland Environmental Zones, we found the same trend at the country level, with no difference between England & Wales and Scotland. We observed the opposite trend in the upland Environmental Zones, with a high proportion of new Improved grassland coming from Acid grassland and Neutral grassland (Zone 3) or Acid grassland (Zone 5 and 6).

Table 2.5: Confidence limits 95% after 1000 bootstraps of the amount of Broad Habitat converted into Improved grassland per Environmental Zone and country between 1990 and 1998 expressed as area (in '000 ha) and, when relevant, within brackets, as a percentage of the 1998 stock of Improved grassland.

	From Arable & horticultural	From Permanent grassland			From Heathland & moorlands
		Neutral	Calcareous	Acid	
1	**141-270 (11-20)**	**13-35 (1-3)**	**0-12 (0-1)**	**0-20 (0-2)**	**0.4-2**
2	**145-259 (6-11)**	**30-64(1-3)**	**0-11**	**16-59 (1-2)**	**2 -19 (0-1)**
3	**3-37 (0-5)**	**12-38 (2-5)**	**0**	**21-70 (3-10)**	**4-23 (0-3)**
E&W	**332-488 (7-11)**	**71-119 (2-3)**	**0.3-18 (0)**	**54-123 (1-3)**	**10-37 (0-1)**
4	**50-127 (8-19)**	**4-35 (1-5)**	**0**	**2-10 (0-2)**	**0-4 (0-1)**
5	**6-25 (2-8)**	**1-32 (0-11)**	**0-10 (0-3)**	**3-30 (1-10)**	**0-4 (0-1)**
6	**0.4-8 (0-9)**	**0-0.4**	**0**	**0.1-39 (0-42)**	**0.2-12 (0-13)**
Sc.	**64-144 (6-14)**	**12-57 (1-5)**	**0-10 (0-1)**	**15-63 (1-6)**	**4-17 (0-2)**

Overlap with designated areas

118 There was little available data for a statistical comparison of trends between designated and non-designated areas (see Topic 7). This situation resulted from the limited spatial overlay between Countryside Survey squares and parcels which were entered into different schemes. In addition, the date of agreement was missing, except for the Countryside Stewardship scheme, which made the interpretation of results difficult.

119 In England, there were 26 squares (292 parcels) in which a Countryside Stewardship agreement was signed between 1991 and 1997 on parcels that were allocated Permanent grassland or Heathland & moorlands in 1990. This amount was far too small to perform analyses.

120 There were 31 squares (2110 parcels) in which ESA agreements have been signed in England at any time (even after 1998) on parcels that were allocated Permanent grassland or Heathland & moorlands in 1990. In those squares, 13% of the permanent grassland found in 1990 had been converted to Improved grassland in 1998 and 0.6% into Arable & horticultural. However, an amount equivalent to 9% of the Permanent grassland found in 1990 had been converted from Improved grassland to Permanent grassland between 1990 and 1998. This result can of course not be generalised given the small size of the sample. In addition, any attempt to relate the trend to designation would be spurious given the lack of information as to when parcels were entered to the scheme.

Describe for each BH the condition of habitats that have been converted to cultivated land (with reference to vegetation type and other relevant available information).

121 Information on the condition of Permanent grassland and Heathland & moorlands in 1990 that were converted to cultivated land between 1990 and 1998 was extracted from the CS databases and compared to characteristics of parcels that remained uncultivated in 1998. We examined attributes such as primary codes and other available information on the general condition and use of parcels.

Primary codes and use of parcels

122 Figures 2.1 and 2.2 present primary codes and use of Neutral grassland and Acid grassland that either did not change allocation, were converted to Improved grassland or were converted to Arable & horticultural (Calcareous grassland are not presented given their low representation in the dataset). Dominant primary codes for Neutral grassland that were not converted in 1998 were 'Fertile' and 'Unmanaged grass' while, as could be expected, parcels allocated to Acid grassland had the 'Acid grassland' primary code but quite a large proportion with a 'Fertile' code in Environmental Zones 1 and 2 (in that case, the allocation to Acid grassland resulted from the presence of key plant species).

123 It appears that the parcels converted to cultivated land were not representative of the total pool of Acid grassland in term of primary codes. Parcels of Acid grassland with a 'Fertile' primary codes were significantly less likely to remain Acid grassland ($Chi^2 = 144.5$, $df = 4$, $p < 0.0001$) and significantly more likely to be converted to Improved grassland ($Chi^2 = 252$, $df = 4$, $p < 0.0001$) or to Arable & horticultural ($Chi^2 = 26.3$, $df = 4$, $p < 0.005$). We found no such significant differences for parcels of Neutral grassland.

124 Neutral grassland were used in a fairly diversified way (Figure 2.1) while Acid grasslands were primarily grazed by sheep (Figure 2.2). Both Neutral and Acid grassland being used for dairy were significantly more likely to be converted to Improved grassland than parcels with other use (Neutral $Chi^2 = 27.6$, $df = 16$, $p < 0.05$; Acid $Chi^2 = 26.4$, $df = 16$, $p < 0.05$). Both Neutral and Acid grassland with no apparent use were more likely to be converted to Arable &

horticultural than parcels with other use (Neutral $Chi^2 = 30.4$, df = 16, $p < 0.05$; Acid $Chi^2 = 33.4$, df = 16, $p < 0.05$).

125 Areas of Heathland & moorlands converted to cultivated land were negligible compared to the area that remained the same between 1990 and 1998 and therefore statistical analyses could not be performed. As shown in Figure 2.3, converted areas tended to be more fertile with primary codes such as 'Fertile', and the combined categories 'Marsh and fertile marsh' and '*Pteridium* and fertile *Pteridium*'. In terms of use, Heathland & moorlands that were used for beef, sheep or beef+sheep grazing tended to more likely to be converted to Improved grassland.

Figure 2.1: Primary code and use of Neutral grassland in 1990 that either did not change allocation, were converted to Improved grassland or were converted to Arable & horticultural between 1990 and 1998, per Environmental Zone.

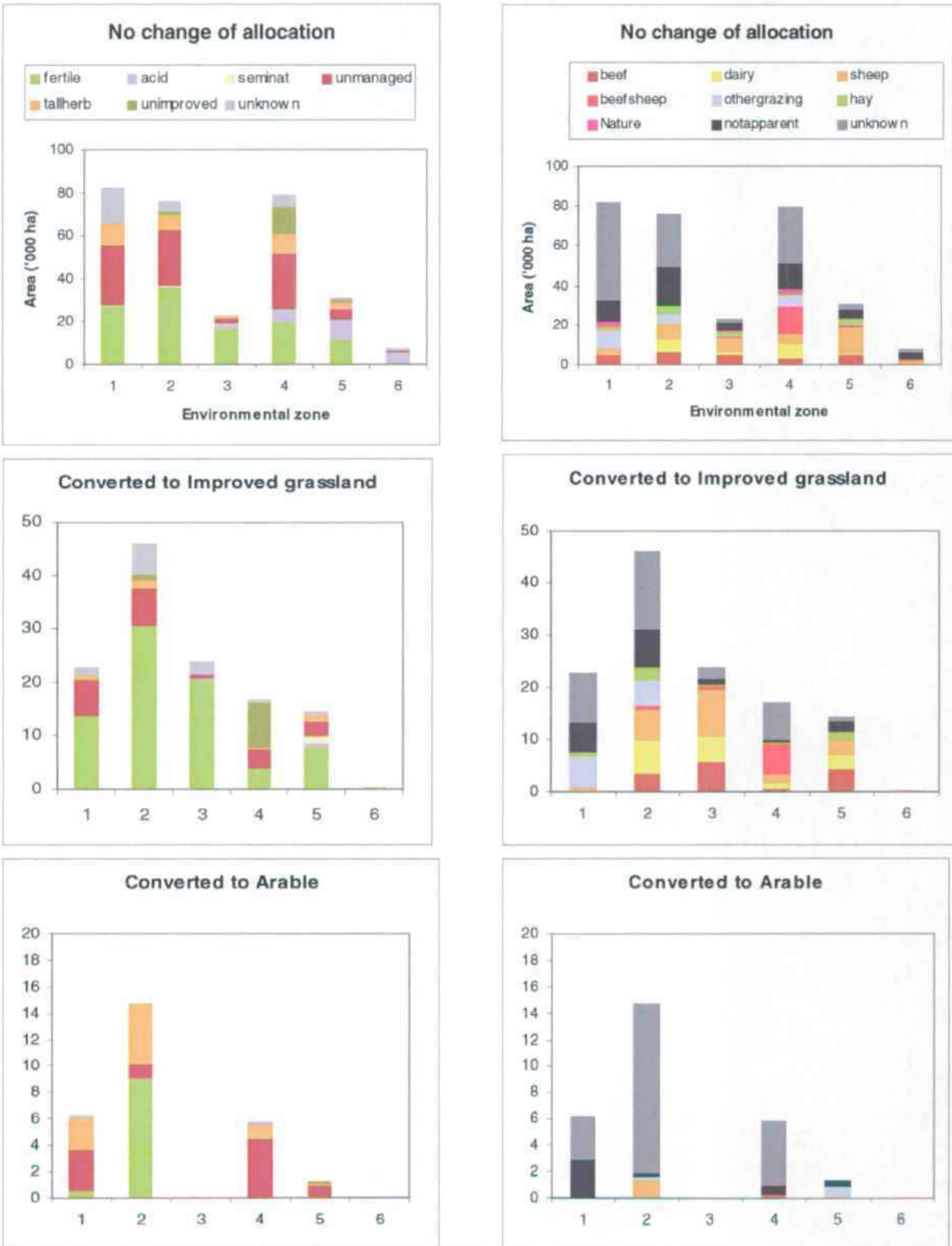


Figure 2.2: Primary code and use of Acid grassland in 1990 that either did not change allocation, were converted to Improved grassland or were converted to Arable & horticultural between 1990 and 1998, per Environmental Zone.

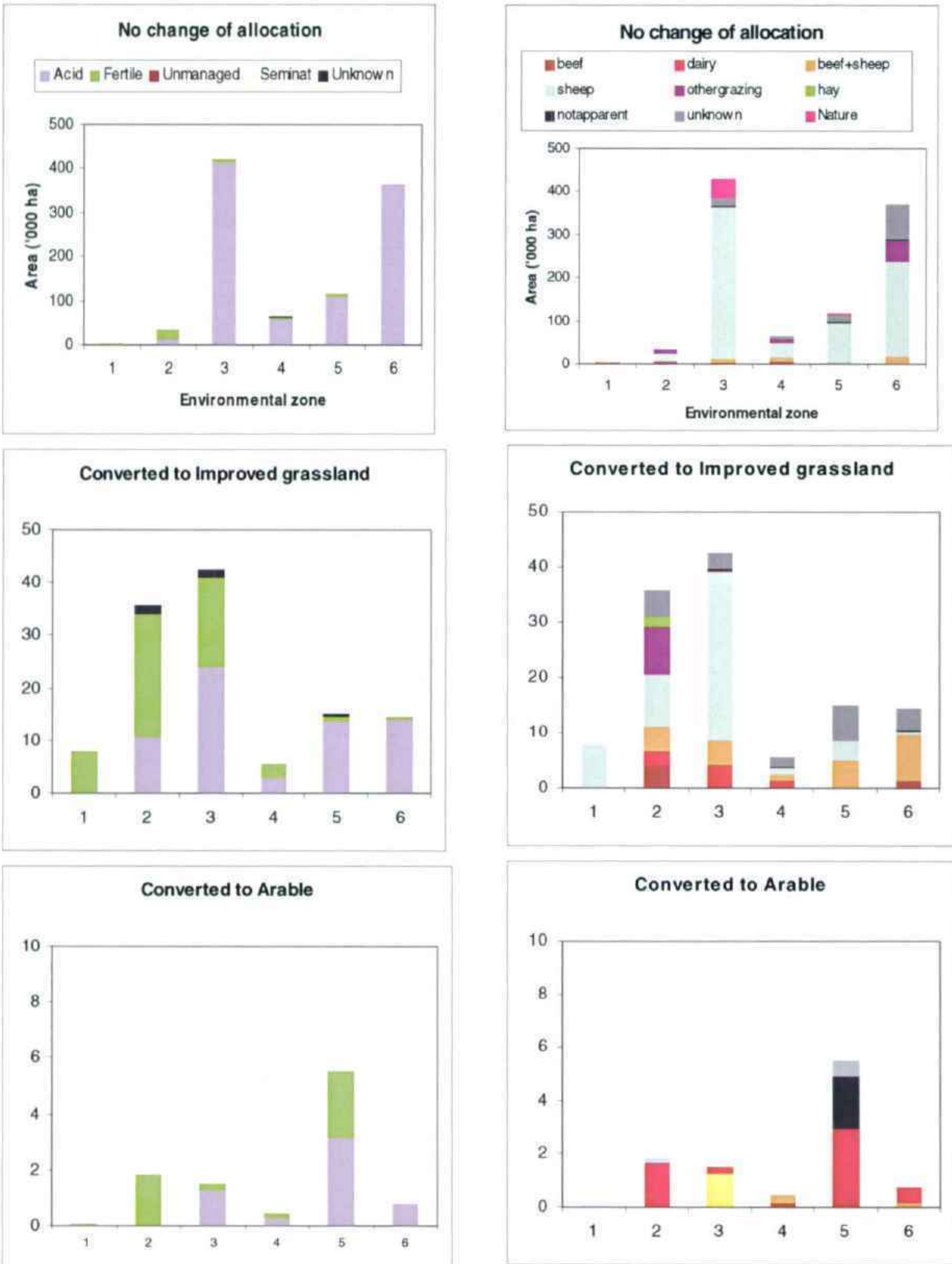
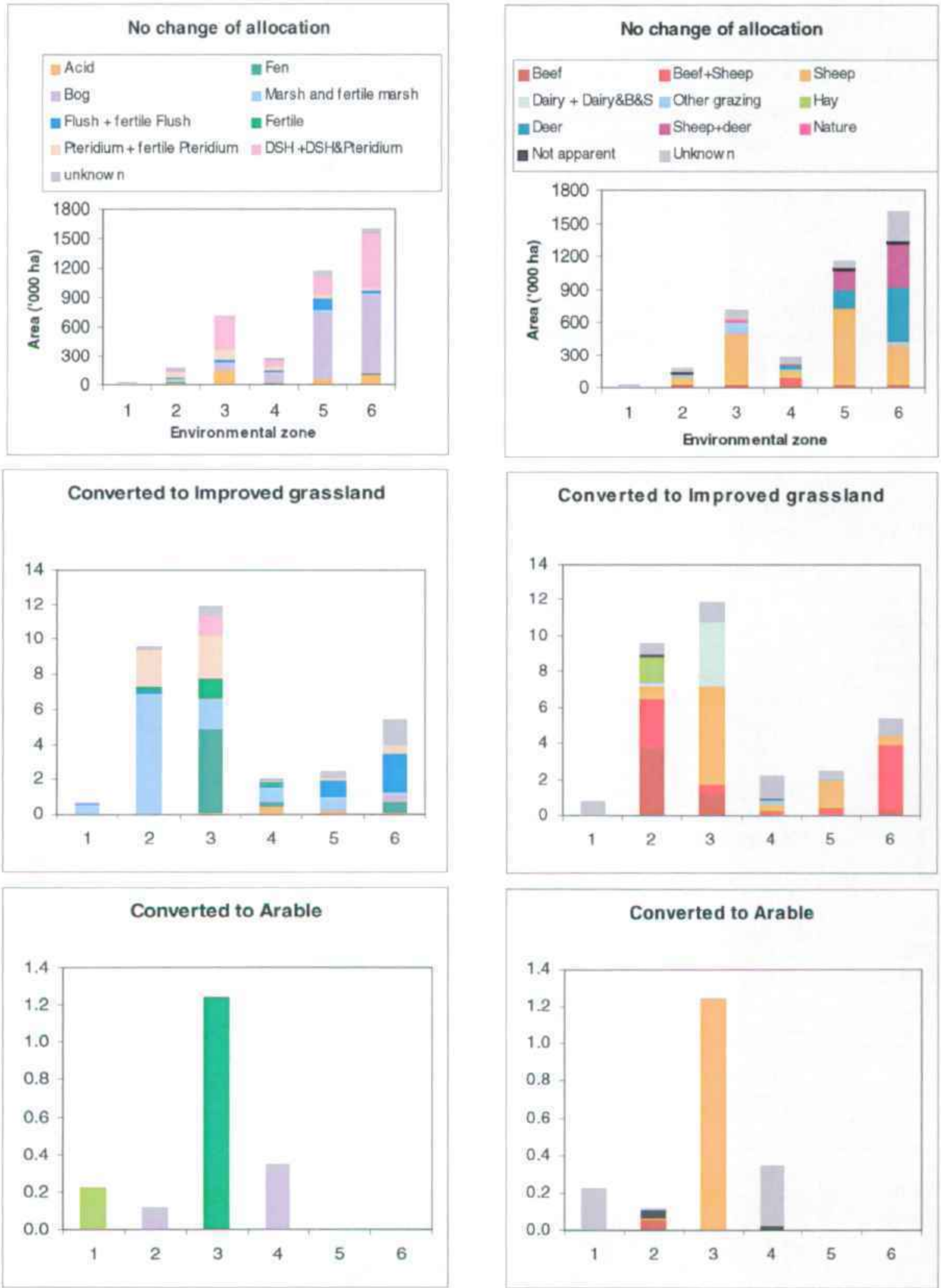


Figure 2.3: Primary code and use of Heathland & moorlands in 1990 that either did not change allocation, were converted to Improved grassland or were converted to Arable & horticultural between 1990 and 1998, per Environmental Zone.



Characteristics of the vegetation

126 Vegetation plots that were recorded in1990 in parcels allocated Permanent grassland and Heathland & moorlands were extracted to analyse a number of indicators for the condition of habitats, namely Ellenberg scores of vegetation communities, vegetation types as defined in the Countryside Vegetation System and some indicators of the conservation value of communities.

127 Ellenberg scores for fertility, wetness and pH are indirect measures of the soil fertility, moisture and pH characterising the habitat where the plot was recorded. Table 2.6 presents the mean value and standard deviation of the Ellenberg scores for different Broad Habitats that underwent either no change in allocation or a conversion to Improved grassland or Arable & horticultural. The result obtained from the vegetation plots are in accordance with the results presented earlier on primary codes (Figures 2.1 and 2.2). It appears that the condition of Neutral grassland (and Calcareous grassland) was very similar in 1990 for parcels that did not change allocation and parcels that were to be converted to cultivated land by 1998. In contrast, for Acid grassland, the vegetation communities found in 1990 in parcels that would be converted to cultivated land by 1998 were indicative of both more fertile and a higher soil pH (i.e. were less acid) conditions, which is in accordance with the over-representation of the primary code 'Fertile' in Acid grassland that was converted to cultivated land.

Table 2.6: Number of vegetation plots corresponding to different combinations of transitions between Broad Habitat types for the period 1990-98 with mean and standard deviation for the Fertility, Wetness and pH Ellenberg scores in 1990.

BH90	To BH98	No plots	Fertility	Wetness	pH
Neutral grassland	To Neutral grassland	435	5.36 (1.01)	5.71 (0.66)	6.02 (0.72)
	To Improved grassland	97	5.10 (0.90)	5.81 (0.75)	5.82 (0.66)
	To Arable & horticultural	21	5.81 (0.73)	5.33 (0.34)	6.26 (0.51)
Calcareous grassland	To Calcareous grassland	37	4.0 (0.8)	4.92 (0.38)	6.24 (0.53)
	To Improved grassland	10	4.71 (0.44)	5.29 (0.7)	6.16 (0.33)
	To Arable & horticultural	2	4.56 (0.29)	5.07 (0.43)	5.94 (0.08)
Acid grassland	To Acid grassland	418	3.32 (0.99)	6.27 (0.66)	4.18 (0.98)
	To Improved grassland	74	4.82 (0.93)	5.77 (0.59)	5.43 (0.78)
	To Arable & horticultural	8	5.11 (0.98)	5.64 (0.42)	5.26 (1.16)
Bracken	To Bracken	163	3.76 (0.97)	6.08 (0.69)	4.51 (0.94)
	To Improved grassland	5	4.72 (0.22)	5.47 (0.24)	5.39 (0.31)
Fen marsh swamp	To Fen marsh swamp	368	3.99 (1.12)	6.72 (0.75)	4.90 (0.94)
	To Improved grassland	14	4.45 (0.9)	6.12 (0.61)	5.31 (0.77)
	To Arable & horticultural	2	6.17 (0.99)	6.2 (0.0)	6.62 (0.44)

128 The frequency of distribution of the 8 vegetation types of the Countryside Vegetation System (CVS) in 1990 was analysed for parcels that did not change allocation between 1990 and 1998 and those that were converted to Improved grassland or Arable & horticultural.

129 There were no major differences in vegetation types for Neutral grassland, although the Crops and weeds class tended to be more represented in plots that would be converted to cultivated land (Figure 2.4) and the Tall grass and herb class more represented in parcels that would converted into Arable & horticultural (in accordance with the over-representation of the Tall herb vegetation primary code for those parcels, see previous results).

130 In contrast, the vegetation type of parcels of Acid grassland tended to differ for those parcels that remained unchanged between 1990 and 1998 and those that underwent a conversion into cultivated land (Figure 2.5). Plots recorded in parcels that would undergo conversion were characterised by communities indicative of Unfertile grassland, Fertile grassland and Tall grass and herb. Plots recorded in parcels that would remain the same in 1998 were dominated by communities indicative of Moorland grass mosaic and to a lesser extent Heath and bog as well as Unfertile grassland. This is in accordance with the strong association between area of Acid grassland that remained unchanged between 1990 and 1998 and the Acid grassland primary code, as well as with the differences in habitat condition indicated by Ellenberg scores (parcels that remained unchanged were more acid and less fertile).

Figure 2.4: Frequency distribution of the vegetation types of the CVS in 1990 plots recorded in Neutral grassland for parcels that either did not change allocation or were converted to Improved grassland or Arable between 1990 and 1998. n = number of vegetation plots.

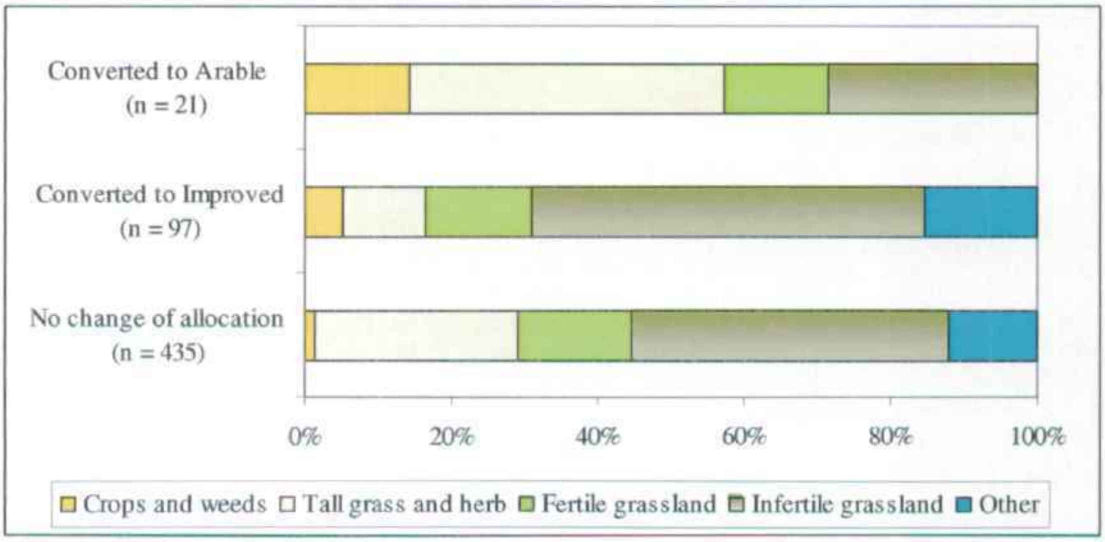


Figure 2.5: Frequency distribution of the vegetation types of the CVS in 1990 plots recorded in Acid grassland for parcels that either did not change allocation or were converted to Improved grassland or Arable between 1990 and 1998. n = number of vegetation plots.

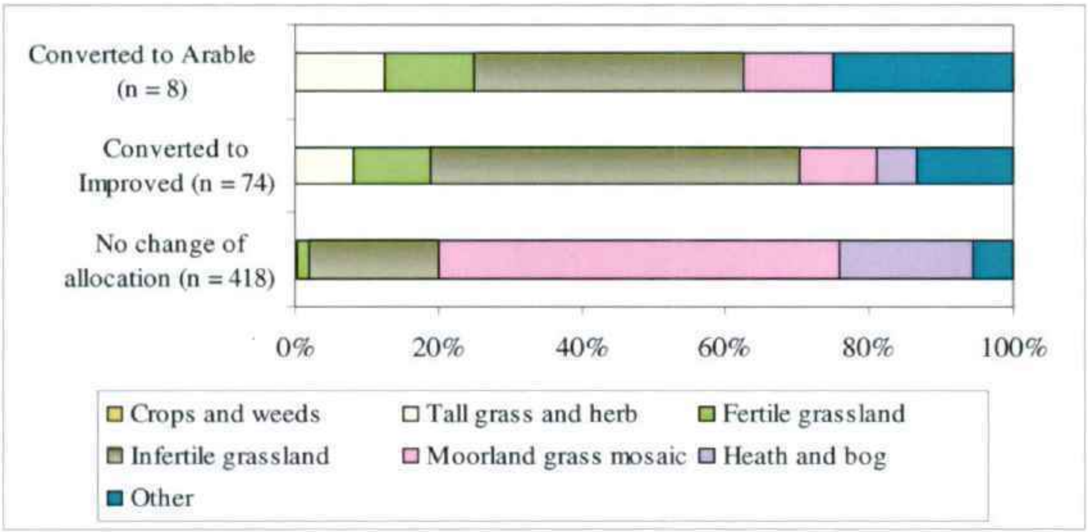


Table 2.7: Number of vegetation plots corresponding to different combinations of transitions between Broad Habitat types for the period 1990-98 with mean and standard deviation in 1990 for the total number of plants and the number of bird and butterfly food plants recorded in plots.

BH90	To BH98	No plots	No plant species	No bird food plant sp	No butterfly Food plant sp
Neutral grassland	To Neutral grassland	435	15.4 (6.9)	7.4 (3.9)	7.5 (3.6)
	To Improved grassland	97	16.8 (7.2)	8.2 (3.1)	7.8 (3.4)
	To Arable & horticultural	21	15.2 (6.8)	8.1 (4.2)	7.6 (4.0)
Calcareous grassland	To Calcareous grassland	37	25.5 (10.1)	9.0 (3.6)	10.0 (4.2)
	To Improved grassland	10	22.6 (7.4)	10.3 (3.4)	11.2 (3.9)
	To Arable & horticultural	2	22.5 (4.9)	12.5 (2.1)	9.0 (0.0)
Acid grassland	To Acid grassland	418	15.9 (7.2)	5.1 (3.8)	7.6 (3.3)
	To Improved grassland	74	16.6 (6.5)	8.7 (3.9)	8.8 (3.5)
	To Arable & horticultural	8	11.7 (6.8)	6.1 (3.8)	6.0 (3.2)
Bracken	To Bracken	163	16.0 (6.6)	5.8 (3.5)	7.4 (3.2)
	To Improved grassland	5	22.6 (14.5)	10.8 (6.6)	12.2 (8.3)
Fen marsh swamp	To Fen marsh swamp	368	17.6 (8.1)	6.5 (4.0)	7.2 (3.8)
	To Improved grassland	14	19.1 (7.5)	8.4 (4.5)	9.1 (3.4)
	To Arable & horticultural	2	19.0 (5.7)	7.0 (1.4)	8.0 (2.8)

131 To estimate the conservation value of vegetation of Permanent grassland and Heathland & moorlands that was either converted to cultivated land or did not change Broad Habitat allocation in 1998, we analysed three recognised indicators i.e. the total number of plant species, the number of farmland bird food plants and the number of butterfly larvae food plants. All the Broad Habitat types and combinations of change between 1990 and 1998 for which we had vegetation information are presented in Table 2.7. There were no differences for these three indicators between parcels that either remained unchanged or were converted to Improved grassland or Arable & horticultural.

Examine the spatial characteristics of parcels of land converted in term of size, adjacent land use and the overall BH composition of the 1 km square.

Analysis of the distribution of parcel size

132 It appears that in GB overall, converted parcels of Permanent grassland tended to be larger than those which remained unchanged between 1990 and 1998 (Table 2.8). However, this difference in size is only significant for Neutral grassland. For Permanent grassland overall, differences in the size of parcels were marked in the Easterly lowlands of England & Wales (Environmental Zone 1) but inexistent in the Westerly lowlands (Environmental Zone 2).

133 Parcels of Heathland & moorlands that were converted to cultivated land were significantly smaller than those that remained unchanged at the GB level (Table 2.8).

Table 2.8: Mean size of parcels with standard error for different Broad Habitats and combined categories for parcels that either did not change (*Stay-same*), were converted to Improved grassland (*C. Improved*) or to Arable & horticultural (*C. Arable*) between 1990 and 1998; n squares is the number of squares used for each analysis. T test presents the probability of significance of differences in the size of converted parcels and the size of parcels that remained unchanged between 1990 and 1998 .

		n squares	Mean size (ha)	SE Mean (ha)	t test
Neutral grassland	Stay-same	304	0.32	0.03	
	C. Improved	169	0.47	0.06	0.05
	C. Arable	62	0.40	0.14	ns
Acid grassland	Stay-same	201	0.39	0.06	
	C. Improved	75	0.57	0.11	ns
	C. Arable	15	0.55	0.13	ns
Permanent Grassland	Stay-same	419	0.37	0.04	
	C. Improved	204	0.49	0.06	ns
	C. Arable	77	0.42	0.12	ns
Heath. & moor.	Stay-same	304	0.43	0.03	
	C. Improved	65	0.25	0.06	0.05
	C. Arable	15	0.28	0.03	ns

Effect of adjacent land uses found in the 1 km square

134 We found a number of strong significant relationships between the proportion of Permanent grassland converted to cultivated land and the Broad Habitat composition of the 1 km square.

135 The proportion of Neutral grassland that remained unchanged in a square was negatively correlated to the percentage of the square occupied by Improved grassland in 1990 and positively correlated to the percentage of the square occupied by Heathland & moorlands (Table 2.9). The proportion of Neutral grassland that was converted to Improved grassland in a

square was negatively correlated to the percentage of the square occupied by Arable & Horticultural in 1990 (so more likely to occur in pastoral landscapes) and positively correlated to the percentage of the square already occupied by Improved grassland. The proportion of Neutral grassland that was converted to Arable & horticultural in a square was positively correlated to the percentage of the square already occupied by Arable & horticultural.

Table 2.9: Neutral grassland: Pearson coefficient of correlation and significance between the proportion of Neutral grassland in a square that experienced different trajectories of change between 1990 and 1998 and the Broad Habitat composition of the square in 1990. n = 328 squares; * = significant at p = 0.02; ** = significant at p = 0.0001.

	% no change of allocation	% converted to Improved grassland	% converted to Arable
% Arable in square	0.09	-0.258**	0.253**
% Improved grassland in square	- 0.237**	0.308**	-0.101
% Heath. & moor. in square	0.134*	- 0.08	- 0.108
% Woodland in square	-0.07	-0.03	-0.07

136 The proportion of Acid grassland that remained unchanged in a square was negatively correlated to the percentage of the square occupied by Improved grassland and Arable & horticultural in 1990 and positively correlated to the percentage of the square occupied by Heathland & moorlands (Table 2.10). Inversely, the proportion of Acid grassland that was converted to Improved grassland in a square was positively correlated to the percentage of the square occupied by Improved grassland and Arable & horticultural in 1990 and negatively correlated to the percentage of the square occupied by Heathland & moorlands. The proportion of Acid grassland that was converted to Arable & horticultural in a square was positively correlated to the percentage of the square occupied by Arable & horticultural in 1990 and negatively correlated to the percentage of the square occupied by Heathland & moorlands.

Table 2.10: Acid grassland: Pearson coefficient of correlation and significance between the proportion of Acid grassland in a square that experienced different trajectories of change between 1990 and 1998 and the Broad Habitat composition of the square in 1990. n = 220 squares; * = significant at p = 0.05; ** = significant at p < 0.001.

	% no change of allocation	% converted to Improved grassland	% converted to Arable
% Arable in square	-0.412**	0.359**	0.158*
% Improved grassland in square	- 0.237**	0.308**	-0.101
% Heath. & moor. in square	0.460**	- 0.375**	- 0.214**
% Woodland in square	0.01	-0.018	0.013

SUMMARY

- Most of the conversions to cultivated land occurred on previously Neutral grassland (BH6) and Acid grassland (BH8).
- CS also recorded conversions from Calcareous grassland (BH7) and the Heathland & moorlands category (BH9 to BH12) but amounts were usually too small to obtain reliable area estimates and information on the condition of habitats.
- Conversions from Neutral grassland represented less than 1% of the 1998 stock of Arable & horticultural in GB (predominantly in the lowlands) and between 2 and 3% of the 1998 stock of Improved grassland. A comparison between parcels that were converted to cultivated land between 1990 and 1998 and those which remained Neutral grassland revealed no significant difference in the condition or conservation value of habitats in 1990. In terms of spatial characteristics, conversions occurred significantly more in squares where cultivated land was already well represented and parcels that would be converted tended to be larger.
- Conversions from Acid grassland represented less than 0.5% of the 1998 stock of Arable & horticultural and between 1.5 and 3% of the 1998 stock of Improved grassland and occurred predominantly in the uplands (Environmental Zones 3 and 5). Analyses of CS survey codes and vegetation plot data both indicated that converted parcels were significantly more fertile and less acid in 1990 than those which remained Acid grassland in 1998. There were no differences in the conservation value of converted and non-converted parcels. Conversions were significantly more likely to occur in squares where cultivated land was already present.

FURTHER WORK AND RECOMMENDED CHANGES TO CS METHODS

137 Targeting of survey if we are to provide information on unlikely conversions

Question 3: What is the status of, and changes in, the weed flora of different crop types (eg roots and vegetables) as recorded in CS2000 and what is the conservation value of the species concerned?

INTERIM REPORT - ***Dr Les Firbank***

DUE START DATE:

- August 2002

DUE FINISH DATE:

- November 2002

OVERALL PROGRESS

- Work started ahead of schedule with the publication of results of change data on bird food plants (Firbank & Smart, 2002).
- This work was presented and discussed at the Association of Applied Biologists meeting "Birds and Agriculture", March 2002.
- The A plot data presented in the CS2000 report (Firbank et al., 2002) have been re-analysed, and a draft paper has been prepared for "Weed Research".
- It is anticipated that the work will be completed by the end of November.
- The next meeting of the Cereal Field Margin Action Plan is planned for December 2002, and this work is on the agenda for discussion.

DEFINITIONS

- Arable plants are all whose habitats include the cultivated areas of arable fields; normally crop plants and volunteers are excluded.
- "A plots" are the arable field margin plots introduced in CS2000. They run 100 m along arable field edges, and extend from the limit of cultivation inwards towards the field centre by 1 m. All plant species are recorded in each plot (Firbank et al., 2002).

POLICY CONTEXT STATEMENT

138 Changes in the flora of arable fields were recognised in the early 20th century, when it was noted in regional florae that some former arable plants were becoming scarce. (Firbank, 1988) Studies during the later half of the 20th century demonstrated a shift in arable plant flora towards grass weeds, that were associated with changes in tillage and increases in winter crops and inputs of fertilisers and herbicides (e.g. Firbank, 1999) Some arable plants became increasingly localised, to the point that the arable flora was the most threatened group of plants in GB (Stewart et al., 1994).

139 The changes in the arable flora were also being implicated in the declines of farmland bird species. Potts (1997) demonstrated the links between arable plants, invertebrates and population change in grey partridge, and Wilson et al. (1999) noted the relationships between arable flora and other farmland birds. In general, the shift away from dicotyledonous plants to grass weeds disfavoured the plants that are important food sources for birds, leading to the development of prescriptions for Conservation Headlands, intended to maintain these food resources at little cost to the farmer (Sotherton, 1991).

140 Concern over the direct and indirect conservation value of arable plants remains high. The UK Biodiversity Action Plan names several arable plant species, including *Adonis annua* and *Centaurea cyanus*, while *Agrostemma githago* is now considered extinct in the wild. The Cereal Field Margin Habitat Action Plan aims to maintain and restore 15,000 ha of habitat (Anon, 1995). This plan is supported through over 40 local BAPs, and, in England, through the new Arable Options of the Countryside Stewardship Scheme.

141 Countryside Survey records arable plants from main plots, the new arable margin plots and field boundary plots. These have already demonstrated national declines in food plants for farmland birds between 1978 – 90 (Smart et al. 2000), and confirmed the impression of shifts towards greater levels of grass weeds (Bunce et al., 1999). The new research will update these results, stressing differences between crop types, and the further analysis of the Arable Margin plots will give a baseline assessment of species diversity in this habitat.

SCIENCE OUTPUTS

Examine the frequency of arable dicotyledons, food plants and scarce arable plants recorded in the A plots for the following categories of crops i) cereals ii) maize iii) break crops (rape, beet) and iv) other, including set aside. Include the effect of soil type in the analysis.

142 Data reported by Firbank et al. (2002) have been re-analysed, and a paper has been prepared for submission; this is awaiting approval from DEFRA. The main set of new analyses are due in October / November, and these will address the frequencies of the groups noted in this task in more detail.

Examine change in the frequency of these between 1978 and 1998 using all repeat plots.

143 Changes in frequency of bird food plants have already been analysed and published in the proceedings of the AAB conference "Birds and Agriculture" (Firbank & Smart, 2002). The summary of this work is as follows:

> One of the explanations for declining populations of farmland birds is the decline in frequency of food plant species that are important in bird diets. Published results from the Countryside Surveys of 1978 and 1990 have demonstrated that such declines did, indeed, take place in the wider countryside. Here we include data from the Countryside Survey 2000, considering plots taken from field centres on arable land in 1990 and 1998. These show a range of trends for food plants, ranging from increases (e.g. *Cirsium arvense*), stabilisation of past declines (e.g. *Poa annua*) to continued declines (*Polygonum aviculare* and *Stellaria media*). The last two species are now found in only around 20 % of sample plots, compared with around 50 % in 1978. In general, arable field centres remain a much poorer source of food plants for farmland birds than in 1978.

144 The key evidence for these statements are to be found in the tables extracted from the paper, that consider changes in key bird food plants observed in main plots recorded in 1978 and 90 (Table 3.1), 1990 and 98 (Table 3.2), with results converted into percentage change for easy interpretation (Table 3.3):

Table 3.1. Changes in frequency of bird food plants from 141 main plots sampled during Countryside Surveys of 1978 and 1990. Data are given for numbers of plots in 1978 only, 1990 only and in both 1978 and 1990, followed by the significance test of the direction of change. Percent frequencies are given in Table 3.

Plants	1978	1990	Both years	Chi square	Significance	Direction
Cerastium fontanum.	10	5	1	1.07	ns	-
Cirsium arvense	22	13	3	1.83	ns	-
Holcus lanatus	8	6	0	0.07	ns	-
Holcus mollis	1	1	0		Too few	None
Lolium perenne	24	15	5	1.64	ns	-
Persicaria maculosa	25	7	6	9.03	**	-
Poa annua	40	14	37	11.57	***	-
Poa pratensis	6	9	0	0.27	ns	+
Poa trivialis	34	4	7	22.13	***	-
Polygonum aviculare	41	19	28	7.35	**	-
Rumex acetosa	3	1	0		Too few	-
Rumex obtusifolius	10	9	2	0.00	ns	-
Stellaria media	49	17	32	14.56	***	-
Taraxacum agg.	6	8	1	0.07	ns	+
Trifolium pratense	5	0	0		Too few	-
Trifolium repens	12	11	4	0.00	ns	-
Urtica dioica	8	7	3	0.00	ns	-

Table 3.2. Changes in frequency of bird food plants from 287 main plots sampled during Countryside Surveys of 1990 and 1998. Data are given for numbers of plots in 1990 only, 1998 only and in both 1990 and 1998, followed by the significance test of the direction of change. Percent frequencies are given in Table 3.

Plants	1990	1998	Both years	Chi square	Significance	Direction
Cerastium fontanum	3	4	0		Too few	+
Cirsium arvense	14	31	7	5.69	*	+
Holcus lanatus	4	4	0		Too few	None
Holcus mollis	4	1	0		Too few	-
Lolium perenne	27	25	8	0.02	ns	-
Persicaria maculosa	16	20	3	0.25	ns	+
Poa annua	47	60	43	1.35	ns	+
Poa pratensis	8	11	1	0.21	ns	+
Poa trivialis	23	28	3	0.31	ns	+
Polygonum aviculare	57	33	29	5.88	*	-
Rumex acetosa	1	0	0		Too few	-
Rumex obtusifolius	10	18	7	1.75	ns	+
Stellaria media	55	34	27	4.49	*	-
Taraxacum agg.	8	17	1	2.56	ns	+
Trifolium pratense	0	2	0		Too few	+
Trifolium repens	15	8	4	1.57	ns	-
Urtica dioica	18	14	2	0.28	ns	-

Table 3.3. Frequency of food plant species as a percentage of total number of plots in weed-crop plant communities in 1978, 1990 (a, using only those plots surveyed in 1978, and b, using those plots surveyed in 1998) and 1998. Percentage changes are shown per year between two sets of survey data; note inconsistencies arise because of rounding.

Plants	% frequency of plots				% annual change	
	1978	1990a	1990b	1998	78-90	90-98
Cerastium fontanum	8	4	1	1	-4	3
Cirsium arvense	18	11	7	13	-3	7
Holcus lanatus	6	4	1	1	-2	0
Holcus mollis	1	1	1	0	0	-6
Lolium perenne	21	14	12	11	-3	0
Poa annua	55	36	31	36	-3	1
Persicaria maculosa	22	9	7	8	-5	2
Poa pratensis	4	6	3	4	4	3
Poa trivialis	29	8	9	11	-6	2
Polygonum aviculare	49	33	30	22	-3	-2
Rumex acetosa	2	1	0	0	-6	-8
Rumex obtusifolius	9	8	6	9	-1	4
Stellaria media	57	35	29	21	-3	-2
Taraxacum agg.	5	6	3	6	2	8
Trifolium pratense	4	0	0	1	-8	-
Trifolium repens	11	11	7	4	-1	-3
Urtica dioica	8	7	7	6	-1	-2

Discuss results with relevant arable weed specialists (including members of the Cereal Field Margins HAP Steering Group) and report likely consequences of the results for wildlife conservation.

145 The next meeting of the Cereal Field Margins HAP Steering Group is scheduled for 6 December 2002, and LGF, a member of that Group, will be presenting this work at that meeting. In addition, the results were discussed at the Birds and Agriculture meeting, and have been reviewed by Hails in a recent paper for Nature (Hails, 2002).

SUMMARY

146 Work thus far seems to confirm the findings of the Main Report that arable plants of conservation value have declined less in the period 1990-98 than in 1978-90, although the continued declines of the major bird food plant species *Polygonum aviculare* and *Stellaria media* are of potential concern. The arable plot data provide an important baseline for detection of future trends, but the lack of comparable data make them rather hard to interpret at the moment.

FURTHER WORK AND RECOMMENDED CHANGES TO CS METHODS

147 CS methodology is less than ideal for recording arable plants, because of the rapid change in the arable flora within and between seasons (Firbank, 1999). However, this is an argument for a more focussed survey on arable plants that goes beyond the CS methodology, rather than for changes to the core CS programme itself. Planned discussions at the CFM will help clarify relationships between CS and other available data on the condition of this habitat. Forthcoming results from the Farm Scale Evaluations of GMHT Crops (Firbank et al., 1999) will also add important information about the condition of arable plants in maize, oil seed rape and beet crops, and to a lesser extent in cereals; first results are due to be reported in summer 2003.

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Question 4: What evidence is there that length of hedges declined between 1990 and 1993 and increased between 1993 and 1998 in England and Wales?

DRAFT FINAL REPORT - ***Rick Stuart & Colin Barr***

DUE START DATE:

- March 2002

DUE FINISH DATE:

- June 2002

OVERALL PROGRESS

- Work completed

DEFINITIONS

- A Hedge is defined as 'A more or less continuous line of woody vegetation that has been subject to a regime of cutting in order to maintain a regular shape. This category includes both recently-managed and other hedges, including hedges with walls or fences.'
- The summary groupings, including 'hedge', have been used as described in '*Accounting for nature: assessing habitats in the UK countryside*' (Haines-Young *et al.* 2000).

POLICY CONTEXT STATEMENT

148 *The following Policy Context Statement was drafted in May, and takes account of comments made by attendees at the May FOCUS Workshop:*

149 Estimates of the length of hedgerow in the UK, and in countries within the UK, have been derived from successive Countryside Surveys and related projects since 1984. Results are given in a number of papers and reports (and, most recently, web sites) (see References, below).

150 The most recent report was '*Accounting for nature: assessing habitats in the UK countryside*' (Haines-Young *et al.* 2000) which presents results from Countryside Survey 2000. In this report it is stated that, in contrast with the period 1984 to 1990, there is no statistically significant change in the length of hedgerows in England and Wales or in Scotland, between the two most recent Countryside Surveys in 1990 and 1998. There was a reported loss in N Ireland.

151 However, the report also includes reference to a partial survey in England and Wales in 1993 which visited a sub-sample of survey sites and recorded hedgerow length. The results of this survey showed a continuing reduction in hedgerow loss. The '*Accounting for nature*' report says "Although there was no net change for hedges in England and Wales over the full period from 1990 to 1998, there is some evidence from the interim survey of hedges in 1993 that net losses, recorded in the first part of this period, 1990-93, were reversed in the latter part. The apparent increase in hedges between 1993 and 1998 needs to be confirmed by a more detailed

analysis of the data from 1993, and comparison with other sources of information on hedgerow planting within agri-environments schemes.".

152 Given the introduction of policy measures in the early 1990s designed to halt the decline of hedgerows, in both quantitative and qualitative terms, it is important to know from a policy perspective whether there has been a real increase in the length of hedgerows in England and Wales between 1993 and 1998, or whether the results from the 1993 survey are unreliable and are giving a false picture of trends.

153 This piece of work will therefore re-examine aspects of the databases from the 1990, 1993 and 1998 surveys (including case studies of individual sites) and will also re-assess the statistical reliability and robustness of the results, taking into account the construction of the sampling frame and the adequacy of feature definitions, used in the three surveys. The outputs will give a definitive statement on trends in hedgerow change in the 1990s in England and Wales.

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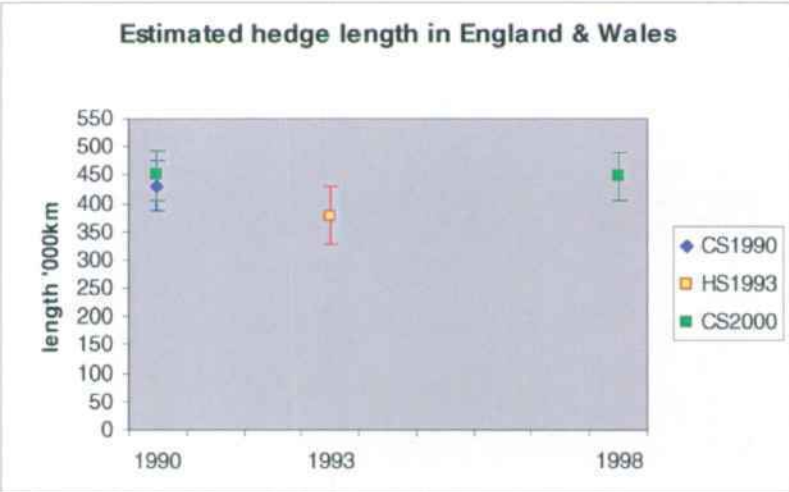
Background to published figures for length of hedge in England and Wales to date.

154 Published stock estimates for England & Wales of length of 'Hedge' for 1990, 1993 and 1998 are available from three separate surveys and are shown in Figure 4.1.

Figure 4.1 Estimates of length of hedge in England & Wales by year, by survey. CS1990 = Countryside Survey 1990, HS1993 = Hedgerow Survey 1993, CS2000 = Countryside Survey 2000. The estimate for 1990 was revised during CS2000 analysis due to changes to the sampling stratification and updated records. See Annex 4.2 for data.



155 All estimates of length of hedge are derived from the largest available sample size for each survey. These are shown in Table 4.1.

Table 4.1 Sample sizes for England & Wales hedge estimates for 1990, 1993 and 1998. * Although Hedgerow Survey 1993 surveyed 108 1km squares the sample size was boosted by applying a weighted mean change from 1990 (derived from the 108 sample) to a further 57 1km squares that contained 'hedge' between 1984-90. This gave a boosted sample size of 165.

		year	
Survey	1990	1993	1998
Countryside Survey '90	n=311	-	-
Hedgerow Survey '93	-	n=108 (165)*	-
Countryside Survey 2000	n=311	-	n=366

SCIENCE OUTPUTS

Approach:

All relevant analyses from CS2000 Module 1 will be re-visited and re-validated, especially in relation to the 'allocation procedure' used to categorise each hedge.

156 Spatial data held in the GIS for linear boundary features from the 1993 Hedgerow Survey had been previously combined with the 1990 and 1998 data set during summer 2000. This combined data set was checked against the original 1993 data set for consistency of length. A loss of 1.5% in raw data length was found and attributed, in the main, to spatial discrepancies with comparable existing lines in the 1990/98 dataset. However, for a time-series comparison based on the same features this would not bias the results for any one year.

157 The combined data set enables a time series analysis per feature from 1990-1993-1998. Due to refused access, one survey square was not surveyed in 1998 so the original sample of 108 squares was reduced to 107 squares for time-series analysis. Automated linear boundary feature allocation programmes written specifically to produce a 1990, 1993 and 1998 dataset were reviewed. Each linear feature was allocated from codes recorded in the field held in different database tables to a consistent summary group code. The summary groupings are those used in Haines-Young *et al.* 2000. A manual check on 10% of the squares confirmed that the allocation programme was consistent in the allocation to these summary groups from surveyor codes used in all three surveys.

158 Summary groupings used are:

- HEDGE - A more or less continuous line of woody vegetation that has been subject to a regime of cutting in order to maintain a linear shape.
- REMNANT - A woody field boundary feature with a residual hedge structure but without evidence of recent hedge management .
- LINE of TREES/SCRUB and RELICT HEDGE - Line of trees or shrubs, including those originally planted as hedges but lacking any significant hedge structure and with a fence forming a field boundary.
- OTHER – any linear boundary feature not including a 'woody feature' e.g. fence
- CURTILAGE – a feature within an area of ground that is associated with a building and which has a use linked with that building e.g. gardens, 'grounds', forecourts etc.
- NO FEATURE – no linear boundary feature recorded

159 Due to partially refused access to 3 survey squares in 1998 a further 619 rows of data were discounted for comparison. The final data set has 22629 records containing allocations for all three years.

160 A sub-set was created of 'woody features', that is, features where a either a hedge, remnant hedge or relict hedge and/or line of trees/scrub was present in any of the three years. There were 13524 features in this sub-set, of which 9852 records (43% of total , 73% of the 'woody features' subset) were where a 'hedge' was allocated in any one year. 39% were allocated as 'hedge' in all three years with no other combination of allocations individually accounting for more than 5%. A frequency summary of the chronological allocations for the 'woody features' sub-set are shown in the column entitled 'Original allocation' of Annex 4.1.

Possible discrepancies resulting from the 1990 - 1993 - 1998 allocation

161 From the 'hedge' sub-set, 1705 records (17%, 7.5% of total and 13% of 'woody features') had unchanged 1990 and 1998 automatic allocations but the 1993 allocation differed. The interpretation of this is that the 1998 surveyor confirmed that the feature had not significantly changed since 1990 but the 1993 surveyor had recorded codes showing a major change from 1990. These possible discrepancies are shown in Table 4.2

Table 4.2 Chronological allocations for 1990-93-98 which were identified as unlikely to have occurred.

1990-93-98 allocation	Frequency of occurrence	Total length in database (km)
HRH	667	30.8
HNH	242	11.2
HOH	233	8.9
NHN	222	9.0
OHO	168	6.1
RHR	101	4.6
LHL	68	2.6
HLH	4	0.1
total	1705	73.3
Key: H = hedge R = remnant hedge N = no feature C = curtilage O = other feature L = line of trees/scrub/relict hedge		

162 The allocation programme was discounted from having contributed to discrepancies as it had been found to be consistent in the use of surveyor codes in all three surveys.

163 Using a sub-sample, the recorded field codes used for the allocation were checked in the original field record sheets and maps. It was apparent that the high number of scenarios where the 1990 and 1998 allocations remained unchanged but the 1993 allocation differed were due to differing field codes recorded for the same spatial feature in the 1993 records.

164 Whilst it was considered possible for a feature to undergo a major change from 1990 to 1993 and then be restored to the original feature by 1998 two factors suggested that these may be improbable changes:

- had the feature been restored to it's 1990 condition since 1993 new management codes would likely be recorded in 1998 e.g. recently laid, trimmed, filled gaps etc.
- the large number of records exhibiting this apparent unusual change

165 It was surmised that there may have been four factors responsible for these apparent improbable changes, which were then checked:

d) different field code use during the 1993 survey

e) different field code definitions during the 1993 survey

f) different interpretation of the field-codes during the 1993 survey

g) different historical data given to field-surveyors and their instructions for recording change

166 The field-survey handbooks from each survey were checked for consistency:

a) Field codes used that were taken into account during the allocation procedure were identical in all three surveys. There was a change of one feature code from 'trimmed' in

1990&93 to 'recently planted' and the addition of 7 new codes to describe the shape of the hedge in 1998, however, these do not affect the allocation procedure.

b) Definitions given for codes used in the field-survey handbooks for each survey are consistent in the main with some minor changes made resulting in more exact definitions from 1993 onwards. These definitions are given below (changes shown in ***bold italics***):

- CS1990 Field Handbook:
- HEDGE - Woody vegetation that has been subject to a regime of cutting in order to maintain a linear shape. When hedge management is abandoned, and the natural shape of the tree is regained then the feature can no longer be described as a hedge.
- Use of 'Derelict' code – Still obviously a hedge but all attempts at management have been abolished.
- LINE OF RELICT HEDGE – usually a line of shrubs showing where a hedge has once been (see definition of hedge; can be used in addition to forestry codes).
- HS93 & CS2000 Field Handbook:
- HEDGE - A more or less continuous line of woody vegetation that has been subject to a regime of cutting in order to maintain a linear shape. When hedge management is abandoned and the ***overall*** natural shape of the ***component*** tree species has been regained , ***or when the bottom 2m (or less) of the feature is no longer continuous*** , then the feature can no longer be described as a *hedge* ***(and might be considered as, for example, a scattered line of shrubs or trees).***
- Use of '*Overgrown*' code – Still obviously a hedge but all attempts at management have been abolished.
- LINE OF RELICT HEDGE – usually a line of shrubs showing where a hedge has once been (see definition of hedge; can be used in addition to forestry codes).

c) surveyors may have put more emphasis on recording change, especially in relation to 'relict' hedges during the 1993 Hedgerow Survey (because the identification of 'relict' hedgerows was a major objective of this interim survey).

d) Field-surveyors were provided with different levels of historical spatial and attribute data and instructions for mapping in each of the surveys. The 1990 surveyors mapped and recorded attribute data from basic base maps only. The 1993 surveyors were given the spatial locations of features from the 1990 survey but no data indicating what features had previously been recorded there. The 1998 surveyors were supplied with maps and attribute data from 1990 only and instructed to record change where absolutely sure. This approach was taken to reduce the likelihood of features changing due to subjectivity (even taking into account the definitions in the field-guide and the one week training course for surveyors).

Alternative allocation codes for 1998.

167 As a result of the discrepancies an attempt was made at simulating the probable codes recorded by 1998 surveyors had they had the 1993 data in the field. A new data column was created for use as an alternative allocation in these cases, the original allocation for 1998 remaining unaltered.

168 Records showing an unchanged allocation in 1998 from 1990 but with a changed allocation in 1993 had been previously manually checked by referring to the field record sheets and maps from all three years and, using a decision tree (see Figure 4.2), creating an alternative 1998

allocation where directed. In summary, the 1993 allocation was carried through to 1998 unless the 1998 surveyor had recorded codes that were interpreted as there having been a change from the 1993 allocation.

Figure 4.2 Decision tree for creation of alternative 1998 allocation.

Hedge in 98

Change in codes since 1990

+ filled gaps
+ recently planted
+ laying
- derelict

= Allocate as hedge in 1998

No change in codes since 1990

= Allocate same as 1993

169 As a result of manual checking of the recorded codes in each of the three years , from the 1705 records with 'hedge' where the 1990 and 1998 automatic allocation had not changed but the 1993 allocation differed, a total of 1049 records (62%) had alternative allocations created. This represents 5% of all records, 8% of the 'woody' sub-set and 10% of records where a hedge was recorded in any year. The frequency and total length of records and the effect of manual checking are shown in Table 4.3.

Table 4.3. Original allocations and result of manual checks

allocation	Original allocation		Stayed same		Given alternative 1998 allocation	
191990-93-98	freq	length km	freq	length km	freq	length km
HRH	667	30.8	42	1.8	625	29
HNH	242	11.2	49	2.9	193	8.2
HOH	233	8.9	41	1.6	192	7.3
NHN	222	9	217	8.6	5	0.4
OHO	168	6.1	156	5.7	12	0.4
RHR	101	4.6	92	4.4	9	0.2
LHL	68	2.6	59	2.2	9	0.4
HLH	4	0.1	0	0	4	0.1
total	1705	73.3	656	27.2	1049	46

170 The frequency of allocations, for features with a hedge in any year, shown using the original and alternative allocations are summarised in Annex 4.1. The most frequent chronological allocation for a feature is a hedge allocated in all three years and accounts for 53% of all allocations where a hedge was present in any year. There is no percentage change in this group using the alternative allocation for 1998. The chronological allocation HRH accounts for 7% of the total but falls to less than 1% using an alternative allocation. HRR increase from 5% to 11% using an alternative allocation.

171 Two estimates of length of hedge in England & Wales in 1998 were produced from this dataset. The first used the original 1998 allocation based on field records, the second used the

'alternative 1998 allocation' to allocate based on simulated codes of what may have been recorded in the field in 1998 had the surveyors been provided with 1993 information.

Exploration of the relationship between differences in stock, change and change using different sample sizes.

172 Sample sizes for England & Wales vary depending on year surveyed, whether repeat surveyed and whether the sample previously contained hedge in 1990. Table 4.4 shows sample size available.

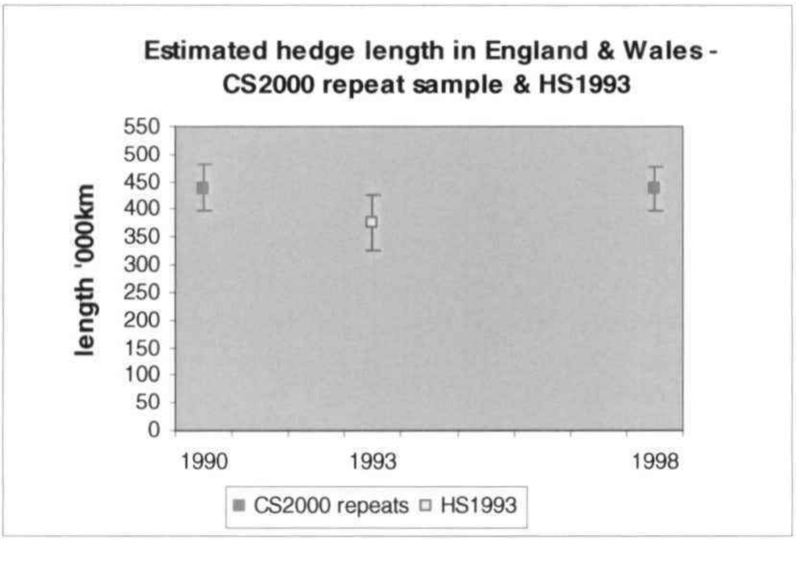
Table 4.4 Sample size for England and Wales by year.

Year surveyed	Sample size ($1km^2$)
1990	311
1998	366
1990+98	308
1990+98 (with hedge)	249
1993	108
1990+93+98	107

173 The previously published results for 1990 and 1998 from CS2000 and for 1993 from HS1993 are based on the largest sample available for each year.

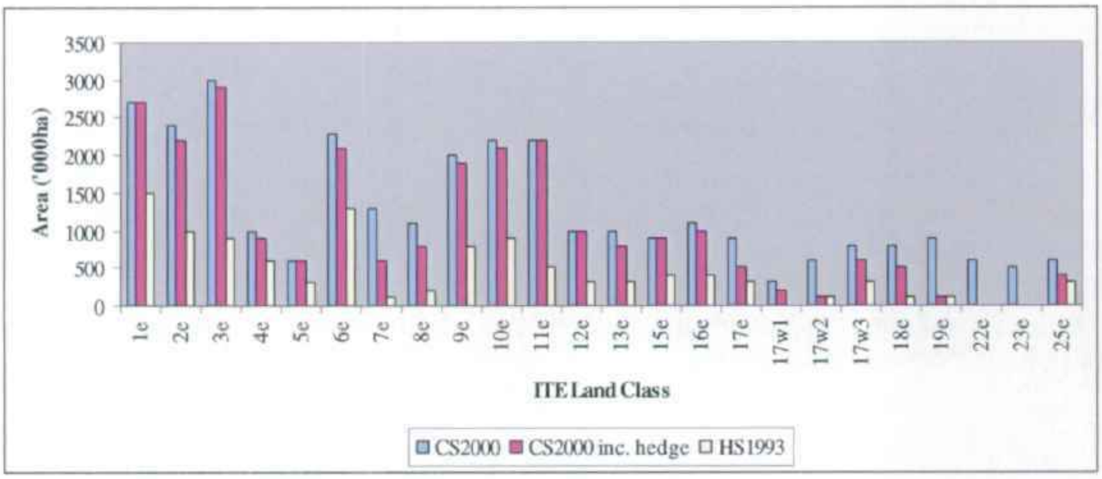
174 Restricting the sample for the 1990 and 1998 estimates to the 308 squares repeated in both years shows little difference in overall stock figures, nor trend, as shown in Figure 4.3.

Figure 4.3 Estimates of length of hedge in England and Wales based on stock figures from largest repeat sample available for 1990-1998 (n=308) and largest sample available for HS1993 (n=108). See Annex 4.2 for data.



175 The sample of 107 squares repeat surveyed in 1990, 1993 and 1990 represent 34% of the total repeat squares (43% of those containing some hedge) and 90% of land classes represented in England and Wales. See Figure 4.4.

Figure 4.4 Area in England and Wales sampled by Countryside Survey 2000 (repeat survey in 1990 and 1998) and Hedgerow Survey 1993 shown by ITE Land Class. England & Wales contains 24 ITE land classes from a total of 40 covering Great Britain.



176 Comparisons were made between the following stock estimates:

a) At the time of the 1993 Hedgerow Survey the sub-sample of 108 squares were allocated to amalgamated land classes in order to produce national estimates that were comparable to those produced from a much larger sample for 1990. Amalgamating land classes is not necessary when producing estimates for 1990, 1993 and 1998 based only on the sub-sample of 107 squares as they are directly comparable.

b) The mean change per amalgamated land class (from the Hedgerow Survey 1993) for 1990-93 and 1993-98, derived from the 1993 sub-sample of 108 squares, has been applied to the further 142 squares in England & Wales. This boosted sample size has been used to create national estimates.

National estimates of stock

177 A number of comparable national estimates of length of hedge in England & Wales for 1990, 1993 and 1998 were produced using differing sample sizes (Table 4.5).

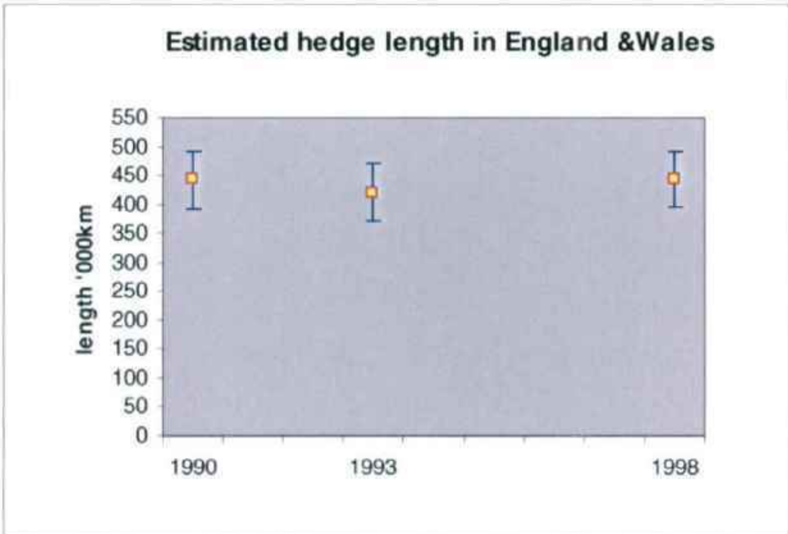
Table 4. 5 Sample sizes for different surveys producing national estimates of hedge length.

Sample size	comment
107	Largest sample of squares repeat surveyed in 1990, 1993 and 1998
249	107 sample plus 142 squares that had hedge in 1990, with length in 1993 derived from ratio-ed mean change 1990-93 of 108 sample
164	107 sample plus 54 squares from original HS1993 sample selection that had hedge in 1984&1990, with length in 1993 derived from ratio-ed mean change 1990-93 of 108 sample

National estimate of stock based on sample of 107 squares:

178 The sample is restricted to squares repeat surveyed 1990-1993-1998, the resulting estimates being directly comparable (Figure 4.5). The ITE Land Classes have not been amalgamated as this is unnecessary due to the sample being treated equally for all years.

Figure 4.5 Estimates of length of hedge in England and Wales based on stock figures from largest repeat sample available for 1990-1993-1998 (n=107).

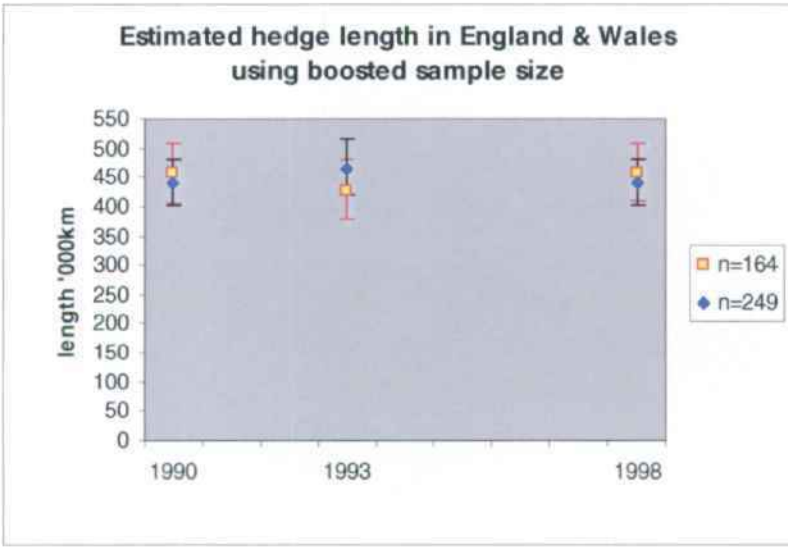


National estimate of stock based on boosted sample of 164 & 249 squares:

179 Using the 108 sample a mean change in length per ITE Land class between 1990 and 1993 was calculated (Figure 4.6). The sample size could then be boosted by calculating an estimate for 1993 raw data length from the known 1990 length for further Countryside Survey squares. The 107 sample was boosted to 165 by estimating 1993 hedge length for 58 squares that were originally identified for the Hedgerow Survey 1993 but not surveyed. The sample was then reduced by 1 square not surveyed in 1998 to equal 164. This sample included some squares where no length of hedge was present. Another boosted sample (n=249) was produced by

estimating 1993 length for a further 142 squares repeat surveyed in 1990 and 1998 that contained hedge in 1990.

Figure 4.6 Estimates of length of hedge in England and Wales based on stock figures from largest repeat sample available for 1990-1993-1998 (n=107) boosted by applying weighted mean change to remaining Countryside Survey repeat squares that included hedge in 1990



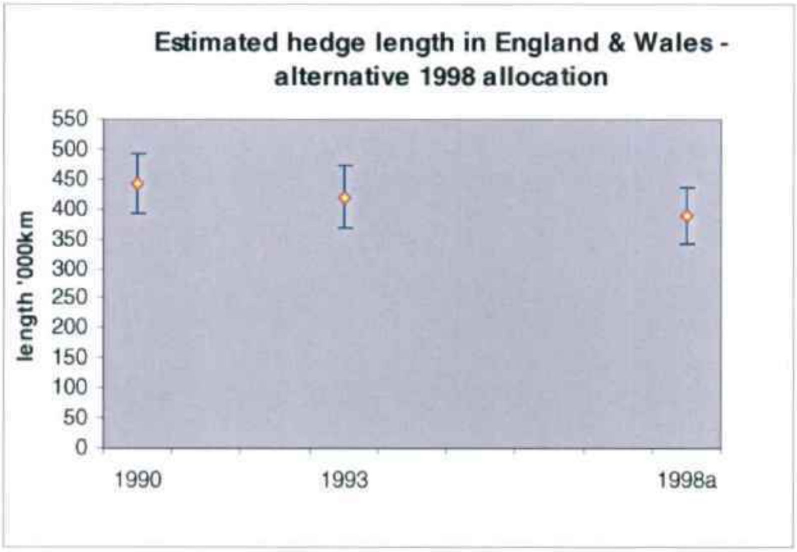
180 Using the boosted sample of 164 squares the trend is similar to that of the original 107 squares, a decrease from 1990 to 1993 followed by an increase back to the 1990 level in 1998. However, when using the boosted sample of 249 squares an opposite trend is seen with an increase from 1990 to 1993 followed by a loss from 1993 to 1998 to the 1990 level. This is due to additional squares having a large effect on the land class means, themselves calculated from a relatively small number of squares initially.

National estimate of stock based on full sample from 1990 and 1998 using HS 1993 amalgamated land classes

181 Background work had been carried out to enable the full sample of 1990 and 1998 survey squares to be allocated to the same amalgamated land classes used to produce results in the Hedgerow Survey 1993. These would be compared to the published Module 1 results to assess the effects of amalgamating land classes in order to produce national scale estimates from the Hedgerow Survey 1993 sample. However, as the completed time-series analyses provide comparable results this was deemed a low priority and was not completed due to time constraints.

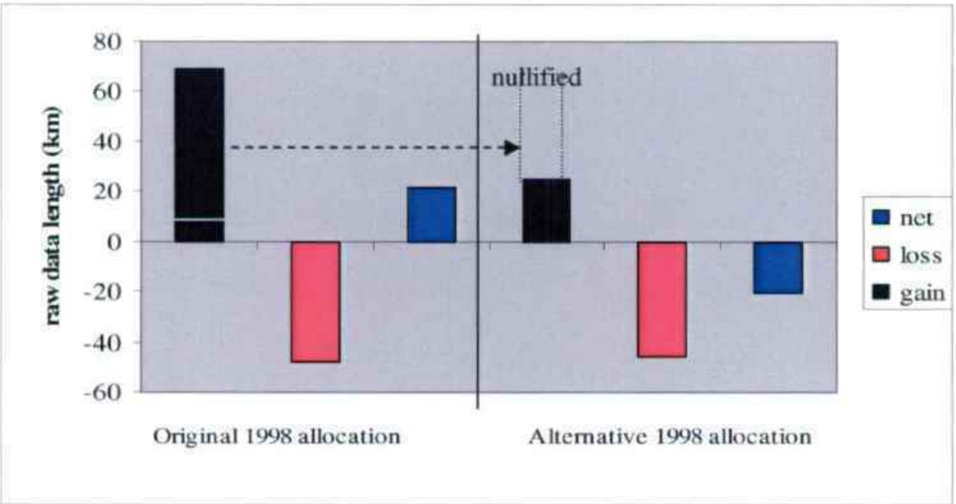
National estimate of stock using alternative allocations for 1998

Figure 4.7 Estimates of length of hedge in England and Wales based on stock figures from largest repeat sample available for 1990-1993-1998 (n=107). 1998 estimate is based on an alternative allocation – see text.



182 When the alternative 1998 allocation is used the trend shows a further decrease in hedge from 1993 to 1998 (Figure 4.7). The original 1998 total shows a net increase over 1993 because there are larger gross gains than losses. The alternative allocation nullifies the majority of the gains resulting in the gross losses becoming greater that the gains. This explains how the alternative 1998 stock figures are lower than the 1993 stock figures. Figure 4.8 shows the gross gains and loss of hedge for 1993 to 1998 using both estimates.

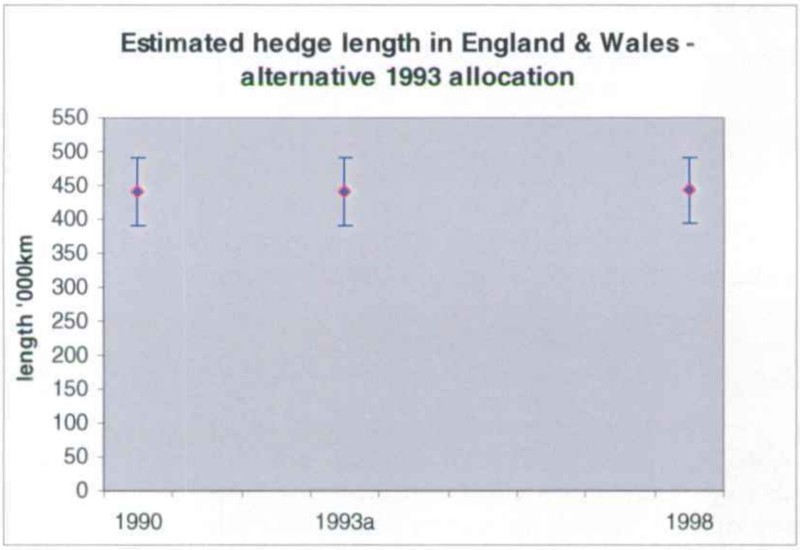
Figure 4.7 Estimates of length of hedge in England and Wales based on stock figures from largest repeat sample available for 1990-1993-1998 (n=107). 1998 estimate is based on an alternative allocation – see text.



National estimate of stock using alternative allocations for 1993

183 The FOCUS workshop of May 2002 recommended that the data re-analysis as a result of possible discrepancies between 1993 and 1998 be looked at a different way. An alternative allocation for 1993 was created, simulating the probable 1993 allocation had the 1993 surveyors had the 1990 data and been given the same instructions for mapping as in Countryside Survey. The alternative 1993 allocation was created by taking the sub-set of data that was given an alternative 1998 allocation (1049 records, Table 4.3) and creating an alternative 1993 column entry equal to the 1990 allocation. Statistics for frequency of allocations and changes are the same as those given in Table 4.3.

Figure 4.9 Estimates of length of hedge in England and Wales based on stock figures from largest repeat sample available for 1990-1993-1998 (n=107). 1993 estimate is based on an alternative allocation – see text.



184 By estimating 1993 lengths using an alternative 1993 allocation the results indicate that the trend between all 3 surveys would be static (Figure 4.9).

185 A number of 'case studies' (a sub-sample of the overall population) will be examined in terms of the codes used to describe the same hedge at each of the three survey dates, and how these codes have subsequently been used in data analysis.

186 A complete dataset has been created with allocations per feature in a time series for 1990, 1993 and 1998.

187 Two datasets of a sub-sample of the overall population were created of codes used to describe the same hedge at each of the three survey dates. The first was created manually from the actual surveyors records in the Field Assessment Booklet and is a smaller sub-sample. The second was created from Database queries and was cross-checked to the manually created dataset for validation.

188 From these data, changes in codes used and /or changes in allocation were looked for. A number of change scenarios between allocation in 1990 – 1993 – 1998 were looked at and some general conclusions reached.

1990-93-98 allocation of Hedge-Remnant-Hedge

189 A number of cases suggested the 1993 surveyors were more inclined to record a line of scrub/relict hedge whereas the 1998 surveyors would make no changes to the main 1990 codes other than to record new condition or management codes e.g. Unfilled gaps >10%.

190 A number of other cases showed the 1993 surveyors were more inclined to record a line of scrub/relict hedge where the 1990 surveyor recorded a hedge with a 'derelict' code as opposed to a 'line of relict hedge' code. The use of these codes were re-affirmed by the 1998 surveyor.

1990-93-98 allocation of Remnant-Hedge-Remnant :

191 Most cases showed that the 1998 surveyor reaffirmed the 1990 codes showing a remnant hedge with little change but the 1993 surveyor recorded a hedge feature. Checks with surveyors maps from CS2000 and Hedgerow Survey 1993 showed correct spatial correlation.

1990-93-98 allocation of Hedge-Other feature/no feature-Hedge:

192 Most cases showed that the 1998 surveyor reaffirmed the 1990 codes showing a hedge with little change but the 1993 surveyor recorded no hedge or other linear woody feature. Checks with surveyors maps from CS2000 and Hedgerow Survey 1993 showed correct spatial correlation. It is difficult to offer any explanation in these cases.

193 A number of cases were due to incorrect spatial correlation between the datasets. In the majority of cases these were short lengths of lines amongst a complexity of other lines and would likely cancel each other out when stock totals by feature by year for the sample square were computed.

1990-93-98 allocation of Other feature/no feature-Hedge-Other feature/no feature:

194 Many cases showed that the 1998 surveyor reaffirmed the 1990 codes showing no hedge or other linear woody feature with little change but the 1993 surveyor recorded a hedge. Checks with surveyors maps from CS2000 and Hedgerow Survey 1993 showed correct spatial correlation. It is difficult to offer any explanation in these cases.

195 A number of cases were due to incorrect spatial correlation between the datasets. In the majority of cases these were short lengths of lines amongst a complexity of other lines. Each of these records would need manual checking in order to rectify but would likely be cancelled out by an opposite incorrect allocation record when stock totals by feature by year for the sample square were computed. In total these may account for 1-2% of the total number of records in the 'woody features' sub-set.

SUMMARY

196 The time-series analysis of directly comparable 107 samples between 1990, 1993 and 1998 indicates that there is some evidence that there has been a decrease in the length of hedgerow between 1990 and 1993 and an increase between 1993 and 1998. Although there is confidence in the definitions associated with field codes and in the allocation procedures, there is some uncertainty over the way codes were used by surveyors in different surveys. By re-interpreting the data in the light of these uncertainties the evidence would indicate that there has been either no change or a loss between 1993 and 1998 (as well as between 1990 and 1993) depending on which of the two differing ways of reinterpreting the data was chosen.

197 The evidence may be further weakened by the relatively small sample size of the Hedgerow Survey 1993. The sample of 107 squares where comparable estimates can be made does not

sufficiently represent land classes in many cases and, based on the size of the error estimates, cannot be said to be representative of trends at the national scale in England and Wales.

FURTHER WORK AND RECOMMENDED CHANGES TO CS METHODS

198 No changes to Countryside Survey methodology are necessary as a result of the work directed at this question although any method development that helps ensure a more consistent use of field codes would be helpful. The issues arising within the question are founded in the comparison of a sub-sample survey with a fuller sample survey for example, Hedgerow Survey 1993 was not expected to produce national scale estimates. This might be a valuable lesson when considering the advisability of introducing future interim sample surveys.

ANNEX 4.1

Annex 4.1 Chronological allocations and frequency summary based on either original 1998 allocation or alternative 1998 allocation.

allocation	original allocation		alternative 1998 allocation	
1990-93-98	freq	length km	freq	length km
HHH	5228	300.6	5243	301.5
HRH	667	30.8	42	1.8
HRR	534	25.2	1087	51.3
OHH	292	13.5	304	13.9
NHH	288	13.1	296	13.6
HNH	242	11.2	49	2.9
HOH	233	8.9	41	1.6
NHN	222	9.0	217	8.6
RHH	194	9.4	203	9.6
OHO	168	6.1	156	5.7
HHR	131	6.0	113	5.1
HHO	115	5.6	111	5.4
HOO	110	4.5	246	9.3
RHR	101	4.6	92	4.4
LHH	84	4.2	93	4.7
OOH	75	3.7	75	3.7
HRO	69	2.9	95	4.0
HON	68	2.3	117	4.5
LHL	68	2.6	60	2.3
NHO	61	1.1	61	1.1
RRH	59	2.7	59	2.7
ORH	57	2.1	58	2.1
HNN	55	2.3	154	6.6
HHN	52	2.7	52	2.7
LRH	47	2.5	47	2.5
NRH	44	2.1	44	2.1
HNR	43	2.0	41	2.0
HRN	43	2.3	71	3.3
HRL	40	2.0	57	2.8
OHL	38	2.0	38	2.0
HNC	37	1.6	102	4.1
ONH	35	2.1	35	2.1
HNO	33	1.7	47	2.1
HHL	30	1.5	36	1.6
OHN	26	0.9	26	0.9
RHL	26	1.2	26	1.2
NOH	25	0.9	25	0.9
NHL	22	0.7	22	0.7
HOR	18	0.5	16	0.5
NHR	17	0.6	14	0.6
NNH	17	0.6	17	0.6
RHO	16	1.0	16	1.0
OHR	15	0.5	15	0.5

ROH	15	0.5	15	0.5
LOH	14	0.4	14	0.4
RNH	11	0.6	11	0.6
HNL	9	0.3	26	1.4
HHC	8	0.2	9	0.2
RHN	8	0.3	8	0.3
NHC	6	0.5	6	0.5
RHC	6	0.4	6	0.4
OHC	5	0.2	5	0.2
HLH	4	0.1		0.0
LHR	4	0.3	3	0.1
LNH	4	0.3	4	0.3
HRC	3	0.2	4	0.3
HOL	2	0.0	9	0.3
LHC	2	0.0	2	0.0
HLL	1	0.1	1	0.1
HLO	1	0.1	1	0.1
LHN	1	0.1	2	0.1
LHO	1	0.0		0.0
LLH	1	0.0	1	0.0
ORO	1	0.0		0.0
HLN			2	0.1
HLR			2	0.0
HOC			2	0.0
total	9852	506.3	9852	506.3

Key:

H = hedge   R = remnant hedge   O = other

N = no feature   C = curtilage   L = line of trees/scrub/relict hedge

ANNEX 4.2

Data tables for Figures in text

Figure	Analysis	Sample size	year	length (000km)	SE	95% Lower limit	95% Upper limit
4.1	CS1990	311	1990	431.8	22.3	n/a	n/a
	CS2000	311	1990	450.1	22.3	408.7	495.5
	HS1993	108	1993	377.5	25.5	n/a	n/a
	CS2000	366	1998	449.3	21.2	408.6	490.4
4.2	FOCUS	308	1990	439.5	22.4	399.5	479.6
	HS1993	108	1993	377.5	25.5	n/a	n/a
	FOCUS	308	1998	438.4	22.1	398.4	477.1
4.4	FOCUS	107	1990	442.5	30.7	391.0	492.5
	FOCUS	107	1993	418.5	30.8	369.6	471.8
	FOCUS	107	1998	443.0	30.0	394.1	492.0
4.5	FOCUS	164	1990	458.1	29.6	402.8	515.6
	FOCUS	164	1993	427.3	29.6	374.6	482.6
	FOCUS	164	1998	458.4	29.3	406.0	511.3
	FOCUS	249	1990	441.4	23.0	404.0	481.9
	FOCUS	249	1993	465.2	28.1	421.8	514.9
	FOCUS	249	1998	440.4	22.6	403.0	480.4
4.6	FOCUS	107	1990	442.5	30.7	391.0	492.5
	FOCUS	107	1993	418.5	30.8	369.6	471.8
	FOCUS	107	1998alternative	388.2	28.9	340.9	436.6
4.8	FOCUS	107	1990	442.5	30.7	391.0	492.5
	FOCUS	107	1993alternative	441.5	30.6	389.9	491.7
	FOCUS	107	1998	443.0	30.0	394.1	492.0

n/a = not available

Question 5: What is the relationship between plant diversity in 10m and 30m hedge plots, hedgerow characteristics/management and adjacent land use?

INTERIM REPORT - ***Rick Stuart & Colin Barr***

DUE START DATE:

- June 2002

DUE FINISH DATE:

- September 2002

OVERALL PROGRESS

- A database has been constructed linking data for each H plot, associated D plot, adjacent hedge characteristics and management and adjacent land use.
- Some preliminary analyses have been carried out .
- It is anticipated that the work will be completed shortly.

DEFINITIONS

- 'Plant diversity' – can be measured in at least two ways; here we mean (i) mean number of plant species per plot, and (ii) mean number of species groups per plot.
- 'Characteristics' (of hedges) – this is taken to mean all 'attributes' recorded in the field when mapping hedges.

POLICY CONTEXT STATEMENT

199 *The following policy context statement has been drafted but has not been circulated for comment.*

200 Hedgerows are important components of the patchwork landscape of much of lowland Britain. In many situations, they may constitute the only vertical structures and the only woody vegetation. Their historical, landscape and ecological importance has never been as high on the political agenda as now and there is a strong need for information about hedgerows, and the processes that lead to their survival in good condition. A significant aspect of hedgerows is the associated ground flora (or hedge-bottom flora) which, in many agricultural landscape, may provide the only semi-natural vegetation for miles around. The sympathetic management of this valuable resource has important policy implications but it is by no means clear which are the major drivers in the maintenance of 'good quality' hedgerow ground flora. The information necessary to formulate agri-environment policies is, at best, piecemeal and often absent altogether.

201 Nevertheless, in a review of hedgerow research, Barr, Britt & Sparks (1995), reflecting the views of several researchers, concluded that there was little evidence for a relationship between the diversity of woody species in the hedgerow and the diversity of the ground flora. Further,

change in the hedge bottom flora was thought to be associated most strongly with adjacent land use.

202 The first of the Countryside Survey-type surveys, The Ecological Survey of GB, completed in 1977/8, recorded vegetation in up to two linear plots adjacent to hedgerows in those sample 1 km squares where hedgerows were present. These plots were surveyed again in 1990 and in 1998. By 1998 (CS2000), both the draft hedgerow protection legislation, and the UK Habitat Action Plan for Ancient and/or Species-rich hedgerows, required knowledge of the number of native woody species in a 30 m length of hedge, as measures of species richness. Accordingly, MAFF (as was) funded a work as part CS2000 Module 3 whereby the woody vegetation in up to ten 30 m plots per 1 km square was recorded, in England and Wales. Funding from the Natural Environment Research Council allowed similar recording in some squares in Scotland. Two of these 30 m woody diversity plots (D plots) in each square were co-registered with the existing 10 m plots (H plots). Thus, in CS2000 for the first time in the CS series, information from ground flora plots and adjacent woody hedgerow canopies had been recorded, and in a relatively large number of plots (thought to be >500).

203 The dataset from CS2000 gives an opportunity to examine the relationships between ground flora, woody species, physical hedge characteristics and management, and adjacent land use.

SCIENCE OUTPUTS

Assemble a database for each H plot, including (a) condition measures from analysis of the plot vegetation, (b) woody species information from associated D plot, (c) all characteristics/management data, as defined below (under Q7) and (d) adjacent land use (usually on the 'field side').

204 A database has been compiled linking data for H plots surveyed in 1998. A total of 484 H plots are present where associated D plot information is available, recorded from 301 survey squares.

205 Linked data tables are as follows:

a) **H plot** - contains 15 condition measures from analysis of the plot vegetation

b) **D plot** - contains woody species information for associated D plots

c) **hedge characteristics / management** - links H plots to the following measures for each adjacent hedgerow:

- Type of hedge (hedge, remnant of relict)
- 1 of 3 species composition codes
- up to 6 management codes
- up to 6 condition codes
- presence of adjacent steam or ditch

d) Land use

- Broad Habitat code of area in which plot was recorded
- Main land cover codes of area in which plot was recorded
- Feature codes of area in which plot was recorded e.g. land use, attributes of land cover
- Agro-environment scheme information for area in which plot was recorded

206 A total of 91% of H plots in the database were adjacent to a hedge with the remainder adjacent to other woody hedge features. These have been further broken down into types of adjacent hedge as shown in Table 5.1.

Table 5.1 Frequency of H plot by associated linear boundary feature. For description of 'Summary group' see (1) and 'Intermediate group' see (3).

Associated linear feature		
Summary group	**Intermediate group**	**Frequency of H plot**
Hedge	Recently managed hedge plus fence	224
Hedge	Recently managed hedge	179
Hedge	Other hedge plus fence	18
Hedge	Other hedge	20
Hedge Total		441
Remnant	Remnant plus fence	22
Remnant	Remnant	15
Remnant Total		37
Relict /line of trees/scrub	Relict hedge / line of trees plus fence	3
Relict /line of trees/scrub	Relict hedge / line of trees	1
Relict /line of trees/scrub	Relict hedge / line of scrub plus fence	2
Relict /line of trees/scrub Total		6
Grand Total		484

207 A total of 83% of H plots (see Table 5.2) were associated with intensively managed landscapes (arable and improved grassland habitats). Linear habitats, including roads, railways, canals and tracks accounted for 7% of plots with no other Broad Habitat accounting for more than 4%.

Adjacent Broad Habitat in 1998	**Frequency of H plots**
Broadleaf	17
Conifer	3
Linear	33
Arable	181
Improved grassland	220
Neutral grassland	13
Calcareous grassland	1
Bracken	4
Fen	3
Open water	1
Urban	8
Total	484

Table 5.2 Frequency of H plot by adjacent Broad Habitat.

208 The FOCUS workshop of May 2002 recommended exploring impacts of agri-environment schemes, for example what impact does Countryside Stewardship have on plant diversity? The dataset compiled from data collated as part of Topic 7 was used to identify H plots within the dataset that are located in land under selected agri-environment schemes. The results of GIS

analysis shows low sample sizes of 39 plots located on land in Countryside Stewardship agreement in England, 12 plots in ESA agreement in England and only 3 plots in ESA in Wales. No data is available for Scotland.

Using multivariate statistics, this database will be explored to identify relationships between ground-flora diversity, woody species diversity, hedge management (inferred from characteristics data) and adjacent land use.

209 A small workshop has been set up within the project team to clarify the best approaches to be taken.

Identify hypotheses to explain causal relationships.

210 This work has not started.

SUMMARY

211 Work on this question is at a very early stage. A database is starting to be assembled.

FURTHER WORK AND RECOMMENDED CHANGES TO CS METHODS

212 It is too early to comment.

REFERENCES

(1) Haines-Young, R.H., Barr, C.J., Black, H.I.J., Briggs, D.J., Bunce, R.G.H., Clarke, R.T., Cooper, A., Dawson, F.H., Firbank, L.G., Fuller, R.M., Furse, M.T., Gillespie, M.K., Hill, R., Hornung, M., Howard, D.C., McCann, T., Morecroft, M.D., Petit, S., Sier, A.R.J., Smart, S.M., Smith, G.M., Stott, A.P., Stuart, R.C., and Watkins, J.W. (2000). *Accounting for nature: assessing habitats in the UK countryside.* Department of the Environment, Transport and the Regions, London.

(2) Hooper, M.D. (1992) *Hedge Management.* (Unpublished Institute of Terrestrial Ecology report for the Department of the Environment. August 1992).

(3) CS2000 Module 1 Results http://www.cs2000.org.uk/M01_tables/reports/explanatory_notes.htm#linearb

Question 6: What evidence is there, from the survey of birds in Module 5 and other sources, of the value of different types/patterns of hedges for birds and, by comparison with previous surveys, of changes in the condition of hedges (for birds)?

INTERIM REPORT - *Colin Barr & Rick Stuart*

DUE START DATE:

- August 2002

DUE FINISH DATE:

- November 2002

OVERALL PROGRESS

- Work started ahead of schedule with the digitising of transects mapped during Module 5 fieldwork.
- The project is currently at a critical phase with a detailed work plan having been agreed at a meeting between CEH and BTO on 1st October 2002.
- Relevant databases are being assembled and a literature search is under way.
- It is expected that work is unlikely to have been completed by the end of November 2002.

DEFINITIONS

- 'Types/patterns' (of hedges) – the creation of a typology of hedges will form part of the research.
- 'Condition' – no *a priori* judgement is made about what is meant by condition; the definition of this term forms part of FOCUS Question 8.

POLICY CONTEXT STATEMENT

213 *The following policy context statement has been drafted and presented at the May 2002 workshop. Input from relevant Department policy advisers has yet to be made.*

214 The importance of birds as ecological indicators is now widely recognised. In particular, farmland birds (as a group) are the subject of concern as declining numbers in many species are observed and reported. One of the key habitats in many of the farmed landscapes is hedgerows and their associated features. Research shows that there is no ideal shape or size of hedge for birds. It is suggested that on balance, birds prefer a hedge with high volume, few gaps and plentiful protection from predators (thorns). However, some birds (eg cirl bunting) are known to like low trimmed hedges with occasional song perches, while other species (eg corvids) prefer large, overgrown hedges for nesting.

215 The routine collection of physical and management data on hedgerows as part of CS2000, and the introduction of Module 5 whereby transects were walked in a large proportion of the 1 km

sample squares, and birds recorded at different distances from the transect lines, allows an assessment of the association between different hedge types and bird frequency. This research is further enhanced by the potential to examine aspects of landscape pattern associated with hedgerows and to relate this to bird numbers and distribution.

216 Thus, the analysis in this are of the research programme will show, in general terms, which types of hedgerow, and which spatial characteristics, are best suited to particular bird species and to overall avian diversity. This is important in planning new landscapes, through, for example, agri-environment schemes, so that optimal conditions for a range of bird species can be achieved.

SCIENCE OUTPUTS

217 The original specification for addressing this question included the following statements:

In using the bird data collected under Module 5 to answer this question we would bear in mind that the methods we used were designed to give a 'whole square' appraisal of the bird community. Therefore it will be difficult to relate the bird counts to individual hedges.

However, it is planned to use subsets of the squares to examine how bird populations varied in relation to different densities/patterns of hedges at the whole square level. Costs assume that digitising of the Module 5 transects have not been completed as part of Module 13.

We will also look at the proportions of different hedge types. This would be additional to the completed Module 5 analysis which is targeted very much at the broad national and regional scales.

We would review the significance for birds of the changes that CS2000 has identified in hedge condition between c1990 and c2000. We would do this based on existing knowledge of the requirements of different bird species (there is a good literature on this) coupled with reference to other material that is available at the BTO (to whom a sub-contract would be let to provide (a) joint method development (b) a literature review and (c) a report).

218 This has been translated into a more detailed research plan. It is proposed to classify the 335 squares into sub-sets in two separate ways, by:

- dominant hedge type
- landscape pattern (where hedges exist).

219 The hedge types will be determined by a multivariate classification of the attribute data associated with each hedge; a list of bird-relevant attributes has been agreed with BTO and include those associated with:

- the physical characteristics of the hedge
- woody species information
- associated features
- context.

220 CEH has started to assemble the database necessary to perform the analysis. It is expected that this analysis will result in no more than ten different hedge types.

221 The landscape classification will take place at the whole square level and will recognise the importance of:

- hedgerow connectivity
- hedgerow density

- the presence of woodland
- land cover diversity
- main farming systems.

222 The two separate classifications will then be correlated with a number of parameters derived from the Module 5 survey data including:

- Individual, widespread/common bird species
- Families (eg finches, tits, warblers etc)
- Farmland indicator species

223 These parameters will be derived by the BTO using their distance sampling techniques to generate bird population densities.

224 Once the relationships between bird densities and existing hedge and landscape classes has been understood, then trends in the frequencies of these classes over time will be derived from CS data. BTO will then assess the likely benefits/disbenefits of these changes to the different bird species and bird assemblages. Work has already started on this aspect in that BTO have already started a comprehensive literature review of bird species requirements in relation to hedges and to landscape parameters.

225 Although the outputs will not make an input to work within FOCUS, it was agreed that the digitising of transects mapped during Module 5 fieldwork would form part of the project, in preparation for other research studies. Existing GIS linear feature datasets are being edited to add transect data and all 335 squares are estimated to be complete by 8th October 2002.

SUMMARY

226 CEH and BTO staff have developed a clear research plan and work has started to assemble relevant databases and to complete a literature review. Digitising of the transects recorded in CS2000 Module 5 is nearly complete.

FURTHER WORK AND RECOMMENDED CHANGES TO CS METHODS

227 It is too early to comment at this stage.

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Question 7: What were the characteristics and locations of the hedges that were gained as opposed to those that were lost? To what extent do new and restored hedges compensate for hedges that are lost or degenerate into lines of trees?

INTERIM REPORT - ***Colin Barr & Rick Stuart***

DUE START DATE:

- October 2002

DUE FINISH DATE:

- January 2003

OVERALL PROGRESS

- Work started ahead of schedule because there was some commonality of tasks with Question 5.
- An appropriate database has been created and an initial, preliminary analysis has been completed.
- It is anticipated that the work will be completed by the end of January 2003.

DEFINITIONS

- 'Characteristics' (of hedges) – this is taken to mean all 'attributes' recorded in the field when mapping hedges, as well as a summary of botanical information from vegetation plots associated with hedges.
- 'Locations' (of hedges) – this is taken to mean geographical locations (as opposed to spatial positions within landscapes) and covers (a) countries, (b) Environmental Zones (*sensu* CS2000) and, (c) where statistically meaningful, Government Office Regions (in England).

POLICY CONTEXT STATEMENT

228 *The following policy context statement has been drafted but has not been circulated for comment.*

229 Estimates of the length of hedgerow in the UK, and in countries within the UK, have been derived from successive Countryside Surveys and related projects since 1984. Results are given in a number of papers and reports (and, most recently, web sites).

230 The most recent report was 'Accounting for nature: assessing habitats in the UK countryside' (Haines-Young *et al.* 2000) which presents results from Countryside Survey 2000. In this report it is stated that, in contrast with the period 1984 to 1990, there is no statistically significant change in the length of hedgerows in England and Wales or in Scotland, between the

two most recent Countryside Surveys in 1990 and 1998. There was a reported loss in N Ireland.

231 The zero net change between in Great Britain between 1990 and 1998 reflects a balance of losses and gains. Indeed, the main report of CS2000 results shows that, for example, in England and Wales the estimated total stock of hedgerows in 1998 was 468,000 km which included gains of about 39,900 km and losses of about 40,100 km. Thus, nearly 9% of the stock resulted from 'turnover'.

232 The obvious question that arises, from biodiversity, landscape and management perspectives relates to 'compensation': do new hedges compensate for removed ones? The question incorporates some value judgement but a clear starting point is to identify the physical and biological characteristics of both the gained and lost hedgerows.

233 A comparison of these characteristics, broken down by the type of change that has occurred (eg from 'hedge' to 'no boundary', or 'hedge' to 'line of trees') will allow some general assessments to be made as to the extent to which new and restored hedges compensate for hedges that are lost or degenerate into lines of trees. Such conclusions will be made in the context of deliberations by groups such as the UK Steering Group for the Ancient and/or Species-rich Hedgerow HAP which is expected to produce guidelines on what constitutes favourable condition of hedgerows.

SCIENCE OUTPUTS

Identify the hedges that have been gained and those that have been lost.

234 A database has been assembled. All 1990 or 1998 features that were classified as being 'hedges' in the presentation of earlier CS2000 results (eg Haines-Young *et al.* 2000) were included. Features classified as 'remnant', 'relict' or 'derelict' hedges were not included. The database comprises 1495 records (individual lengths) of hedges that have been gained between 1990 and 1998 and 1802 records of hedges that have been lost.

Describe these hedges in terms of mean recorded characteristics (species dominance in three classes, height, stockproofness, gappiness, management, shape, any relevant associated descriptions (eg recent laying, signs of removal of a boundary, regrowth from cut stumps), connectedness of hedgerow network, adjacent land use, adjacent features (eg ditch, hedgerow trees), all by Environmental Zone (and by Standard Regions if data adequate).

235 A simple, initial analysis of attributes used when mapping hedges has been completed. A fuller assessment, complete with conventional statistical analyses, will be undertaken before the project is completed.

236 The following tables (Tables 7.1 - 7.6) show results to date, grouped by broad attribute type (N.B. no significance tests (of differences) have yet been carried out):

Woody species composition

237 Results are given in Table 7.1. There appears to be remarkably little difference in the woody species composition between gained and lost hedges.

Table 7.1 Length of hedgerow lost and gained between 1990 and 1998 in GB, by dominant woody species.

	Lost ('000 km)				Gained ('000 km)			
	Hedge to nothing	Hedge to remnant	Hedge to line trees	Total lost	Nothing to hedge	Remnant to hedge	Line trees to hedge	Total gained
>50% hawthorn	11.9	2.7	3.1	17.7	11.8	5.9	1.2	18.9
>50% other	2.5	0.8	0.9	4.3	3.4	0.7	1.0	5.1
mixed	10.3	2.5	5.0	17.7	13.8	2.3	2.4	18.5
Total	24.7	6.0	9.0	39.7	29.0	8.9	4.6	42.5

Height classes

238 Height of hedge was an attribute that was not well recorded by surveyors; in this sample over 13% of lost hedges (recorded in 1990) and 21% of gained hedges (recorded in 1998), were not allocated a height category. A summary of lengths by height class is given in Table 7.2.

Table 7.2 Length of hedgerow lost and gained between 1990 and 1998 in GB, by height class.

	Lost ('000 km)				Gained ('000 km)			
	Hedge to nothing	Hedge to remnant	Hedge to line trees	Total lost	Nothing to hedge	Remnant to hedge	Line trees to hedge	Total gained
>2 m	9.9	3.8	6.5	20.2	6.3	2.4	0.7	9.4
1-2 m	10.3	1.6	1.2	13.1	14.1	4.7	1.9	20.7
<1 m	0.9	0.2	0.1	1.2	2.5	1.0	0.1	3.6
Unknown	3.7	0.3	1.4	5.4	6.2	0.9	1.8	8.9
Total	24.8	6.0	9.2	40.0	29.0	8.9	4.6	42.5

239 Of those where height was described, the majority of lost hedges had been in the >2 m category (58%), and most of those had been removed completely (49%) or become lines of trees (32%). A surprising number of gained hedges were also in the >2m class (28%), and two-thirds of these were there had been no boundary feature before (67%) suggesting, perhaps, that they had not been managed since planting.

'Stockproofness'

240 A relatively high proportion of hedges were not coded for stockproofness (36% of lost hedges and 18% of gained hedges). A summary of lengths by stockproofness is given in Table 7.3.

Table 7.3 Length of hedgerow lost and gained between 1990 and 1998 in GB, by stockproofness.

	Lost ('000 km)				Gained ('000 km)			
	Hedge to nothing	Hedge to remnant	Hedge to line trees	Total lost	Nothing to hedge	Remnant to hedge	Line trees to hedge	Total gained
Stockpr'f	7.4	1.2	2.0	10.7	11.6	1.4	2.1	15.1
Not stockpr'f	9.7	2.5	2.7	14.9	12.6	5.9	1.5	19.9
Unknown	7.8	2.2	4.4	14.4	4.8	1.7	1.0	7.5
Total	24.8	6.0	9.2	39.7	29.0	8.9	4.6	42.5

241 Where this attribute was recorded, there was little difference in the percentage of lost and gained hedges that were classified as stockproof (42% and 43% respectively).

Filled gaps

242 The lengths of hedge that were coded with either of the 'filled gaps' attributes is a relatively small proportion of the whole (c. 12% of lost hedges and c. 11% of gained hedges). From the foregoing, it may be assumed that this may include an element of non-recording. A summary of length by gap type is given in Table 7.4.

Table 7.4 Length of hedgerow lost and gained between 1990 and 1998 in GB, by gap type.

	Lost ('000 km)				Gained ('000 km)			
	Hedge to nothing	Hedge to remnant	Hedge to line trees	Total lost	Nothing to hedge	Remnant to hedge	Line trees to hedge	Total gained
<10% of length	1.7	0.1	0.6	2.4	2.2	0.3	0.2	2.6
>10% of length	1.8	0.2	0.2	2.2	1.1	0.6	0.2	1.9
Total	3.5	0.3	0.8	4.6	3.3	1.0	0.4	4.6

243 Where filled gaps have been recorded, there is a very similar proportion of lost and gained hedges that have gaps that have been filled but hedges that have been lost have a higher proportion of hedges where more than 10% of the hedge is comprised of filled gaps (48% as opposed to 41% for gained hedges). Interestingly, the hedges that came from remnant hedges tend to have a higher proportion of >10% gaps than any other type of hedge (gained or lost). This suggests either (a) that some remnant hedges have had a degree of gapping as a part of their reclamation or (b) the results confirm the already documented difficulties in applying the definition of 'hedge' consistently between surveys.

Trimming and shape

244 Signs of management were not well recorded by surveyors. From the table above, only about 17,500 km of gained hedge were coded whereas, from results elsewhere, it is known that the total length of gained hedge was about 42,500. A summary of length by trimming regime is given in Table 7.5.

Table 7.5 Length of hedgerow lost and gained between 1990 and 1998 in GB, by trimming regime.

	Lost ('000 km)				Gained ('000 km)			
	Hedge to nothing	Hedge to remnant	Hedge to line trees	Total lost	Nothing to hedge	Remnant to hedge	Line trees to hedge	Total gained
Trimmed	9.5	1.9	2.0	13.4	9.6	2.3	1.0	12.9
Box-shape	n/a	n/a	n/a	n/a	5.7	1.2	0.7	7.5
Pointed box	n/a	n/a	n/a	n/a	0.2	0.0	0.0	0.2
Chamfered	n/a	n/a	n/a	n/a	0.3	0.0	0.0	0.3
A-shaped	n/a	n/a	n/a	n/a	0.1	0.1	0.0	0.3
Topped A	n/a	n/a	n/a	n/a	0.6	0.4	0.0	1.0
Round-topped	n/a	n/a	n/a	n/a	0.3	0.1	0.0	0.4
Untopped	n/a	n/a	n/a	n/a	2.4	0.6	0.2	3.1
Uncut	n/a	n/a	n/a	n/a	3.8	0.6	0.2	4.6

245 The only category which was used by surveyors in both CS1990 and CS1990 was 'trimmed' and, still bearing in mind the incompleteness of the data, this is where the only direct comparison that can be made. There is little obvious difference between the trimming status of lost and gained hedges.

Other characteristics

246 The 'signs of replacement' attribute was only used for hedges where surveyors recognised that a previous boundary had been replaced by a hedge (and therefore should only be applied to gained hedges). If all such cases were adequately recognised by surveyors, this would suggest that of the 42,500 km of new hedge, less than 2% were on the lines of previous boundaries. This seems unlikely. A summary of length by other management characteristics is given in Table 7.6.

Table 7.6 Length of hedgerow lost and gained between 1990 and 1998 in GB, by other management characteristics.

	Lost ('000 km)				Gained ('000 km)			
	Hedge to nothing	Hedge to remnant	Hedge to line trees	Total lost	Nothing to hedge	Remn't to hedge	Line trees to hedge	Total gained
Signs replacem't	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.7
Signs removal	0.2	0.1	0.1	0.4	0.0	0.0	0.0	0.0
Recently planted	0.0	0.0	0.0	0.0	4.2	1.9	0.3	6.5
Recent laying	1.6	0.4	0.6	2.6	0.3	0.1	0.3	0.7
Flailing	1.0	0.2	0.4	1.6	3.3	1.2	0.1	4.6
Re-growth cut stumps	0.3	0.0	0.1	0.4	0.3	0.0	0.4	0.7

247 The 'signs of removal' code was used where surveyors judged that a hedge was no longer present (from signs of disturbance, bare earth or burned remains) and was only likely to apply where hedges have been removed shortly before the survey.

248 Recently planted hedges were noted if it was estimated that a the hedge had been planted in the previous five years.

249 Similarly, recently laid hedges were recorded if the surveyor believed that laying had taken place in the previous five-year period. It is interesting to note that as much as 7% of the total length of lost hedge has been laid in the five years prior to loss. Conversely, and as expected, less than 2% of new hedges had been laid; of this length, a significant proportion was from hedges regained from lines of trees (where laying might form part of a restoration process) and from hedges being newly planted (where normal management cycles would not see hedges laid within seven to ten years of planting).

250 A greater length of hedge was recorded as flailed in the gained hedges category (c. 11%) than in the case of lost hedges (c. 4%). It has been estimated elsewhere (Hooper, 1992) that up to 90% of hedgerow management takes place by the use of a flail but surveyors may not have had evidence to use the code more frequently than they did.

251 Re-growth from cut stumps is a coding which applies to hedges that have been cut to ground level but have sprouted again, often at intervals along the old boundary. It is interesting to note that small percentages of both gained and lost hedgerows were coded in this way, again, perhaps, as part of restoration management techniques.

Assess the characteristics of the vegetation in associated hedgerow plots.

252 This work has yet to be started, although some exploration of the data is under way (see below).

253 There is a theoretical flaw in the use of CS2000 data for this task: although the vegetation plots associated with lost hedgerows can be identified and their 1990 vegetation described, hedgerows that have been gained since 1990 are unlikely to have associated vegetation plots.

This is because the protocols for survey do not require surveyors to place additional plots (eg where a new hedgerow appears), only to re-survey earlier plots.

254 Although more GIS work is needed to confirm the number of 1990 plots that are associated with hedgerows that have been lost, an initial inspection of the vegetation database suggests that only about 7 1990 hedge plots were not recorded in 1998, probably because the hedges were lost. Similarly, a rapid analysis has revealed that only about 4 plots recorded in 1998 are associated with hedges that have been gained . Some of them undoubtedly have come from features reclassified as true hedges. This may make a meaningful comparison very difficult.

Assess the balance of ecological value from gained and lost hedgerows.

255 Work has not yet started but it is hoped that the outputs from Question 8 will help to define the criteria to be used in assessing the 'ecological value' of hedgerows.

SUMMARY

256 The work was scheduled to start in October 2002 but, already, much of the preparatory work has been completed, alongside work associated with Question 5. Preliminary analyses suggest that, apart from height, there is little difference in the physical and management characteristics between hedges that have been lost since 1990 and those that have been gained. As far as height classes are concerned, hedges that were lost tend to be taller than those that have been gained. It might be assumed that the total volume of such hedges might therefore be greater (although width measurements were only introduced in 1998, so it is difficult to confirm this) and therefore the value of such lost hedges would be greater. CS data are unlikely to yield much information on the vegetative character of associated hedge bottom flora because of the scarcity of plots associated with gained hedges.

FURTHER WORK AND RECOMMENDED CHANGES TO CS METHODS

257 Within this area of work, proper statistical analyses will be completed and an attempt to compare vegetative characteristics of hedgerows will be undertaken.

258 In future surveys:

1. consideration must be given as to characterising the vegetation associated with new features (eg gained hedges) – this recommendation applies to other aspects of CS protocols.
2. mechanisms must be implemented to ensure that surveyors gather the full suite of records when describing hedgerows; this would be most easily done using compulsory fields in an electronic data-logging system.

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Question 8: How far is it possible to provide an assessment of the condition, and changes in condition, of ancient and/or species-rich hedgerows using CS2000 observations?

INTERIM REPORT - *Colin Barr & Rick Stuart*

DUE START DATE:

- November 2002

DUE FINISH DATE:

- February 2003

OVERALL PROGRESS

- Work started ahead of schedule with attempts to engage the UK Steering Group for the Ancient and/or Species-rich Hedgerows (ASRH) HAP in defining 'favourable condition' as applied to hedgerows.
- It is anticipated that the work will be completed by the end of February 2003 although the success of the research is dependant on the deliberations of the ASHR SG.
- The next meeting of the ASRH SG is planned for late 2002.

DEFINITIONS

- 'Condition' – no *a priori* judgement is made about what is meant by condition since the definition of this term forms part of the research question.
- 'Ancient and/or species-rich hedgerows' (ASRH) – as defined in the UK national Biodiversity Action Plan, Ancient hedgerows are those that were in existence before the Enclosure Acts (1720 to 1840) and tend to be those which support the greatest diversity of plants and animals. Species-rich hedgerows are taken to be those which contain five or more native woody species on average in a 30 metre length, or four or more species in northern England, upland Wales and Scotland.

POLICY CONTEXT STATEMENT

259 *The following policy context statement has been drafted and presented at the May 2002 workshop. Input from relevant Department policy advisers has yet to be made.*

260 The Habitat Action Plan for Ancient and/or Species-rich Hedgerows includes a target of achieving the *favourable management* of 25% (c. 47,500 km) of species-rich and ancient hedges by the year 2000, and of 50% (c. 95,000 km) by 2005. The HAP says that the majority of hedges are likely to need some management in the long term and if left for more than about 10 years there is a major risk that they will either change beyond a recoverable state or become so open that they cease to be hedges.

261 The BAP also includes a number of proposed actions which relate to the *favourable management* of hedgerows

262 At the BAP Steering Group meeting on 22 April 1999, members suggested that it would be difficult to obtain a standard definition for the term *'favourable management'* because this could vary according to the function of the hedge, the species in it, and the species for whose benefit it was being managed. Instead, it was concluded that information was needed to assess the conservation status of hedgerows and, especially, to consider the 'favourable condition' of hedgerows as a precursor to recommending favourable management.

263 To date, the Steering Group has not reached a view of what constitutes favourable condition and CS2000 provides, potentially, a means of examining this issue. The 'Hedgerow Diversity' plots (D plots) will allow the definition of species-rich hedgerows and the associated ground flora, management and adjacent land use will allow an assessment of condition.

SCIENCE OUTPUTS

To identify which hedgerows are 'ancient', a critical review of existing resources will be made to identify the likely costs and implications.

264 Work has not yet started.

To clarify how CS2000 sample hedges best meet the existing definitions of species-rich, recommendations will be put to the HAP Steering Group (through DEFRA) and feedback received.

265 Work has not yet started.

A critical review of the field survey codes will be made and discussed with the newly-formed sub-group (of the HAP Steering Group) which has been charged with defining 'favourable condition'.

266 Before FOCUS Question 8 can be addressed in November, it is important to have an authoritative statement as to what is meant by 'favourable condition'.

267 At its eighth meeting, on 29 October 2001, the ASRH Steering Group decided to set up a sub-group (chaired by the Rural Development Service) to consider the definition of 'favourable condition' of hedgerows. To date, this sub-group has not been established, and therefore has not met.

268 On 19 June 2002, we sent a letter to each member of the ASRH HAP Steering Group inviting comments on an earlier meeting paper, '*The favourable conservation status of hedgerows and the availability of relevant information from Countryside Survey 2000*' (Barr et al. 1999). This paper had been presented to the group at its fifth meeting in September 1999 but had not been discussed in any detail nor had any other feedback been received subsequent to that meeting. It contained not only information on CS2000 but also some discussion of the issues surrounding favourable management and favourable condition of hedgerows.

269 By the end-of-July deadline, only three responses had been received to the invitation to comment (from DEFRA London, DEFRA Bristol and English Nature). Only one of these sets of comments contained any significant contribution to the debate on favourable condition.

270 A meeting of the Steering Group was scheduled for 10th September 2002 but was postponed because revisions of the hedgerow regulations (to have been a major discussion item at the meeting) had not been completed.

271 This postponement also further delayed the setting up of the 'Favourable Condition Sub-group' because the organisers of the sub-group, the RDS, felt that a meeting should take place after discussion of our 'favourable conservation status' paper at the Steering Group meeting.

272 In an attempt to achieve some momentum, and to fulfil FOCUS obligations, CEH has set up a meeting of interested SG members and acknowledged hedgerow experts to take place on 14th November 2002. Outputs from this meeting should allow some progress on addressing FOCUS Question 8 in November.

A pilot study will be undertaken to assess the viability of (a) identifying ancient and/or species-rich hedgerows in CS sample squares and (b) assessing their condition. Based on the results of the pilot study, a realistic cost for completing the work for all sample squares (and making national and regional estimates) will be identified.

273 Work has not yet started.

SUMMARY

274 Although not scheduled to start until November 2002, CEH has recognised the importance to this question of being able to define 'favourable condition' (of hedgerows) and, in the absence of progress by the ASRH Steering Group, has taken the initiative through canvassing views from Steering Group members and by organising a meeting in November.

FURTHER WORK AND RECOMMENDED CHANGES TO CS METHODS

275 It is too early to comment at this stage.

REFERENCES

Barr et al 1999

Department of the Environment (DoE) 1994

Question 9: Why are there differences in estimates of stock of woodland cover and changes in woodland cover obtained from Forestry Commission surveys and CS2000 (including LCM2000)? How are Ancient Woodland Inventory sites represented in the CS2000 field survey sample and LCM2000? What evidence is there in CS2000 for the location and reasons for changes in woodland cover?

INTERIM REPORT - *Dr David Howard*

DUE START DATE:

- March 2002

DUE FINISH DATE:

- October 2002

OVERALL PROGRESS

- The Policy Context Statement has been drafted, circulated for comment and re-drafted accordingly
- Under Part (a), meetings have been held with the Forestry Commission, forest cover categories have been identified, datasets have been acquired and formatted, spatial overlays have been completed, national estimates of forest cover have been computed and sources of error have been partitioned.
- Under Part (b), contact has been made with all relevant agencies, datasets have been acquired, spatial overlays have been performed and analysis is ongoing.
- Under Part (c), analysis has started.

DEFINITIONS

- "Woodland" from CS2000 is defined as the amalgamation of *Broadleaved, mixed and yew woodland* with *Coniferous woodland* Broad Habitats
- "Stable area" is defined as an area remaining in the same Broad Habitat in all the Countryside Surveys

POLICY CONTEXT STATEMENT

276 It can be argued that woodland covers the two most important Broad Habitats - home to more species of conservation concern than any other habitat. They represent what would be the dominant vegetation covering most of Britain if man was not present. Woodland is managed as a source of timber, wood pulp, charcoal and other assorted commodities, for landscape aesthetics and recreation, and more recently has been recognised as an important sink for sequestering carbon to combat global climate change. There is a long history of woodland being directly cited in British policy (both through royal decrees and parliamentary acts) for

reasons ranging from the needs for timber to build ships, through the desire to manage land for game, to the need to provide green-space for the urban population. There is an increasing number of international agreements also making commitments to effective management of woodland.

277 The British Forestry Act of 1919 established the Forestry Commission (FC) [(1)] to oversee the interests of woodland; the initial intention was to replant 'wasteland' and provide reserves of timber. To carry out its mandate, the FC took its first audit of the nations woodland in 1924; surveys have been carried out at approximately 15 year intervals since. The surveys show that the area of woodland in the UK increased through the 20th century, from around 5 per cent land cover to over 10 per cent.

278 A variety of organisations produce statistics describing the extent and composition of woodlands:

- The FC produces the standard definitive statistics describing woodland in Britain from interpretation of aerial photos. Annual reports are produced describing the state of woodland and a national database is maintained (the National Inventory of Woodland Trees - NIWT) and resurveyed approximately every 10 years.
- Ancient woodland inventories English Nature (EN), Countryside Council for Wales (CCW) and Scottish Natural Heritage (SNH) respectively, plus Woodland Trust developing for Northern Ireland by end-2005
- Millennium Forest Guide to Scotland's Forest Resource, including the Caledonian Pine Inventory, produced by the Caledonian Partnership.
- Other organisations such as the nature conservation agencies and special interest groups (e.g. the Council for the Preservation of Rural England (2) and Woodland Trust (3)) may occasionally produce estimates on different types of woodland.
- Countryside Survey field survey records all types of land cover in rural Britain including woodland and publishes statistics once every six to eight years. The Survey records all elements of the landscape, allowing interpretations to be made about the fluxes between different land uses. Moreover, it includes valuable information about the environmental condition from vegetation and soil samples which again is set in context of the wider landscape.
- Countryside Survey Land Cover Maps 1990 and 2000 used satellite imagery to map land cover and Broad Habitats across Great Britain (GB).

279 The figures from the different organisations do not always agree. It would be surprising if the estimates were exactly the same, as contrasting methods and definitions are used. What is important is that the estimates are compared and the differences resolved, so that the information can provide an effective description of all aspects of woodland and identify which figures are most appropriate for different policy development. For example, research is needed to identify what information the Countryside Surveys can provide to describe Ancient Woodland, in terms of quantity, quality and context.

280 The function and value of woodlands in the landscape have changed through the years, and today their contribution to quality of life (or non-market benefits) is increasingly appreciated. The British Government targeted policies at further increasing the area under trees in the 1990s stating "the most significant alternative land use in the next twenty years is likely to be forestry" (4). In 1989 the Countryside Agency and the Forestry Commission initiated the Community Forest (5) programme, in response to the national need to diversify land-use. The aim was to use multipurpose forestry to improve the countryside around towns and cities in a variety of ways including restoration of areas scarred by industrial dereliction, creation of sites

for recreation and sport, forming new habitats for wildlife and making outdoor classrooms for environmental education.

281 The traditional hierarchy of land use, where the most productive rural land is used for agriculture, less productive land for forestry and un-productive land for nature and recreation is breaking down. There is encouragement to plant trees on more productive land and just over a third of the target for new planting is on agricultural land sponsored by the Farm Woodland Premium Scheme (6). The changes have economic, social and environmental implications for a wide range of policies.

282 The United Nations Conference in Rio in 1992 defined a number of objectives to protect the earth's environment, the details of implementation were further developed in a number of Conference of Parties (COP) meetings leading to agreements such as the Kyoto Protocol and the Marrakesh Declaration which specifically identify the role of forestry in combating climate change. Other developments from Rio, such as Agenda 21 had a wider remit. The 1993 Ministerial Conference on the Protection of European Forests in Helsinki led to the formal adoption of a forest policy to promote sustainability. In 1998, the UK Government published the UK Forestry Standard (7) which defined objectives for and methods of assessing forest management. In 1999 the Government published its strategy for sustainable development called *A Better Quality Of Life (6)*. Four of the 147 key indicators refer directly to woodland (see Table 9.1)

Table 9.1 Forests and woodlands in a *Better Quality of Life*

Themes, issues and objectives (Sustainable Development Strategy reference in brackets)	*Key indicators*
Continuing expansion of (UK) woodland area (S10)	Area of woodland in the UK
Protecting ancient and semi-natural woodlands (S11)	Area of ancient semi-natural woodland
Better management of existing woodlands (S12)	Sustainable management of woodland
Sustainable (forestry) management overseas (S13)	Number of countries with national forest programmes

283 The first two objectives will be assessed by statistics of geographic extent using monitoring schemes such as the FC's National Inventory of Woodland Trees (NIWT). Information from Countryside Survey may be seen as independent corroboration of the FC data. The indicator for the third (S12) has not yet been defined, but will cover issues that can be partially addressed by Countryside Survey information. A range of issues are being considered some of which cannot be monitored using remote sensing these include forest soil condition, water quality and movement, carbon sequestration, air pollution, commercial value, nature conservation, other land uses and landscape quality. Other criteria such as workforce skills, rural development, access, recreation, quality of life for local people, increased awareness and participation, community involvement and conservation of heritage features are beyond the scope of Countryside Survey in its present form. The fourth woodland theme (S13) is not covered by Countryside Survey.

284 Statistics describing the extent of woodland are key indicators for monitoring this resource with its wide array of uses. Monitoring is also needed to assess progress and success in the achievement of the aims of different policies. However, changes seen in woodland area can be misleading without reference to turnover and condition. Not only do the three indicators (S10, S11 and S12) need to be considered together, but also the relationship between woodland (a land cover) and forestry (a land use) must be recognised. Changes in woodland area do not

necessarily mean a change in forestry, as the cycle of ground preparation, planting, felling and restocking may leave a forested area without trees for a period.

285 A set of UK Indicators of Sustainable Forestry (7) has evolved from the outline provided from the UK Forest Standard (5) and will be published 31st October 2002. There are 38 indicators grouped into five categories:

- Woodland
- Biodiversity
- Condition of forest and environment
- Timber and other forest products
- People and forests.

286 Although the choice of indicators was influenced by the availability of existing data, some important issues have been included for which novel and new datasets will need to be included.

287 Countryside Survey data have an important contribution to make to application of the indicators, but the difference between woodland as a land use and woodland as a land cover must be explicitly handled. Two of the indicators in the woodland category quantify the system dynamics by measuring gain (A3) and loss of woodland (A4). New woodland as a land use is identified directly from Forest Enterprise or through grant aided planting; felling licenses may offer a measure of woodland loss, but neither are complete descriptions of change in woodland as a land cover. To incorporate Countryside Survey data, the definitions of land parcels with woodland cover will have to be translated into equivalent measures of use.

288 Contribution can be made to other indicators such as Woodlands in landscape (A7) where the spatial pattern and neighbouring land covers can be measured. Within the Biodiversity category, the value of CS2000 FS vegetation plots has already been recognised (B5). The British Trust for Ornithology (BTO) survey in CS2000 (along with other monitoring may be able to contribute to the Richness of fauna (B4). Soil and water samples may provide information for the Condition of forest and environment categories. One big benefit of using CS2000 data is that it sets information in context with the rest of the British environment and trends can be interpreted as common across other habitats or unique to woodlands.

289 Indicators are being developed beyond UK, with the Pan-European Criteria and Indicators (C&I) for Sustainable Forest Management (SFM). Different countries are reporting using C&I and a Temperate and Boreal Forest Resources Assessment has collated the results. A Global Forest Resources Assessment was published in 2001.

290 It is important to recognise the sensitivity of native woodland flora and soil quality to change and relate them to both changes in land cover and land use. An increase in forest area implies a loss in land cover from other uses. If the gain is predominantly from intensive agriculture, it is likely to be beneficial in an ecological sense, but other established semi-natural habitats such as bogs may have greater ecological value. Examination of the pattern, structure and history of the parcels in the landscape should indicate the shifts in land use and demonstrate the success of policy to steer changes in management. Plans for expansion of woodland area need to take into account possible impacts on soil, water, wildlife, heritage features and effects at a landscape scale influencing wider ecology.

291 A recent development that will involve further policy consideration is the devolution of parliamentary responsibilities to Scotland and Wales. The targets and goals of woodland management may be generally the same across Britain, but different parliaments and national assemblies may have different priorities and see different driving forces. The option of transferring functions to national bodies or ministers and so effectively dissolving the FC has

been considered but not recommended. The favoured option has been the decentralisation of the FC with the strengthening of National Offices. The implications of this is that each National Office may collect its own information to meet the requirements of its own parliament, but these may leave gaps in terms of a full GB dataset.

292 Scotland and Wales are already developing independent Sustainable Development Indicators. A set of forestry indicators have been developed for the Scottish Forest Strategy, these have been produced by FC and are compatible with other indicators. The aim of UK Indicators of Sustainable Forestry is that they can be used to provide information for England, Scotland, Wales and Northern Ireland.

SCIENCE OUTPUTS.

Part (a) - Differences in estimates

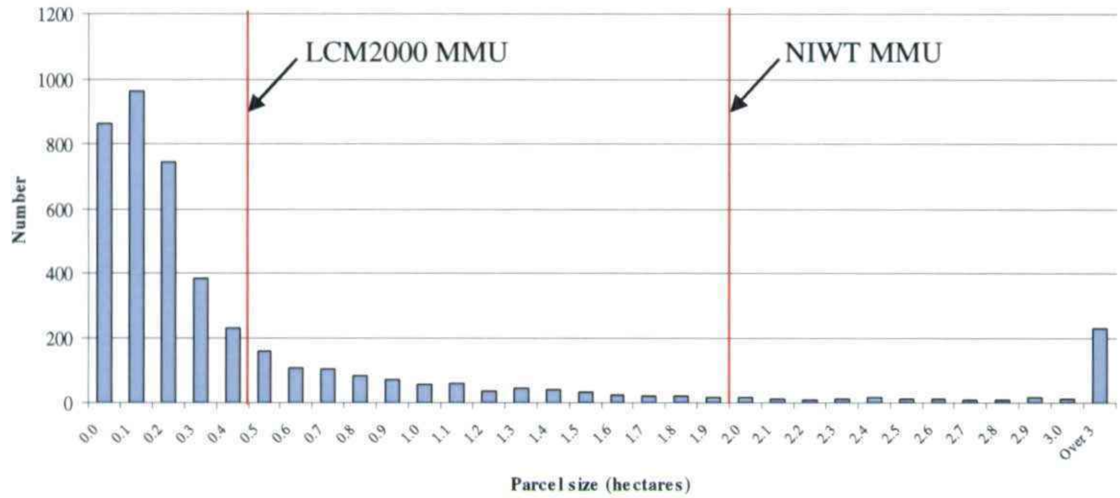
293 The main national datasets for comparison are the two Countryside Survey descriptions of extent of Broad Habitat (Land Cover Map 2000 – LCM2000 and the field survey – CS2000 FS) and the Forestry Commission's National Inventory of Woodland Trees (NIWT). Table 9.2 shows the estimates for woodland area for the three different sources; Countryside Survey woodland is the combination of two Broad Habitats, Broadleaved mixed and yew woodland (BH 1) and Coniferous woodland (BH 2).

Table 9.2 National estimates of woodland area from FC National Inventory of Woodland and Trees (NIWT), Land Cover Map 2000 (LCM2000) and CS2000 field survey (CS2000 FS). Areas in thousands of hectares (ha x 10^3)

	Full	*> 2ha*
NIWT	2518	2147
LCM2000	2832	2087
CS2000 FS	2845	1461

294 The values show clear differences, comparing simple, gross figures (Full) the NIWT produces the lowest estimate with only about 90% of the area of the other two values. However, it is important that the comparisons are made 'like with like' and the first problem is the size of woodland parcels used in generating the estimates. NIWT map woodland parcels over 2 ha in extent, LCM maps land units down to 0.5 ha and FS maps down to 0.04 ha. If all three datasets are restricted to parcels over 2 ha (>2ha), the NIWT and LCM2000 become much closer, however, the FS value halves and becomes markedly lower than the other two estimates. The difference is an effect of the sampling unit in FS. Woodland parcels that extend beyond the sample kilometre square may be over 2 ha, but if the portion within the square is less than 2 ha they will be omitted from the analysis.

Figure 9.1 The distribution of woodland parcel sizes from CS2000 FS showing minimum mappable unit (MMU) cut off for LCM2000 (0.5 ha) and NIWT (2 ha).



295 Figure 9.1 shows the distribution of woodland parcels of different sizes recorded in sample squares of CS2000. The distribution is skewed with a median of between 0.1 ha and 0.2 ha and a very long tail. The vertical lines represent the minimum mapping units (MMU) of the other two datasets and are both well above the median of the distribution. To apply a filter for parcel size would require information about the total area of any parcel that extends beyond the square. Although some information may be available from published maps and aerial photographs it would not match the mapping technique or be contemporary with the field recording.

296 Taking into account the spatial resolution of mapping, the figures appear to show acceptable agreement at a national scale. However, this ignores other aspects of co-registration of the information. When the datasets are spatially matched (Tables 9.3 and 9.4), the agreement still remains strong. The relationship between NIWT and LCM2000 (Table 9.3) shows that mature stands of trees (Broadleaf, Coniferous and Mixed NIWT categories) are recorded by both methods between 70% and 80% of the time. Young trees and Ground under preparation for planting show marginally lower correspondence with the woodland Broad Habitats, but if semi-natural habitats, such as grassland, bracken and dwarf shrub heath are added the agreement becomes extremely good.

Table 9.3 The correspondence of the NIWT categories with LCM2000 categories (BH 1 – Broadleaved, mixed and yew woodland and BH 2 – Coniferous woodland). Values in brackets are percent of NIWT category

NIWT	*LCM2000*			
Broadleaf:	BH 1	(63)	BH 1 + BH 2	(70)
Coniferous:	BH 2	(72)	BH 2 + BH 1	(82)
Young trees:	BH 1 + BH 2	(49)	BH 1 + BH 2 + Semi-natural[+]	(90)
Mixed:	BH 1 + BH 2	(74)		
Ground prep.:	BH 1 + BH 2	(67)	BH 1 + BH 2 + Semi-natural[+]	(99)

[+]BH6 + BH7 + BH8 + BH9 + BH10 + BH11

297 Table 9.4 shows the correspondence between the NIWT and CS2000 FS. The agreement is better than that for the LCM2000 with a 76% agreement (Mixed) being the lowest match to the sum of the woodland Broad Habitats (Broadleaved, mixed and yew with Coniferous woodland). Coppice woodland recorded in the NIWT was mapped as Broadleaved, mixed and yew woodland with very good agreement (98%). The weakest agreement was with NIWT Young trees, the field survey commonly recorded them as the grassland Broad Habitats (Acid, Calcareous, Neutral or Improved grassland). The field surveyors identified 10% of the Young trees categories as Arable and horticultural land, reflecting the occurrence of bare ploughed land.

298 While there was good agreement between total woodland in the two datasets, the split between coniferous and broadleaf was noisy. The Broad Habitat classification aggregates broadleaf and mixed woodland into a single class, so the 29% of NIWT conifers identified in the category may have been mapped (at least in part) as mixed woodland. The definition does not only depend upon the rules for dominance, but the spatial definition of a stand. The FC map woodland as a management tool and are therefore more likely to define stands as homogeneous, whereas field surveyors, given a set of rules about mapping land cover, may divide the parcels in a different way.

Table 9.4 The correspondence of the NIWT categories with CS2000 FS categories. Values are percent of NIWT category, highest values are shown in bold.

	Broadleaved, mixed and yew woodland	Conifer woodland	Woodland (BH1 + BH2)	Arable and horticultural	Grassland	Built up and gardens	Other
Broadleaved	**76**	4	80	1	9	3	7
Coniferous	29	**60**	89	1	4	1	5
Coppice	**98**	0	98	0	2	0	0
Felled	**52**	32	84	1	7	1	8
Mixed	**67**	9	76	3	7	9	5
Shrub	**62**	0	62	0	28	2	7
Young trees	25	21	46	10	**35**	1	8

299 If the correspondences are examined in the opposite direction (percentage of LCM2000 or CS2000 FS), the values include all parcels below 2 ha that are not mapped in the NIWT. The effects of this can be seen in Table 9.5, which shows the extent of overlap of NIWT and LCM2000. The 1047 ha x 10^3 found in LCM2000, but not mapped by NIWT will include woodlots between 0.5 ha and 2 ha.

Table 9.5 Spatial agreement between FC NIWT and CS2000. Areas in thousands of hectares (ha x 10^3)

Source of estimate	Area
FC NIWT	2641.3
LCM2000	2832.4
FC NIWT and LCM2000	1785.3
FC NIWT but not in LCM2000	855.1
LCM2000 but not in FC NIWT	1047.1

300 There are several other potential causes of difference between the datasets, which can be divided into definition, methodology, temporal and accuracy.

Definitions

301 he use of common terms by different groups of people often heightens the expectation of agreement. However, the terms need to be clearly defined in order to ensure that the same features are being discussed. As shown above, features such as the spatial resolution of data can lead to a discrepancy. Other terminology also needs to be unambiguously defined and compared. Forestry has a variety of definitions, but should be considered as a land use in which the management of woodland is a major concern. Woodland is composed of trees and shrubs whose canopy form (or will form) an extensive cover.

302 The characteristics of area and composition of canopy that define woodland has already been mentioned. Within CS2000 FS a clump of trees is defined as "a small woodland or group of trees (6 or more) and of less than 0.25 ha". Once greater than 0.25 ha in extent, it becomes woodland/forest, but only as long as its crown cover is greater than 25% of the area. The FC define woodland as "land with a minimum area of 0.1 ha under stands of trees with, or with the potential to achieve, tree crown cover of more than 20%. Areas of open space integral to the woodland are also included". CS2000 FS would map open space of over 0.04 ha as non-woodland.

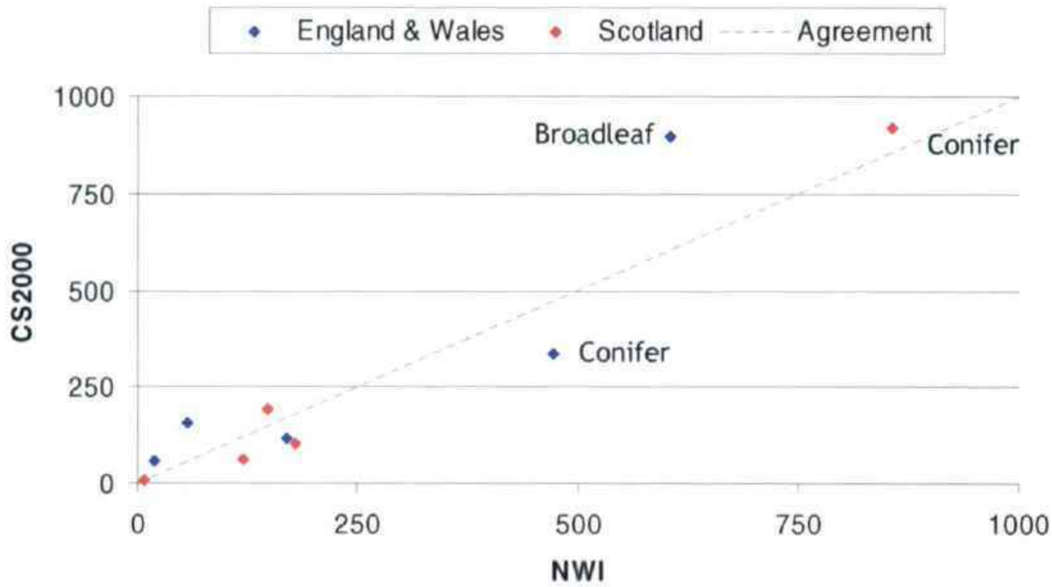
303 As already mentioned, woodland of 2 ha and over, and with a minimum width of 50 m, is included in the FC Main Woodland Survey (NIWT). Other woodland and trees are assessed in the Survey of Small Woods and Trees which uses a sample approach and consequently is more difficult to compare in a spatially disaggregated way with other datasets.

304 FC does not record orchards and urban woodland between 0.1 and 2 ha, while CS2000 FS only omits trees and scrub within curtilage of buildings, but does not survey predominantly urban squares. LCM2000 records all land cover irrespective of location or use. Whilst mapping, FC will omit features such as roads, rivers or pipelines within woodlands if they are less than 50 m in extent; CS2000 FS will record such features, down to the minimum mappable unit, but LCM2000 may miss narrow features due to the 25 m^2 pixel size.

305 The composition of woodland with different tree and shrub species again may be recorded differently. 'Scrubby' vegetation is not defined by FC as a separate category but included in one of the three main woodland types, Conifer, Broadleaved or Mixed. CS2000 FS records dominant tree species where they fill more than 25% of the canopy area; a mixed woodland has to have at least one broadleaf and one conifer species each covering 25%. The FC definition is somewhat sharper, but with a different percentage; conifer is where at least 80% of the canopy is coniferous, broadleaf where at least 80% is broadleaf and mixed where both types fill more than 20% of the canopy.

306 Figure 9.2 shows the matching of categories between the National Woodland Inventory and the CS2000 FS equivalent to produce national estimates. There is a clear relationship, but CS2000 overestimates the extent of Broadleaf woodland in England & Wales which is compensated by the underestimate of Conifer. The Scottish figures show better agreement, possibly reflecting the more polarised nature of woodland with more extensive coniferous areas.

Figure 9.2 Estimates of area of different NIWT categories plotted against the CS2000 FS equivalent (areas in ha x 10^3)



Methodology

307 The three national estimates are produced by three different approaches. NIWT and LCM2000 are both based on interpretation of remotely sensed images, the former using 1:25,000 scale aerial photographs (AP), and the latter satellite imagery (Landsat TM) with a pixel size of approximately 25 m square. The methods of interpretation of the imagery are quite different, with the AP being interpreted by eye and adjusted by Survey Foresters while the satellite imagery is classified using an automated classification procedure, with some supervision and a subsequent secondary spatial mapping (CLEVER mapping) (see Annex 9.1).

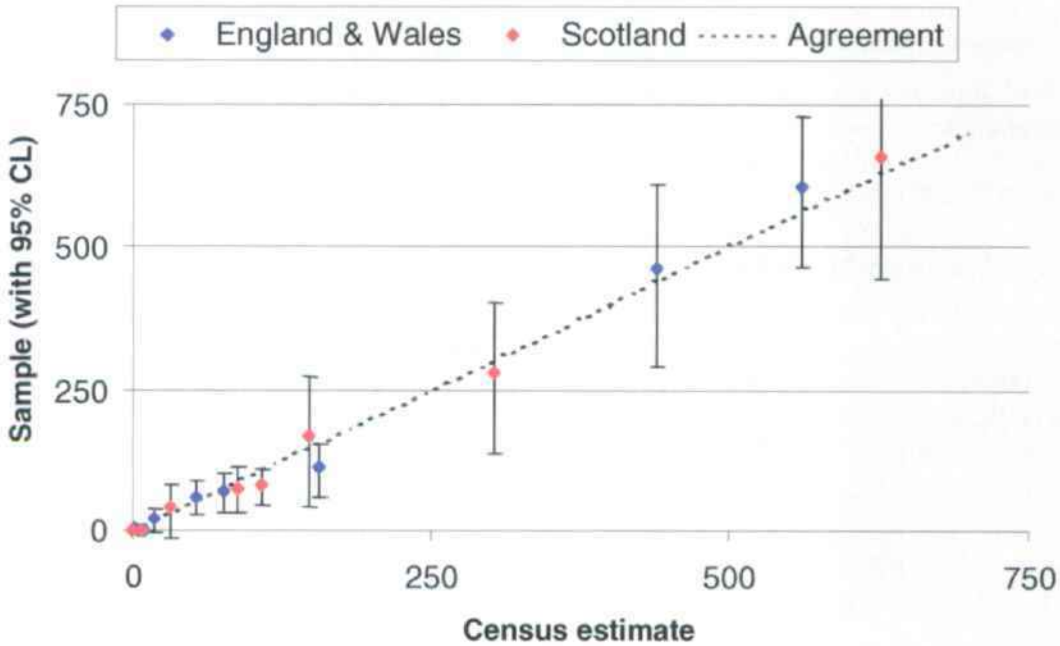
308 CS2000 FS uses a sampling scheme with a sample unit of 1 km^2. Samples are selected using an environmental stratification then mapped and sub-sampled for vegetation, soils and water in the field. National estimates are then produced by calculating the arithmetic mean for each of the strata (land classes), multiplying each mean by the area of the strata and finally totalling the products.

309 The mapping in the FS is guided by OS 1:10,000 scale map sheets so there will be some link to the FC AP, but OS sheets at different scales do not always match perfectly. The satellite map has a tessellated appearance from the edges of the pixels, so the linework is unlikely the match.

310 A major difference between the methods of producing the estimates. LCM2000 and NIWT are census estimates whereas CS2000 FS estimates are weighted totals. The efficiency of the sampling scheme and the size of the sample will effect the accuracy of the result.

311 To test the sampling scheme used in CS2000, the NIWT was sampled in the 569 km squares that were surveyed and national estimates produced. The results for the different woodland categories for England & Wales and Scotland are shown in Figure 9.3.

Figure 9.3 Estimates of area of different NIWT categories estimated using the CS2000 FS sampling scheme (areas in ha x 10^3, 95% confidence limits (CL) produced by bootstrapping)



312 Figure 3 shows that the CS2000 sampling scheme and the sampling intensity are effective for recording all the woodland categories recorded in the NIWT as the line of agreement is within all the 95% confidence bands. The best estimates derived from the sample (identified by the position of the symbols) show some slight deviation from the 'truth' defined by the digital dataset, but generally are very close to the line.

Temporal difference

313 CS2000 FS sample sites were visited predominantly in the summer of 1998, although some squares (mainly in Scotland) were surveyed in 1999. To produce LCM2000, satellite scenes from two different seasons for each site were required; 79 scenes were used from the period 1997 to 2001. The digital woodland map produced in the NIWT survey was made in two parts; England and Wales was derived from aerial photographs flown between 1991 and 2000 that were plotted against OS 1:25,000 map sheets, Scotland was based on the Land Cover of Scotland (1998) dataset flown 1987-1989.

314 Although woodland is generally stable changes do take place within the recording frame of each of the surveys. There has been a long-term trend throughout the twentieth century for woodland area to increase, so the estimates from the two Countryside Survey approaches may be expected to be greater than NIWT, especially in Scotland. Indeed, the Scottish NIWT data should be compared with Countryside Survey 1990 data as there were statistically significant increases in woodland area between 1990 and 1998.

Accuracy

315 It is accepted that all of the three estimates are produced within certain tolerances of accuracy and efforts are made to quantify the level of confidence that can be placed in the estimate are

made. For CS2000 FS, statistical confidence intervals accompany estimates (e.g. Figure 9.3) and quality assurance measures are included in the survey. A sample of the squares was resurveyed during the field season and land cover matched at sites within the square. LCM2000 holds a measure of the heterogeneity of the pixels in each of the clever polygons and has used the FS data to produce a matrix of agreement. NIWT was critically assessed and miscellaneous adjustments prior to release.

316 NIWT provides the most useful and understandable estimates of uniform quality, but does not have information describing the surrounding land cover types (as provided by both Countryside Survey estimates), or the potential to estimate changes in ground flora, soil or water conditions (as in CS2000 FS).

Part (b) - Correspondence with Ancient Woodland Inventory sites

317 EN, CCW and SNH all maintain digital cartographic datasets describing Ancient Woodland Inventory sites. A number of characteristics of the woodlands are recorded describing whether the area has been continuously wooded since 1600 (or 1750 in the case of Scotland) and whether any replanting has taken place. An example of the details is provided in Annex 9.2, with an excerpt from the English Nature web site.

318 Each of the agencies is working with FC to try and coordinate the AWI information with the NIWT. They generally only describe woodland parcels over 2 ha and should correspond to polygons in NIWT. The datasets used in this exercise are provisional, but should still provide an indication of the value of the Countryside Survey datasets to investigations of AWI.

319 The analyses being undertaken include matching to the woodland Broad Habitats in both LCM2000 and CS2000 FS, identifying neighbouring Broad Habitats and the presence of vegetation plots in different types of Ancient Woodland with comparable plots in other woodland. Ancient Woodland sites contain a distinctive ground flora; this will not be detectable using the mapping techniques, but can be tested in the vegetation plots.

320 Using the same cookie cutting techniques described for sampling the NIWT with the CS2000 FS scheme, the three datasets were sampled and just over a quarter of the CS2000 sites were found to contain AWI sites (Table 9.6). AWI sites are classified into three groups, Ancient Semi-Natural Woodland (ASNW), Plantations on Ancient Woodland Sites (PAWS) and in Scotland woodland on the Roy maps.

Table 9.6 The occurrence of AWI sites in CS2000 sample squares

	AWI squares	*% CS2000*
England	72	24
Scotland	52	26
Wales	25	39
GB	149	26

321 Wales has the highest occurrence of Ancient Woodland sites within survey squares at nearly 40%. This does not reflect the proportion of land cover the AWI sites cover in the different countries as Scotland has the highest cover. Scotland has just over 4% of land cover, England and Wales both have coverage of around 3%; the difference may be in part due to the use of additional sources of information (Roy maps) to identify Scottish woodland. GB has about 3% cover of AWI sites, of which just under half (1.4%) is ASNW.

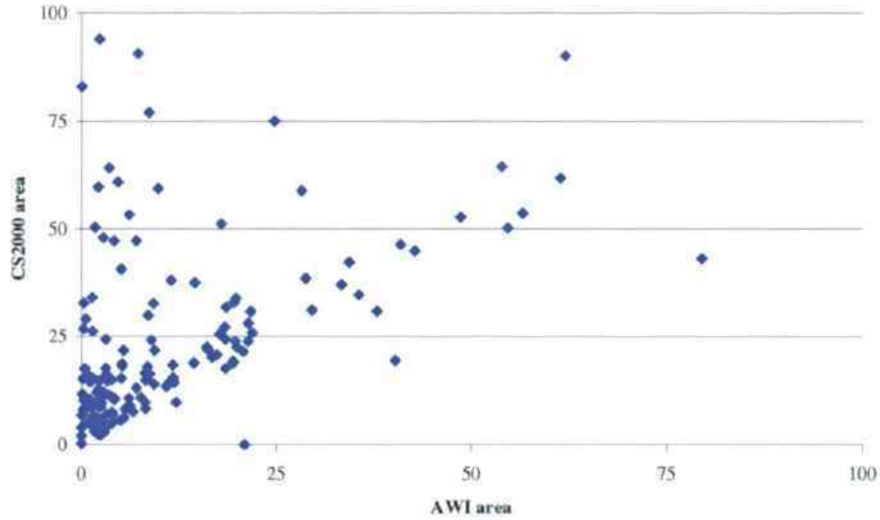
322 Figure 9.4 shows the distribution of AWI sites throughout GB. In England and Wales there are a lot of small woodlands, with only a few areas (such as the Wye valley and parts of Sussex and Kent) standing out as having dense areas. Scotland has more extensive areas of ancient woodland surrounding the highlands, but then there are few sites at high altitude or over areas such as the Flow Country.

Figure 9.4 Composite map of the distribution of Ancient Woodland Inventory sites using information provided by English Nature, Countryside Council for Wales and Scottish Natural Heritage.

323 Figure 9.5 shows the relationship between the estimates of woodland area recorded in CS2000 FS against the AWI woodland area. About 5% of the squares show more ancient woodland in the square than mapped in the Broad Habitat categories. There are a number of possible reasons for this discrepancy, the most likely being mismatch of boundaries arising from the origin of the maps. AWI is derived from 1:25,000 scale maps while CS2000 FS is 1:10,000 although both have been adjusted using aerial photography. Another, though less likely, reason

is the information being recorded for different periods. Ancient woodlands are more likely to be recognised and protected making them a more stable element in the landscape.

Figure 9.5 Woodland area in AWI sites from AWI dataset and CS2000 FS. Areas in hectares



324 Table 9.7 shows the distribution of plots in the AWI sites located in the CS2000 survey squares. Some of the occurrences such as plot types U (unenclosed land), A (arable headlands), H and D (hedge and hedge diversity) are likely to be due to mis-registration of the digital boundaries. For the CS2000 squares with AWI sites, the total plots in those four categories (U, A, H and D) represents only 7% compared to over 30% which is there proportion of the total plots in GB. Not surprisingly, the plot type that stands out as being sampled more intensively in the AWI sites than in GB as a whole is the Y plot. This type of plot is a targeted plot designed to record information about habitats that may otherwise not have been collected. There are nearly twice the proportion of Y plots in AWI sites (30%) as there are in GB as a whole (16%)

Table 9.7 Number of plots found in the AWI sites in CS2000 squares

Plot Type	*GB*	*England*	*Wales*	*Scotland*
X	2787	49	11	33
B	1857	25	2	12
H	593	3		1
V	1258	16	2	21
R	860	10	1	12
W	1402	21	9	25
S	973	16	5	18
Y	2662	74	17	44
U	1479	4		6
A	552			1
D	2466	9	2	4

Table 9.8 The distribution of AWI sites in CS2000 sample squares by land class. CS2000 – number of squares surveyed in land class, % Total – percent of GB sample, AWI CS2000 – number of sample squares with AWI sites, % LC sample – percent of AWI sites out of all squares surveyed in the land class AWI area – average area of AWI sites in land class

LC	*CS2000*	*% Total*	*AWI CS2000*	*% LC sample*	*AWI area (ha)*
1e	30	5.27	13	43	12.86
2e	24	4.22	11	46	12.91
3e	30	5.27	6	20	8.18
4e	14	2.46	2	14	5.24
5e	6	1.05	3	50	19.56
6e	23	4.04	6	26	9.20
7e	16	2.81		0	
8e	10	1.76		0	
9e	22	3.87	7	32	22.17
10e	22	3.87	8	36	5.17
11e	22	3.87	2	9	44.67
12e	10	1.76	1	10	17.35
13e	10	1.76	2	20	3.54
15e	11	1.93	4	36	4.22
16e	15	2.64	4	27	5.99
17e	13	2.28	3	23	5.31
17w1	6	1.05	4	67	8.21
17w2	17	2.99	5	29	10.00
17w3	8	1.41	4	50	6.38
18e	12	2.11	4	33	4.28
19e	19	3.34	6	32	1.40
22e	11	1.93		0	
23e	6	1.05		0	
25e	8	1.41	2	25	11.90
7s	8	1.41	3	38	0.59
13s	8	1.41	4	50	26.50
18s	8	1.41	1	13	3.38
19s	7	1.23	2	29	2.30
21s	19	3.34	5	26	14.74
22s	19	3.34	5	26	14.93
23s	12	2.11		0	
24s	15	2.64	6	40	11.49
25s	19	3.34	10	53	14.36
26s	14	2.46	6	43	10.89
27s	15	2.64	3	20	10.54
28s	13	2.28	3	23	19.58
29s	11	1.93	3	27	19.21
30s	14	2.46		0	
31s	11	1.93		0	
32s	10	1.76		0	

325 Table 9.8 shows the distribution of sample squares with ancient woodland by land class. There is wide range of proportions, from 0 (coastal, islands and extreme uplands) to over two thirds (67%). The highest is in land class 17w1 which is a marginal upland class found in Wales.

326 The average area of AWI woodland in land classes also shows wide variation, but the Scottish land classes (and sites) tend to have more extensive areas of woodland (29 ha per squares compared with 21 ha per square for both England and Wales).

Part (c) - Location and reasons for change

327 A number of lines of analysis are being pursued to address the questions of where the change is occurring, what are the characteristics of the parcels that have changed and how do they relate to the surrounding landscapes.

328 One part of the analysis is to examine change at the level of counties. FC publish statistics at this resolution describing stock and it is possible to subdivide Countryside Survey data into the same categories. Table 9.9 shows a correlation matrix for the county estimates from the three sources. All three datasets are highly correlated, but LCM2000 and NIWT are clearly closest.

Table 9.9 Correlation matrix of Countryside Survey Land Cover Map 2000 (LCM2000), field survey (FS) and Forestry Commission National Inventory of Woodland Trees

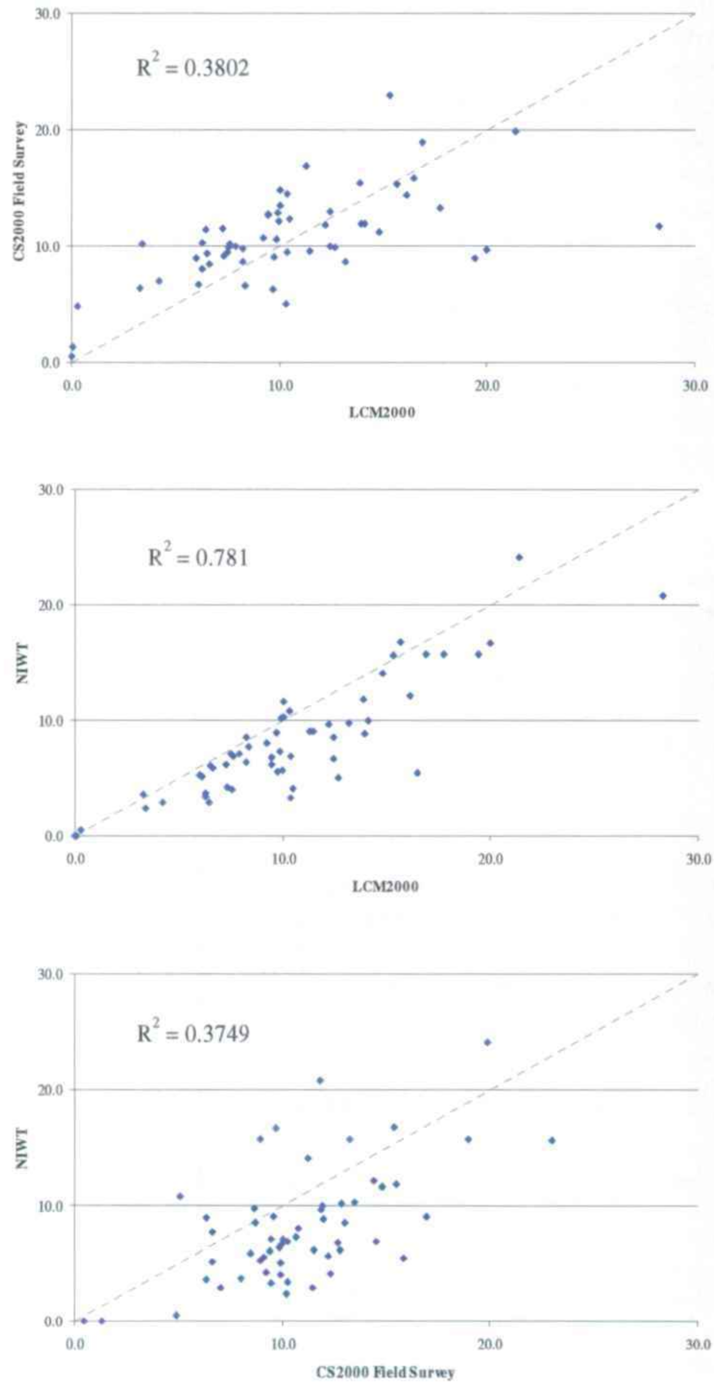
	LCM2000	CS2000 Field Survey
CS2000 Field Survey	0.616	
	0.000	
FC NIWT	0.878	0.607
	0.000	0.000

Cell Contents: Pearson correlation
P-Value

329 The relationship can be examined in detail in the three plots presented in Figure 9.6. LCM2000 and NIWT show the tightest relationship, with NIWT usually under-estimating the LCM2000; this will be due to differences in minimum mappable units. CS2000 FS shows noisier relationships, but in both cases it tends to produce a higher (more realistic, if less accurate) answer. The comparison between NIWT and CS2000 FS has just under 20% of the counties under-estimated by NIWT, this probably reflects the land class composition and sample distribution in CS2000.

330 CS2000 FS statistics represent change in land cover and no equivalent figures are published by FC.

Figure 9.6 Woodland area by county from different sources NIWT and no equivalent figures , LCM2000 and CS2000 FS. Areas in hectares x 10^3



SUMMARY

331 The project has acquired and co-registered several GIS datasets describing woodlands in Britain. Comparisons have been made between the datasets to address the three sub-questions posed within the project.

Part (a) - Differences in estimates

332 Although the estimates of woodland extent differ between Countryside Survey Field Survey (CS2000 FS), Land Cover Map 2000 (LCM2000) and The Forestry Commission's National Inventory of Woodland Trees (NIWT), they does not appear to be any significant difference between the estimates when the constraints imposed by different methodologies are taken into account. The agreement in terms of major woodland types is over 70% for all NIWT types compared to the two woodland Broad Habitats. The agreement between the individual woodland Broad Habitats is not as good. A number of factors need to be taken into account when comparing the figures, these include definition of terms and units, methodology (both collection and analysis), different times of data collection and accuracy.

333 CS2000 FS methodology has been tested using NIWT data and shown to be an efficient method of producing national statistics. The analysis suggests that the noise in the relationship is more likely to arise from comparisons of woodland as a land use with woodland as a land cover.

Part (b) - Correspondence with Ancient Woodland Inventory sites

334 Just over a quarter of the field squares surveyed in CS2000 contained areas of woodland identified in the Ancient Woodland Inventory (AWI). This is considerably higher than the percent land cover by AWI (just over 3% for all types). The discrepancy arises from the size of the woodland parcels and their distribution. Wales had a higher proportion of AWI in its survey squares than the other two home nations. Analysis is continuing to explore the relationship with plot locations and LCM2000.

Part (c) - Location and reasons for change

335 The analysis has started by exploring the estimates for each county produced by the different techniques. NIWT generally underestimates the Countryside Survey techniques, primarily because of the size of the smallest parcel mapped by each survey. There is a strong correlation between LCM2000 county estimates and NIWT. CS2000 FS shows a noisier relationship for reasons being explored in Countryside Survey Module 9.

FURTHER WORK AND RECOMMENDED CHANGES TO CS METHODS

Estimates of habitat volume, canopy structure and density

336 Woodland varies in extent in three dimensions with height varying more than other habitats. Woodland volume is important not only for resource estimation (using techniques such as breast height diameters and timber volume tables) but also to quantify habitat. LIDAR and laser reflections can provide estimates of crown height and ground levels (discrete record) or canopy structure (analogue record). Correction factors for different species may be needed to adjust for their reflectance properties. Properties of canopy structure and density are modified by a number of properties (species, management, age, etc.) and are important in quantifying characteristics such as carbon content. Methods of combining LIDAR and field survey, cost effectiveness and ease of capture, additional field observations and accuracy need to be investigated.

Quantification of biodiversity value (published guidelines)

337 Guidelines have been published on recording woodland components that are indicative of biodiversity value. The component list should be examined and critically assessed for inclusion (in part) in the next survey.

Record of woodland management history

338 Some information can only be recorded by either direct questioning or interrogation of other (digital) dataset Grant support (e.g. Farm Woodland Grant). Planting and felling dates may be useful in interpreting change.

Identification of land under forestry management (whether or not it has trees)

339 Using existing ownership information along with maps from previous visits it may be possible to label parcels with there land use rather than simply their land cover. This would only work with owners and managers whose primary objective is forestry, woodlots on farmed land may still prove problematical.

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(2) http://www.cpre.org.uk/

(3) http://www.woodland-trust.org.uk/

(4) House of Commons 1990 Agricultural Committee second report Land Use and Forestry volume 1 (Session 1989-90) HMSO London

(5) http://www.communityforest.org.uk/pcrr.html

(6) http://www.defra.gov.uk/erdp/schemes/landbased/fwps/fwpsindex.htm

(7) http://www.forestry.gov.uk/website/PDF.nsf/pdf/ukfs.pdf/$FILE/ukfs.pdf

(8) http://www.sustainable-development.gov.uk/sustainable/quality99/index.htm

(9) http://www.forestry.gov.uk/sfindicators/

ANNEX 1

LCM2000

Land Cover Map 2000 (LCM2000) records 27 classes of land cover, on a field-by-field scale, with a minimum mappable unit of 0.5 ha, throughout the UK. Spatial segmentation of satellite images provided a structured picture of the landscape with 'vector' polygons delineating land parcels, treated as 'objects' in a geographical information system. The cover in each land parcel was distinguished using the spectral reflectance data, with additional knowledge-based corrections. Each land parcel carries information about its size, shape, source data, spectral character, lineage, land cover in or around 1998 and a measure of heterogeneity.

LCM2000 records two broad categories of woodland at its Target and Subclass levels which are equivalent to Broad Habitat class (Table 9.1.1). The Subclasses are further divided into Variants giving more thematic detail, but with a reduced accuracy.

Table 9.1.1 LCM2000 classes related to woodland.

BROAD HABITAT	*LCM2000 TARGET & SUBCLASS*	*VARIANTS*
1. Broad-leaved, mixed and yew woodland	Broad-leaved / mixed woodland	Deciduous Mixed Open birch Scrub
2. Coniferous woodland	Coniferous woodland	Conifers Felled New plantation

ANNEX 9.2

Definitions from the English Nature Website

Ancient Woodland.

Land that has had continuous woodland cover since at least 1600AD and may be:

Ancient Semi-natural woodland.
Ancient woodland sites that have retained the native tree and shrub cover that has not been planted, although it may have been managed by coppicing or felling and allowed to regenerate naturally.

Ancient Replanted Woodland.

Ancient woodland sites where the original native tree cover has been felled and replaced by planting, usually with conifers and usually this century. The Ancient Woodland Inventory for England The inventory identifies over 22,000 ancient woodland sites in England. Ancient woodland is identified using presence or absence of woods from old maps, information about the wood's name, shape, internal boundaries, location relative to other features, ground survey, and aerial photography. The information recorded about each wood and stored on the Inventory Database includes its grid reference, its area in hectares, how much is semi-natural or replanted, whether any of the wood has been cleared (since 1920 approx), public ownership details where known, and any conservation status. Prior to the digitisation of the boundaries, only paper maps depicting each ancient wood at 1:50,000 scale were available.

Limitations of the Ancient Woodland Inventory.
Only Ancient Woodland Sites that were over 2HA on the 1920's Base Maps are Included on the Inventory Some of these may now be less than 2ha because of subsequent clearance. Woods that were less than 2ha on the base maps are not included even though some of these are ancient. The inventory is classed as "provisional" because it is under a constant system of review and update as new information is received or actual changes are recorded. If you have information that would help us to update the inventory please let us know. Digital Data

Coverage
All existing sites recorded on the Inventory Database have been digitised. Two types of boundaries are depicted: those for semi-natural ancient woodland and those for replanted ancient woodland.

Data Structure
The digital woodland boundaries and a unique identification number for each site are held in a digital graphics database along with other information calculated via the GIS such as grid reference, total area, semi-natural and replanted areas. A wood may have several component parts or polygons, but the same identification number. This unique identification number allows further information about the wood to be retrieved from the Inventory Database. There may be discrepancies between the area figures associated with the digital boundaries and those previously recorded on the Inventory Database. Such discrepancies relate to the methods used to calculate areas: digital versus manual, respectively.

Scale of Data Capture.
The ancient woodland boundaries were digitised at 1:25000 scale. The boundaries will therefore only be precisely comparable with other boundaries at this scale.

Important fields in the dataset:

Field	*Contents*
aw_total_area	The total area in hectares of each site
aw_semi_nat_area	The semi-natural area of a site in hectares.
aw_replanted_area	The replanted area of a site in hectares.
p_wood_type	Whether that part of a woodland site is semi-natural or replanted.
p_semi_nat_area	The area of that semi-natural polygon in hectares.
p_replanted_area	The area of that replanted polygon in hectares.

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Question 10: What are the possible causes for change in extent and condition of dwarf shrub heath habitats? Are there geographical variations between Environmental Zones? Is there any evidence for positive effects of conservation measures?

DRAFT FINAL REPORT - *Simon Smart*

DUE START DATE:

- March 2002

DUE FINISH DATE:

- June 2002

OVERALL PROGRESS

- The question has been addressed in a draft final report presented here.

DEFINITIONS

- The Dwarf Shrub Heath Broad Habitat has been defined in Jackson (2000) – see policy context statement below.
- 'Extent' refers to estimated area of Broad Habitat.
- 'Condition' refers to the status of Broad Habitat parcels measured in terms of their botanical characteristics. This includes the series of condition measures used in the main report and previously in the EcoFact project. They include mean Ellenberg scores for fertility, light and wetness as well as mean species richness.
- This report focuses on assessing the robustness of mapped change and avoids generating an additional set of national estimates. We therefore concentrate on evidence for change on 'surveyed land'. This means mapped parcels that were assigned to Broad Habitats in CS survey squares.

POLICY CONTEXT STATEMENT

Historical and recent changes in area and condition of Dwarf Shrub Heath[14]

Changes in extent

340 Available evidence suggests that the total area of heathland in GB has declined over the last 200 years (Gilbert & Gibbons, 1996). For English counties, the reduction in extent of lowland heaths between the mid-18th century and mid-1980's was documented by Farrell (1989, 1993) and Evans et. al. (1994), while the Monitoring Landscape Change project estimated that 25,800ha of lowland heath and 91,200ha of upland heath was lost between 1947 and 1969 across England and Wales (Huntings Surveys and Consultants Limited, 1986). In Scotland,

[14] **CS2000 mapping definition (Jackson 2000; CS2000 Field Handbook):** ">25% cover of dwarf shrubs"

Tudor et. al.(1994) used aerial photographs to show that 274,100 ha of heathland had been lost between 1943 and 1979.

341 More recent assessments of change in extent from 1984 to 1998 are covered by the Countryside Surveys of GB. These provide additional information on turnover and hence the patterns of loss and gain to other habitats that have occurred as a result of changes in extent of Dwarf Shrub Heath. Further exploration of their cause and significance forms a major component of this FOCUS topic.

342 CS2000 estimated that Dwarf Shrub Heath made up 6.4% of the land cover of GB in 1998 (Haines-Young et.al. 2000). Proportional cover was highest in Scotland (12.5%) where it was the third most abundant category behind Improved Grassland (13%) and Bog (25%). Between 1990 and 1998 the total British extent of Dwarf Shrub Heath did not show a statistically significant change. However, a significant 8.3% decline in extent was estimated for Environmental Zone 5[15] in Scotland. This decline amounts to an estimated loss of 21,000ha (SE +/-14,000) out of a total of 220,000ha in the Environmental Zone. Net losses were also estimated for Environmental Zone 6 and Environmental Zone 2 while increases were estimated for Environmental Zones 1, 3 and 4. Although none of these net changes were statistically significant this may well reflect high turnover between Broad Habitats leading to low statistical power. Because high turnover implies major habitat change, lack of statistical significance may well conceal important differences in condition between transferred stock (see below).

343 Countryside Survey estimates of land-cover stock and change between 1984 and 1990 (Barr et al 1993) were not based on the Broad Habitat classification, however meaningful comparisons can be drawn between the 1984-'90 and 1990-'98 intervals by summarising across the CS1990 heathland categories. No net change was detected between 1984 and 1990 based on an equivalent loss of 5% of the 1984 heathland stock and a gain of 5% of the 1984 stock. This compares with a 13% loss and a 9% gain between 1990 and 1998 (Haines-Young et al 2000). The largest gain from the shrub heath land-cover type between 1984 and 1990 was to conifer and a smaller but still statistically significant gain to new conifer plantation was also seen in 1990 and 1998 in Scotland. Marked turnover between Acid Grassland and Dwarf Shrub Heath also occurred in Scotland resulting in a net gain to Acid Grassland (McGowan et al 2001). In Scotland, the effects of increased grazing pressure plus afforestation may therefore be implicated in net change in extent. Further analyses of matrices of Broad Habitat change are required to assess dynamics across England and Wales. At the GB level however, most of the losses from Dwarf Shrub Heath translated into gains to Bracken and Bog Broad Habitats.

344 Net change in GB-wide heathland extent between 1990-'98 should be evaluated in terms of the published Biodiversity Action Plan target for upland heathland. This requires that dwarf shrubs increase to at least 25% cover on 50,000 ha of habitat by 2010. Since 25% cover of dwarf shrub is the CS mapping definition of the Dwarf Shrub Heath Broad Habitat we can infer that the 1990-'98 change represents an estimated loss of 58,000ha across GB. Even taking into account the range of the upper and lower 95% confidence limits (124,000 - 6,900ha) it is clear that if the BAP target were achieved by 2010 it will only have served to make up part of the apparent 8 year reduction in extent. Evaluation of the net 1990-'98 change should also take account of the apparent gain to the Bog Broad Habitat from Dwarf Shrub Heath (Haines-Young et al 2000). This may in fact constitute a positive change in line with the BAP objectives for both Broad Habitats. The apparent overall stability but regional net change in extent of Dwarf Shrub Heath between 1990-'98 conceals patterns of loss and gain that are potentially highly significant in terms of BAP objectives. Work carried out under this topic will address assess the significance of these estimated changes in extent (see below).

[15] ..marginal land at sea level and intermediate altitudes, mostly in the west and including the Scottish islands

Change in condition

345 The starting point for the FOCUS follow-up work on vegetation condition is the existing analyses of changes in vegetation condition indicators between 1990 and 1998. These results allow an initial assessment of floristic change in the Dwarf Shrub BH in terms of movement along gradients of disturbance and fertility as well as changes in species richness. At the GB level the balance of plant community types within the Broad Habitat saw grass-dominated moorland increase at the expense of the cover of heath/bog continuing a trend seen between 1978 and 1990 (Bunce et al 1999; Firbank et al. 2000). Mean Ellenberg fertility score also increased in Dwarf Shrub Heath between 1990 and 1998 but only in the England with Wales sample (Haines-Young et al 2000). However, in Scottish Dwarf Shrub Heath there was a significant reduction in mean species richness while the index conveying the proportion of Grime's stress-tolerators decreased (McGowan et al 2001; Haines-Young et al 2000).

The policy context for changes in Dwarf Shrub Heath

DEFRA Public Service Agreement (PSA)[16]

346 The PSA set out the aims and objectives of individual government departments. With the formation of DEFRA in 2001 a new set of PSA statements and targets were drawn up by the ministerial team. The PSA targets are coined as specific actions some of which form relevant policy background to this question. These are:

- PSA Target 6: Bring into favourable condition by 2010 95% of all nationally important wildlife sites compared to 60% of sites currently estimated to be in such condition.
- PSA Target 14: open up public access to mountain, moor, heath and down and registered common land by the end of 2005.
- Remaining CSR 1998 target: Contribute to a more attractive and accessible countryside by increasing the area protected and enhanced under the major agri-environment schemes.

National and international biodiversity policy

347 British obligations for conservation objectives relating to Dwarf Shrub Heath vary in their applicability to designated areas or the wider countryside as well as their emphasis on site safeguard, enhancement or maintenance. Management agreements drafted under the provisions of the Wildlife and Countryside Act (1981), CROW (2000) and legislation that implements the EEC Habitats Directive all focus activity onto designated SSSI and NNR designed to afford protection as well as positive management to the best examples of habitat types across Britain. Schemes. In 1999 about 16% of upland heath was designated as SSSI (includes NNR) in England and Wales and 15% in Scotland (UHAP, 1999). Outside these designated sites, obligations for habitat and species conservation fall under the UK Biodiversity Action Plan that sets out a strategy for conservation of specific habitats and species. Under the UK BAP Dwarf Shrub Heath is divided into two priority habitats, upland and lowland heath, each covered by their own Habitat Action Plans[17]. The total expenditure envisaged in implementing objectives under both plans is around 250K for the period up to 2010 (UHAP 1999; LHAP 1995).

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[16] See www.defra.gov.uk/corporate/busplan/01psa.htm

[17] See action plan texts at http://www.ukbap.org.uk/Library/library_1.htm#P3

The agricultural policy context

348 Since entry into the EU over 30 years ago, livestock (largely sheep) production in the British uplands has been assisted by a variety of price support mechanisms implemented as part of the Common Agriculture Policy. The most important of these measures in terms of impacts on upland heath are the Hill Livestock Compensatory Allowance Scheme (HLCA), Sheep Annual Premium (SAP), Suckler Cow Premium (SCP) and the Beef Special Premium (BSP). Given the predominance of sheep grazing in the British uplands, the HLCA scheme has been probably the most important policy driver. This has operated since 1975 in the Less-Favoured Areas that contain the majority of upland heath in Britain (UMHB, 2002).

349 Until the MacSharry reforms of the CAP in 1992 neither the HLCA or SAP schemes carried any sanction against the ecological effects of over-grazing (UMHB, 2002; Winter & Smith 2000). Since support was available on a per animal basis, the scheme acted as an incentive to increase flock size (Fuller & Gough, 1999). There is now considerable evidence that, since 1975, the impact of this policy driver has been to increase the extent of moorland and grass/heath. Certainly, evidence from analyses of change in plant species composition between 1978 and 1998 are partly consistent with these effects although difficulties still remain in teasing apart the role of additional potential drivers such as deer grazing and pollutant deposition (see below). Also the HLCA driven rate of increase in sheep numbers tailed off in the late-80s to be replaced by either a lower rate of increase or regional stability through the 90s (Fuller & Gough 1999; Kiddle 2000).

350 In response to on-going concerns about subsidised over-grazing, the headage-based HLCA scheme was replaced with the area-based Hill Farm Allowance scheme in 2001 (UMHB, 2002). It is hoped that this change should also help alleviate the particular issue of over-grazing on upland commons (UHAP, 1999).

Environmental Impact Assessment

351 In 2002 the existing government regulations that required EIA to precede planned development and forestry were extended to cover "..the use of uncultivated land or semi-natural areas for intensive agricultural purposes."[18] These extended measures complete the implementation of the European EIA Directive but also contribute to the wider aims of promoting sustainable agriculture. See policy context for T1 – Q2 for further information on the policy background.

Conservation and agri-environment schemes relevant to conservation of the Dwarf Shrub Heath Broad Habitats

- **Environmentally Sensitive Area Scheme**: Targets DSH outside SSSI. Encourages lower stocking levels and appropriate heathland management. In 1999 an estimated 103,057 ha of moorland in GB was estimated as under ESA management agreement of which 71,612ha was DSH (5% of GB extent based on CS2000 estimate of total stock and UHAP (1999)). The first ESA were designated in 1987 with further designations in 1988, 1993 and 1994.
- **Countryside Stewardship, Countryside Premium and Tir Cymen**: Outside ESA and SSSI, conservation management of DSH can be funded under a series of competitive-entry schemes including Countryside Stewardship (England), Countryside Premium (now closed) and Rural Stewardship (Scotland) and Tir Cymen (Wales). These schemes include heathland tiers that fund management agreements designed to allow regeneration of suppressed heather. Recent changes to these schemes include the incorporation of the

[18] See guidelines at http://www.defra.gov.uk/environ/eia/

Moorland Scheme into the Stewardship scheme in England and, in Wales, the replacement of Tir Cymen and ESA agreements by a whole-farm scheme Tir Gofal (UHAP, 1999). The first of these schemes – Countryside Stewardship - was launched as a pilot scheme in 1991.

- **Wildlife Enhancement Schemes:** These schemes offer up to 50% funding of agreements to secure conservation management of SSSI land. They are limited in number and geographic reach. The North Pennines WES is probably the most significant in terms of impact on upland DSH. Pilot schemes were launched in 1991.
- **Moorland Management Scheme:** Run by Scottish Natural Heritage and focussed on moorland within designated SPA, SAC and SSSI.

Key actions from each Priority Habitat Action Plan[19]

Lowland heathland

- Maintain, and improve by management, all existing lowland heathland (58,000 ha).
- Encourage the re-establishment by 2005 of a further 6,000 ha of heathland with the emphasis on the counties of Hampshire, Cornwall, Dorset, Surrey, Devon, Staffordshire, Suffolk and Norfolk in England and Pembrokeshire, Glamorgan and west Gwynedd in Wales, particularly where this links separate heathland areas.
- Through the Change in Key Habitats Project (CKH) it has been estimated that there is 67,000 ha of recently modified heathland with the potential for restoration. The figure of 6,000 ha therefore represents a modest attempt to recreate approximately 10% of the existing lowland heathland resource. This target could be realistically met using existing Countryside Management Schemes. The careful targeting of 6,000 ha of lowland heathland recreation will also make a modest contribution to reversing the effects past fragmentation of the resource.
- Where significant gaps in the SSSI/ASSI coverage of lowland heathland are identified the appropriate SSSI/ASSI procedure should be implemented by 1998.
- Consider expanding Countryside Stewardship, Tir Cymen, Environmentally Sensitive Area (ESA) and Wildlife Enhancement Schemes (WES) to meet the targets for heathland management and re-creation. Determine the applicability of a new scheme similar to Countryside Stewardship for Scotland.
- Take account of the conservation requirements of lowland heathland in developing and adjusting agri-environment schemes.
- Simplify the process for submission of applications to the Secretary of State to fence lowland heathland that is common land for grazing, to maintain its wildlife interest.
- In areas that support lowland heathland, there should be a presumption in favour of re-establishing heathland on derelict land or land that has been used for mineral extraction.
- Encourage Forest Enterprise and the MoD to agree action plans with specific targets for heathland restoration or management for all heathland sites in their ownership with the statutory nature conservation agencies by the end of 2000.
- The long term funding of county heathland management projects, most of which have full time project officers and which play a key role in delivering heathland management needs

[19] Actions taken from each plan at www.ukbap.org.uk/species.htm

to be addressed. Consideration should be given to establishing county heathland projects in Wales

Upland heathland

- Maintain the current extent and overall distribution of the upland heathland which is currently in favourable condition.
- Achieve favourable condition on all upland heathland SSSIs/ASSIs by 2010, and achieve demonstrable improvements in the condition of at least 50% of semi-natural upland heath outside SSSI/ASSIs by 2010 (compared with their condition in 2000).
- Seek to increase dwarf shrubs to at least 25% cover where they have been reduced or eliminated due to inappropriate management. A target for such restoration of between 50,000 and 100,000 ha by 2010 is proposed.
- Initiate management to re-create 5,000 ha of upland heath by 2005 where heathland has been lost due to agricultural improvement or afforestation, with a particular emphasis on reducing fragmentation of existing heathland.
- Review and modify livestock support mechanisms in the Less Favourable Areas (LFAs) through further lobbying for reform of Common Agricultural Policy (CAP), to promote sustainable agricultural management of upland heathland. Promote a more integrated approach to environmental, agricultural and socio-economic policy through CAP reform. Continue to reduce overgrazing by implementing the environmental cross-compliance conditions.
- By 2002 review and consider common land legislation with a view to improving the sympathetic management of upland commons.
- By 2004, review, and modify where necessary, muirburn legislation to ensure appropriate management of upland heathland.
- When reviewing management prescriptions in agri-environment schemes and woodland initiatives, consider whether additional measures are needed to maintain and/or improve the condition of upland heathland.
- Protect upland heathland from inappropriate development, such as wind-farms and quarrying, including by identification in relevant development plans.
- Consider the adequacy of existing planning guidance on the impacts of certain developments on upland heathlands, for example wind farms, and revise if required.
- Acknowledge the importance of upland heathland in country, regional or other forestry strategies.
- Develop by 2005 regional strategies to reduce red deer numbers in Scotland to levels where upland heathland is maintained in favourable condition.

Acknowledgements:

352 Dr Angus MacDonald (SNH) and Professor John Milne (MLURI) provided useful advice for this policy context statement.

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SCIENCE OUTPUTS

Part1: Analyses of change in extent and condition of Dwarf Shrub Heath

Approach

353 Changes in extent and condition of Dwarf Shrub Heath (DSH) could have taken place following the operation of a series of land-use drivers before 1990 and during the eight year interval. These include:

1. Increased grazing by sheep in upland Britain following increases in stocking density through the mid-seventies to the late-nineties (Fuller & Gough, 1999).

2. Increased grazing by deer in upland Britain following local increases in numbers since the sixties (Deer Commission, 2001).

3. Afforestation and clear-felling.

4. Under-grazing and reduced biomass removal in lowland Britain.

5. Atmospheric N deposition in both upland and lowland Britain. This peaked around 1990 (NEGTAP 2001) having increased for most of the 20th century.

6. Changes from and to DSH could have been driven by the effects of conservation measures funded under agri-environment agreements. These measures include reduced grazing in the uplands, rewetting of degraded bog following blocking of grip drains, bracken spraying and increased grazing on lowland heaths. Attempts to detecting the effects of conservation measures are covered under Topic7.

354 In the unenclosed uplands, the changes in Broad Habitat allocation of surveyed parcels are also known to be affected by real difficulties in mapping change in the extent of Broad Habitats. For example, it was acknowledged in Haines-Young et al (2000) that the changes between DSH and Bog "*..probably reflect different interpretations by field surveyors in complex habitats.*" Therefore, in parallel with an assessment of the role of the drivers listed above, the robustness of the mapped change needs to be taken into account. There are however, limits on the extent to which this can be done. This is because mapping in unenclosed upland habitats was done onto a colour coded Broad Habitat map so that mapping decisions were not formulated as code strings available for later analysis. Hence, the only options are manual checking of the field maps (a prohibitively lengthy process in most cases) or extraction of the 1990 mapping data as a guide to the probability that the 1990 Broad Habitat allocation was correct. The shifts from DSH to Conifer plus all those involving lowland heath were checked manually given the small number of CS sample squares involved.

355 In addition to mapped data, condition measures derived from the vegetation plots can be used to compare actual changes in plots within parcels that changed Broad Habitat versus the kind of change that would be expected given Broad Habitat change. To aid interpretation, condition measure data from the changing parcels were also compared with condition measure data for plots in stable parcels. There are however, limits on the extent to which vegetation plot data can be assumed to track mapped changed in the total surveyed area. Firstly, plots sample only a subset of the total number of parcels and secondly, mapped parcels can be heterogeneous so that changes in the botanical character of a plot may not represent the overall change in character of the parcel.

356 The Broad Habitat changes that are covered by this assessment of change in extent and condition are listed in Table 10.1 along with the expected directions of change in plot-derived condition measures.

Table 10.1 Expected changes in vegetation condition measures in plots within parcels that change Broad Habitat allocation between 1990 and 1998.

Broad Habitat grassland change; 90 to 98	Number of repeat plots	Aggregate class change	Light score	Fertility Score	Wetness score	pH score
DSH to Acid grassland	15	VIII to VII	up	Up	n/a	n/a
Acid grassland to DSH	12	VII to VIII	down	down	n/a	n/a
DSH to Conifer			Too few plots			
DSH to Bog	23	Use CVS classes	n/a	down	up	n/a
DSH to Bracken	10	VIII to VI	n/a	up	n/a	up
Bog to DSH	20	Use CVS classes	n/a	n/a	down	n/a
Bracken to DSH	4	VI to VIII	n/a	down	n/a	down

Results – change in mapping codes

DSH to Conifer

357 Nine CS survey squares saw a change in allocation from DSH in 1990 to Conifer in 1998. These nine squares and their respective parcels were checked manually. Out of a total of 42ha of surveyed land that changed Broad Habitat, 9ha was doubtful because of mapping or digitising error while the remainder appeared to reflect real change. The largest loss of DSH occurred in one of the two squares in Environmental Zone 6 where a quarter of the square had been planted with Sitka Spruce since 1990. In all other squares that saw apparently real change, parcel areas were all well below one hectare in size. In one of these squares in Environmental Zone 4, DSH was lost to self-sown *Pinus sylvestris* on part of a disused railway embankment.

Changes involving lowland heath

358 Because of the particular land-use and conservation issues surrounding lowland heathland, any changes involving DSH in CS squares in Environmental Zones 1, 2 and 4 were manually checked (Table 10.2). All of the lowland squares that saw a loss of DSH to conifer were in Environmental Zone 4. Of these three squares one involved a loss of DSH to recently planted *Pinus sylvestris* shelter-belt. According to surveyors notes in 1998 this was designed as a windbreak and for pheasant rearing. The second square in Environmental Zone 4 also saw a loss to plantation while the third square was detailed in the previous section. Of the three other squares in Environmental Zone 4 that lost DSH, two appear doubtful in that the field maps did not appear to support any change while in one square, DSH was again lost to succession on part of a disused railway embankment but this time to tall-herb vegetation and hence, to the neutral grassland Broad Habitat. Of the remaining lowland squares to have seen loss of DSH, one in Environmental Zone 2 seems to have seen a real loss of 6ha to Bracken, while the only square in Environmental Zone 1 lost a small fragment of DSH to tall-herb vegetation dominated by *Deschampsia cespitosa* in 1998 and grazed by horses, cattle and sheep.

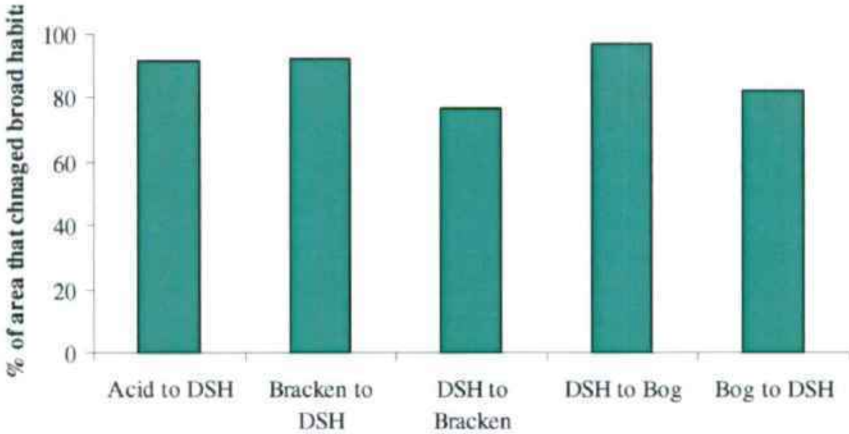
Table 10.2 Changes between 1990-'98 in surveyed area (ha) involving DSH in lowland Environmental Zones only.

Loss from DSH	EZ1 E&W	EZ2 E&W	EZ4 Scotland
To Conifer	0.0	0.0	**0.3**
To Improved & Neutral	**0.2**	0.0	**0.3**
To Acid grassland	0.0	**0.1**	0.0
To Bracken	0.0	**6.0**	**0.2**
Stable	0.0	**50.6**	**4.1**

Other changes from and to DSH

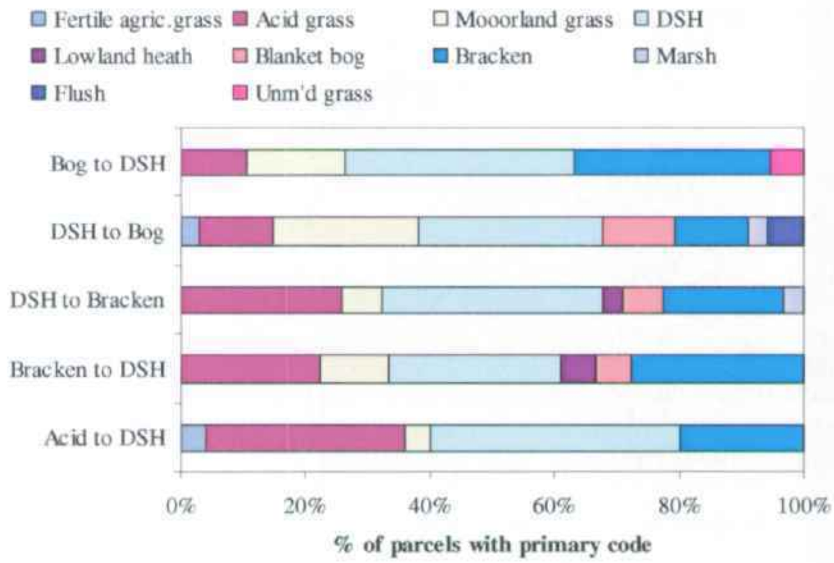
359 The majority of changes from and to DSH involved surveyed land allocated to Broad Habitat mosaics in 1990 (Figure 10.1). However, making an assessment of the reliability and causes of these changes is limited because of the lack of coded mapping data from 1998. The absence of parcel coding for 1998 partly reflects the change in mapping methodology that was made to address the very real problems in mapping change in the unenclosed uplands. The CS2000 pilot mapping exercise showed, for example, that attempts to map upland habitat mosaics in detail at two times and then to measure change were prone to a large amount of mapping error. In light of this, surveyors in 1998 were encouraged to record change only on a pre-prepared Broad Habitat map that amalgamated the numerous parcels recorded in the 1990 survey into a simpler and smaller number of polygons that could be realistically checked while minimising mapping errors. However, only limited information could then be recorded onto the Broad Habitat map. The consequence of this was that often no information was recorded to indicate whether change was real or was intended as a correction to the 1990 map. The issue is particularly important for the treatment of mosaics. Given the absence of information on change and the known problems that existed with upland Broad Habitat mapping, the safest conclusion is that much of the turnover between DSH, bog, bracken and acid grassland is probably attributable to the processing of spatial mapping errors.

Figure 10.1 Proportion of surveyed area in CS squares that saw a change in extent of DSH and that comprised parcels coded as mosaics in 1990.



360 Information on the primary code composition of the mosaics that changed Broad Habitat from or to DSH also illustrate the diverse make-up of these areas of surveyed land (Figure 10.2). The change to 1998 may have involved only a part of the total extent of each mosaic in each square but the absence of 1998 coded data means that further assessment of 1998 allocations is only possible using vegetation plot data, since their locations can be matched with the specific area that saw Broad Habitat change. However, this assessment can only be partial because only a subset of parcels were sampled by vegetation plots.

Figure 10.2 Primary codes associated with 1990 parcels all or part of which changed to or from DSH between 1990 and 1998.

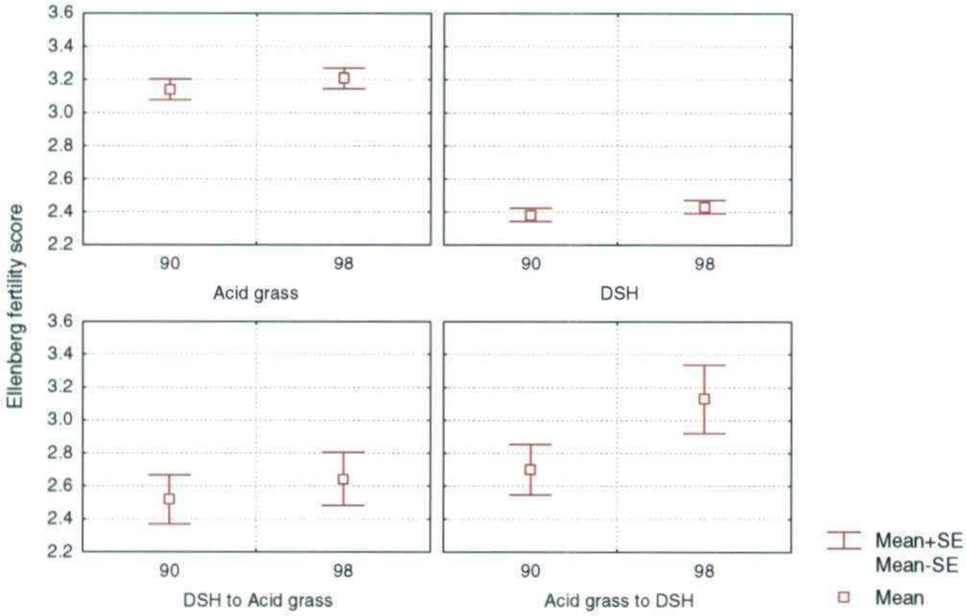


Results – comparison of condition measures

Change between DSH and Acid grassland

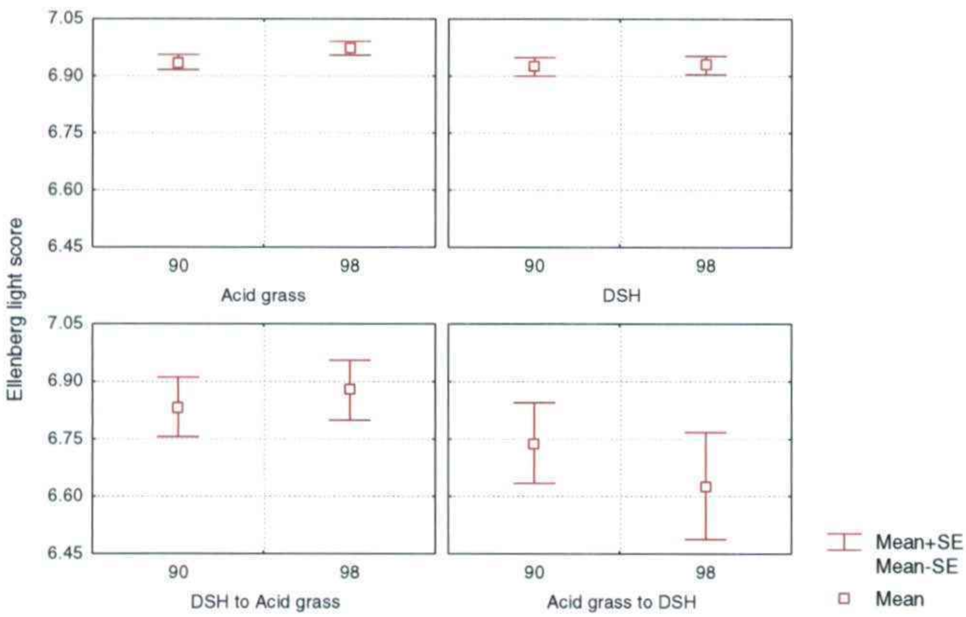
361 Plots located in DSH that changed to acid grassland had a mean fertility score closer to values typical of stable DSH. The small increase in score between 1990 and 1998 is consistent with a change to acid grassland but the magnitude of the change was small and only marginally larger than the increase also seen in stable acid grasslands (Figure 10.3).

Figure 10.3 Change in Ellenberg fertility score in repeat plots located in DSH or Acid grassland in 1990 and 1998



362 The larger increase in fertility score for plots within parcels that changed from acid grassland to DSH is inconsistent since a decrease or stability would be expected (Figure 10.3). Comparing change in light score was not informative because the mean scores for plots in stable DSH and acid grassland were very similar (Figure 10.4).

Figure 10.4. Change in Ellenberg light score in repeat plots located in DSH or Acid grassland in 1990 and 1998



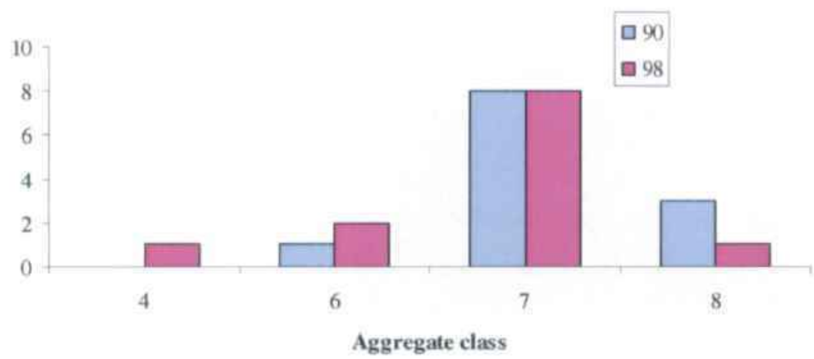
363 Changes in aggregate class membership were based on few plots, so the results should be treated with some caution. Overall, there was little change in aggregate class so that for these subsets of changing parcels any floristic changes could not have been large (Figure 10.5).

Change between DSH and Bracken

364 Mean fertility scores convincingly separated the stock of unchanging bracken and DSH (Figure 10.6). However, the small number of plots from parcels that changed Broad Habitat did change appreciably in their mean score while the mean values for '90 and '98 suggest placed the sample in between the means for stable acid grassland and bracken. This perhaps reflects the variability typical of the vegetation mosaics in which most of the changes to and from DSH occurred. The same inconclusive message comes from the comparison of pH scores (Figure 10.7), although changes in light score do appear to have moved in the expected direction (Figure 10.8).

Figure 10.5 Change in aggregate class membership of plots within parcels that changed, a) from Acid grassland to DSH and b) from DSH to Acid grassland , between 1990 and 1998.

a)



b)

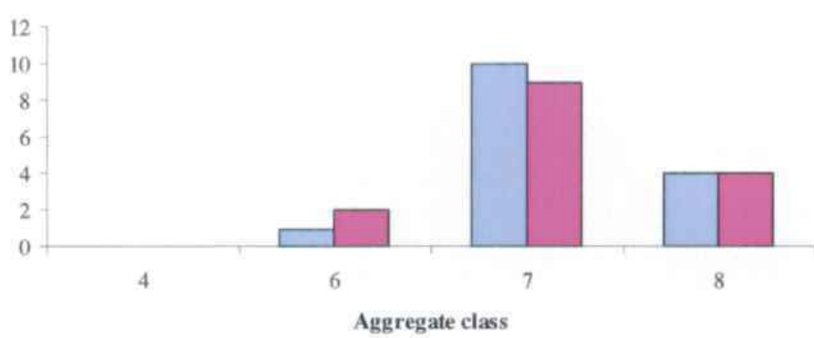


Figure 10.6 Change in Ellenberg fertility score in repeat plots located in Bracken or DSH in 1990 and 1998

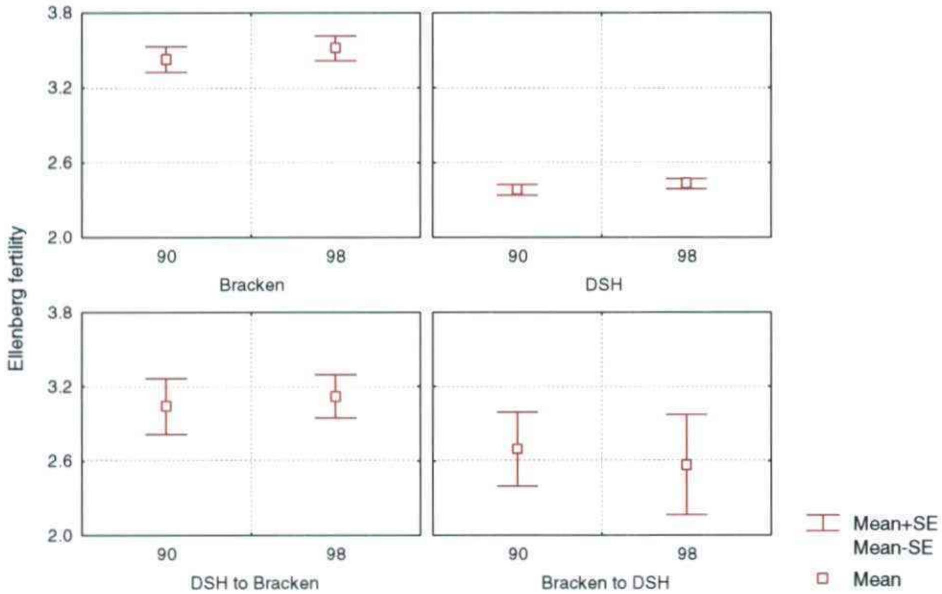


Figure 10.7. Change in Ellenberg pH score in repeat plots located in DSH or Bracken in 1990 and 1998

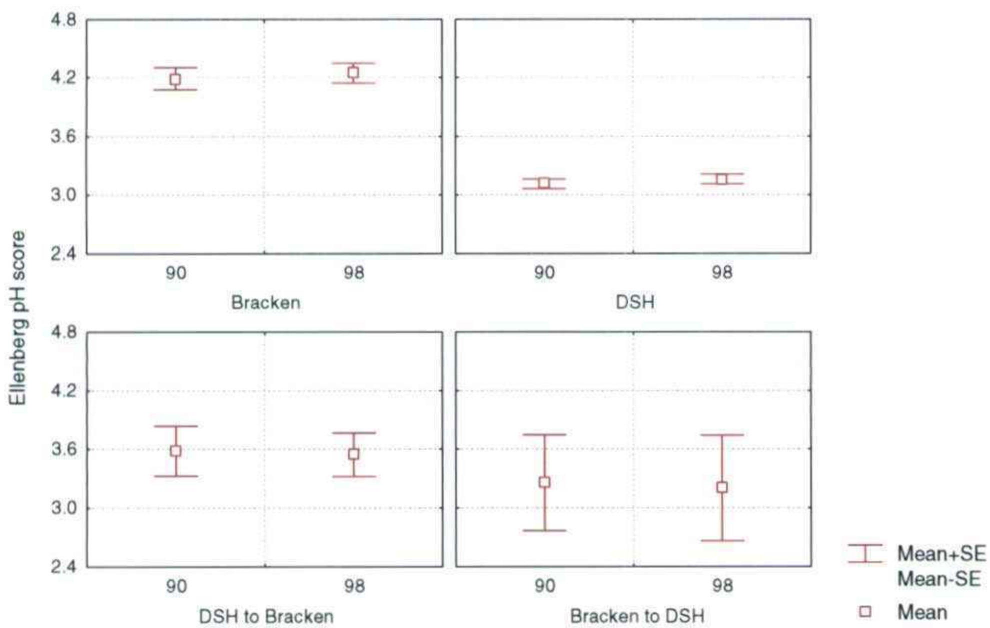
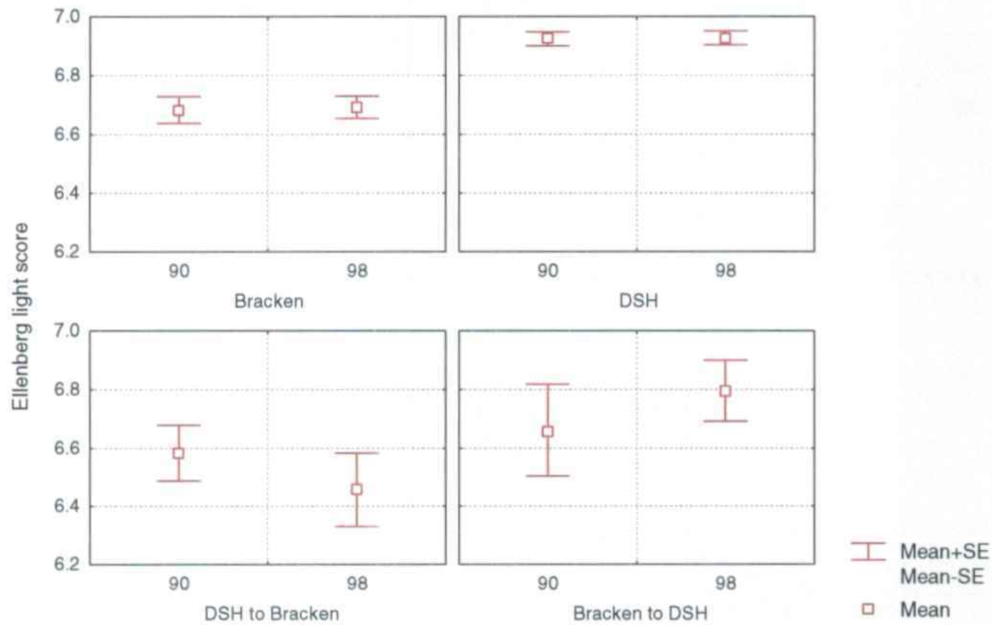


Figure 10.8 Change in Ellenberg light score in repeat plots located in DSH or Bracken in 1990 and 1998



Change between DSH and Bog

365 DSH and bog are well separated by differences in mean fertility score while plots in a subset of parcels that changed between the two had means that are closer to bog rather than DSH (Figure 10.9). An even better separation between DSH and bog is seen in terms of mean wetness score (Figure 10.10). Mean scores for parcels that changed fell between the two and again this may reflect the inherent variability of the vegetation within mosaic parcels. The decline in mean wetness score for plots in parcels that moved from bog to DSH is consistent but a decline in score was also seen in the plots from stable bog parcels (Figure 10.10).

Figure 10.9 Change in Ellenberg fertility score in repeat plots located in Bog or DSH in 1990 and 1998

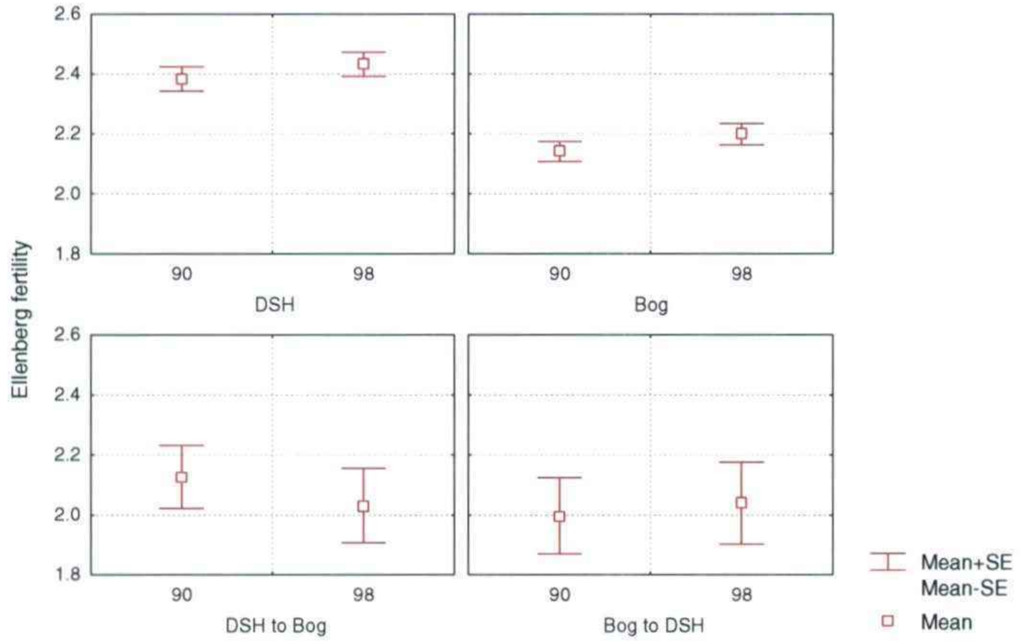
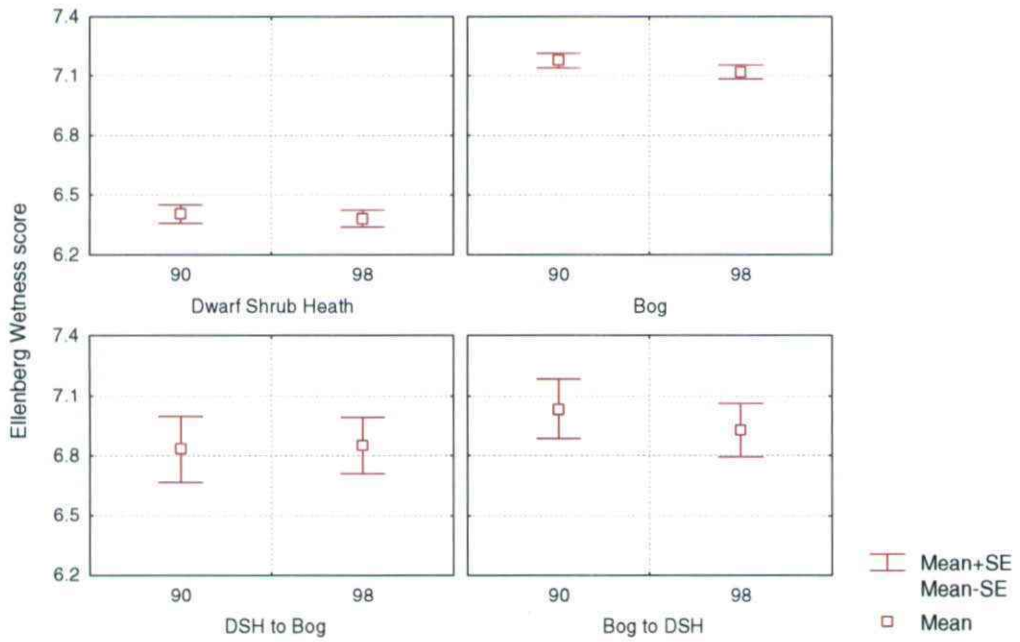


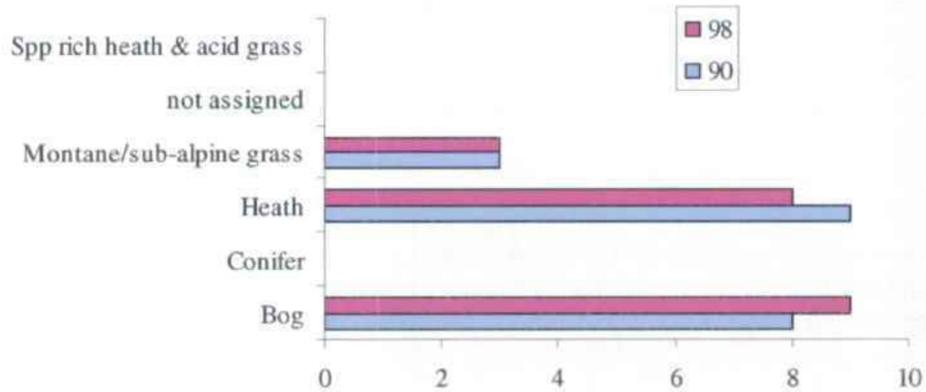
Figure 10.10 Change in Ellenberg wetness score in repeat plots located in Bracken or Acid grassland in 1990 and 1998



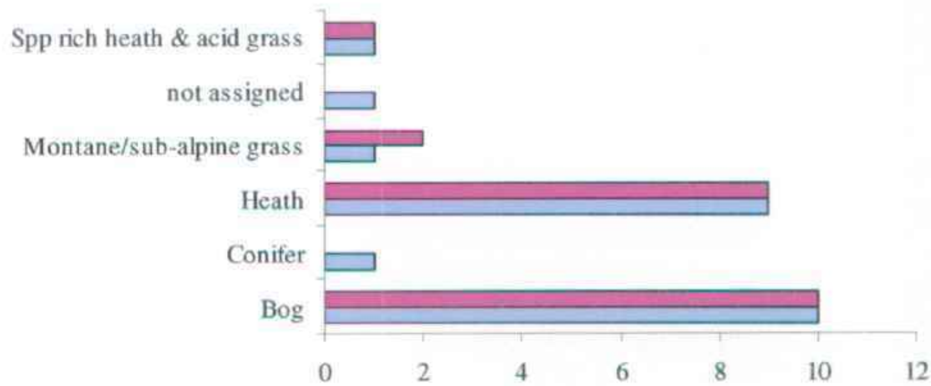
366 The main indication from the pattern of change in condition measures is that floristic change in the small sample of vegetation plots has been slight. This conclusion is reinforced by the overall stability seen in these plots when changes between CVS classes were examined (Figure 10.11). Since DSH and bog are both included in ACVIII (Heath/bog), shifts in plant species composition were examined in relation to a grouping of CVS classes into the habitat types used to determine empirical Critical Loads for nitrogen. This classification conveniently discriminates between heath and bog. Correspondence between CVS classes and the CL habitat classification has been carried out by Prof M. Ashmore as part of a project investigating the relationship between vegetation change and sources of nutrient enrichment in CS plot data.

Figure 10.11 Change in habitat type membership of plots within parcels that changed, a) from Bog to DSH and b) from DSH to Bog , between 1990 and 1998. The habitat types were formed from groupings of individual CVS classes based on the Empirical Critical Loads for Nitrogen habitat classification (Werner & Spranger, 1996). This classification provides a convenient way of discriminating between heath and bog.

a)



b)



Conclusions

- The majority of surveyed lowland heath did not change Broad Habitat between 1990 and 1998. Small losses were attributable to succession, bracken encroachment and improvement.
- Other changes to and from DSH are impossible to fully evaluate because of the lack of 1998 mapping data consistent with the shift to a more realistic and simpler mapping method.
- Condition measure data from plots located in a subset of the parcels that changed from and to DSH, indicated that floristic changes within those parcel had been slight.
- The implications are that documented changes in Broad Habitat extent did not coincide with dramatic changes in land-cover but were associated with a high level of sampling error, especially across vegetation mosaics, plus generally more subtle changes in species composition.

Part 2: Causes of change in extent and condition of Dwarf Shrub Heath

Approach

367 CS provides evidence of change across national ecosystems in terms of the extent of different Broad Habitats and by quantifying change in the condition of the plant communities that make up these Broad Habitats. The use of indices such as Ellenberg scores provides indirect evidence of the processes involved including eutrophication and disturbance. Given that these processes are known to operate as a consequence of environmental and land-use changes it should be possible to test hypotheses about the relative contribution of different drivers if national datasets can be found that track land-use change at complementary scales to CS data.

368 We used three national scale datasets to test whether change in extent and condition of DSH was related to numbers and change in numbers of deer in Scotland, sheep stocking density and wet plus dry deposition of ammonia (Table 10.3).

Table 10.3 Datasets used to quantify hypothesised drivers of change in extent and condition of DSH between 1990 and 1998.

Driver	Dataset
Deer grazing (Scotland only)	Numbers of deer in and change in numbers for open range areas (taken from Deer Commission 2000)
NHx deposition (wet + dry)	Modelled NHx deposition estimates at 5x5km square resolution for GB for 1996 (CEH Edinburgh)
Sheep grazing	Modelled estimates of sheep density per 1km square for 1988 (MAFF census) generated as part of the development of the Dragosits et al (1998) ammonia emissions model.

369 The ability of each driver to explain significant change was tested for all DSH in GB as well as by Environmental Zone in accordance with the requirements of the topic question. Analyses

were also attempted based on whether squares that contained DSH were inside or outside Less Favoured Areas (LFA) and also by division in to Disadvantaged and Severely Disadvantaged areas. In practice, virtually all squares in upland Britain were in LFA. Also all Welsh squares were in SDA while 29 out of 32 English upland squares were in SDA. Therefore this division of upland squares was abandoned. Analyses involving deer commission data were carried out separately reflecting the fact that open ranges only comprise part of the total area of Scotland.

370 Four types of ecological response were analysed:

1. Change in area of DSH from and to any other Broad Habitat type,
2. Change in area of DSH from and to acid, neutral or improved grassland,
3. Change in cover-weighted Ellenberg fertility score in vegetation plots located in parcels mapped as DSH Broad Habitat in 1990 or 1998,
4. Change in Ellenberg fertility score in vegetation plots assigned to the Upland *Calluna* heaths and Lowland dry and wet heaths Critical Load (empirical N) habitat types on the basis of their CVS class membership (see above and Werner & Spranger 1996).

371 Fitting of the explanatory variables to change in fertility scores used a mixed modelling approach to take into account the nestedness of CS plots within squares. In addition, Environmental Zone, mean altitude in each square and minimum January temperature were included to allow for the possibility of climatic and altitudinal constraints on the vegetation response. The proportional extent of other Broad Habitats in each CS square in 1990 were also introduced as explanatory variables to allow for the dependence of change on the amount of different types of land-cover present at the start.

Results

372 The only variability to be significantly explained by the predictors was change in cover-weighted Ellenberg fertility scores in plots defined as heathland on the basis of their species composition in 1990. Even so only 9% of the variation in Ellenberg score was explained (Tables 10.4 & 10.5).

Table 10.4 Results of fitting predictors to change in extent and condition of DSH between 1990 and 1998.

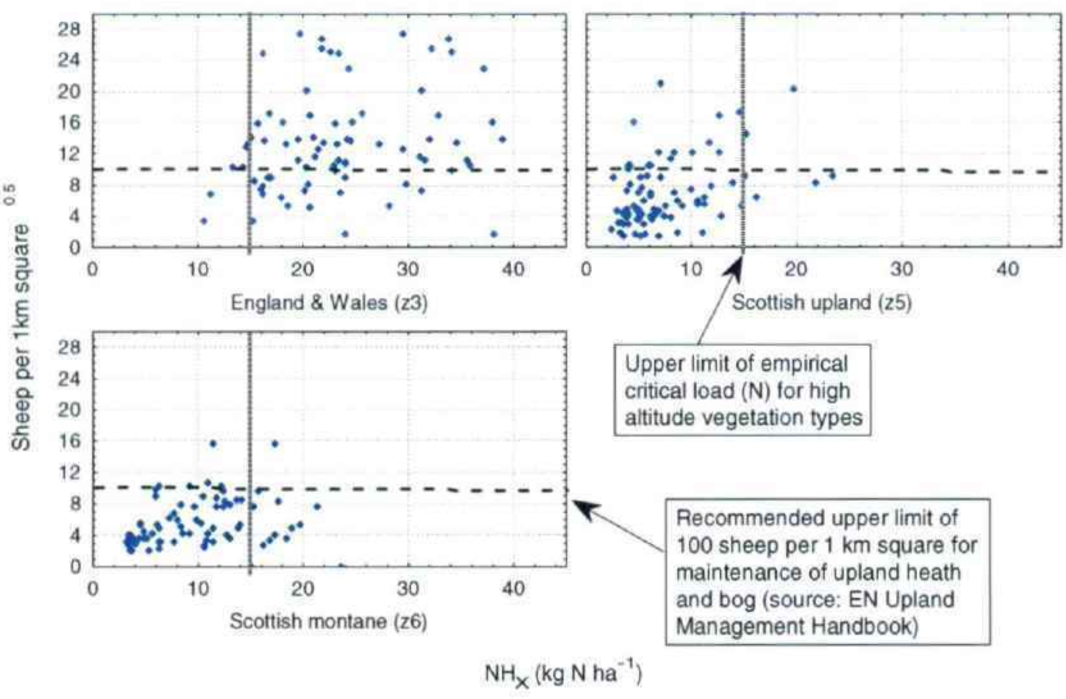
Response	Significant effects
Turnover of DSH area with all other Broad Habitats	None
Turnover of DSH with acid, neutral and improved grassland	None
Change in Ellenberg fertility scores in plots located in DSH Broad Habitat parcels	None
Change in Ellenberg fertility scores in plots in heathland defined by CVS class in 1990	1) Modelled sheep density per 1km square 2) Proportion of acid grassland present in 1990

Table 10.5 Mixed model ANOVA results for change in cover-weighted Ellenberg fertility scores between 1990 and 1998 for plots classed as heathland (n=522 plots).

Effect	Regression coefficients	Estimated DF	F value	P
Modelled sheep density	0.0173	148	12.02	0.0007
% acid grassland in 1990	0.0027	93.4	5.35	0.0230

373 Regression coefficients for the two significant variables were both positive indicating that larger values of sheep density and proportion of acid grassland in 1990 are associated with increasingly positive change in Ellenberg fertility score and therefore a shift toward species compositions that reflect greater substrate fertility. When tested in the absence of all other effects the proportions of woodland and bog in 1990 as well as modelled NHx deposition were also individually significant but when tested together to determine the best but fewest predictors they were excluded. No effect of Environmental Zone was detectable although analyses under a parallel GANE-funded project, has found that more of the variation in Ellenberg fertility change in England & Wales, across all upland vegetation types when analysed together, is explained by sheep density than NHx but the reverse applies in Scottish Environmental Zones. This seems to reflect the greater range of variation in sheep density in English and Welsh CS squares than in Scotland (Figure 10.13).

Figure 10.13 Range of variation in modelled sheep density (1988) and NHx deposition (1996) in CS sample squares in upland Environmental Zones of GB. Note that the y-axis is the square root of estimated sheep count as this was the variable used in regression analyses.



Conclusions

- Analyses attempted to explain change in extent and condition of DSH across Britain in terms of ammonia deposition, sheep grazing, deer grazing (Scotland only) and the proportion of different Broad Habitats present in each CS square in 1990.
- The only ecological response to be partly explained by any of the predictors was change in Ellenberg fertility score. Sheep density and amount of acid grassland present in 1990 were the best predictors such that higher sheep numbers in 1988 and a larger area of acid grassland would be associated with a larger shift toward plant species composition typical of higher fertility.
- Tests of the effects of deer numbers suffered from the coarse resolution of the open range counts while generally high levels of unexplained variation in the response data are likely to be due to the coarse resolution of the other predictors, the absence of finer-scale data on land management plus sampling error in the CS data on extent and condition change.

SUMMARY

The significance of change in extent and condition

- Changes to and from DSH, bog and bracken are impossible to fully evaluate because of the lack of 1998 mapping data consistent with the shift to a more realistic and simpler mapping method in the unenclosed uplands in CS2000.
- The majority of surveyed lowland heath did not change Broad Habitat between 1990 and 1998. Small losses were however, attributable to succession, bracken encroachment and improvement.
- Condition measure data from plots located in a subset of the parcels that changed from and to DSH, suggest that floristic changes within those parcels had been slight.
- The implications are that documented changes in Broad Habitat extent did not coincide with dramatic changes in land-cover and were associated with a high level of sampling error, especially across vegetation mosaics.

Causes of change in extent and condition

- Analyses attempted to explain change in extent and condition of DSH across Britain in terms of ammonia deposition, sheep grazing, deer grazing (Scotland only) and the proportion of different Broad Habitats present in each CS square in 1990.
- The only ecological response to be partly explained by any of the predictors was change in Ellenberg fertility score. Sheep density and amount of acid grassland present in 1990 were the best predictors such that higher sheep numbers in 1988 and a larger area of acid grassland present in 1990 were associated with a larger shift toward plant species compositions typical of higher fertility.
- Tests of the effects of deer numbers suffered from the coarse resolution of the open range counts while generally high levels of unexplained variation in the response data are likely to be due to the coarse resolution of the other predictors, the absence of finer-scale data on land management plus sampling error in the CS data on extent and condition change.

FURTHER WORK AND RECOMMENDED CHANGES TO CS METHODS

374 While recognising the arguments against asking CS square land-owners for management information (potentially eroding their good will and possibly influencing their future management in the square), from the point of view of improving our ability to explain changes, it would be useful to circulate a questionnaire in the next CS. Securing the publicised support of the CLA, NFU, CPRE etc. might be a useful way to allay suspicions among land-owners while also emphasising its importance.

375 In general, future analyses of change in upland Broad Habitats will be strengthened by analysis of repeat data from the U plot baseline laid down in CS2000.

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Question 11: Where did increases in Fen, Marsh & Swamp occur? What are the possible causes? What are the botanical characteristics of these new areas? What are the wider implications for biodiversity?

INTERIM REPORT - ***Simon Smart***

DUE START DATE:

- May 2002

DUE FINISH DATE:

- September 2003

OVERALL PROGRESS

- Policy context completed.
- Techniques and tools developed and trialled for analysis of changes in mapping codes as a result of work on other FOCUS questions.
- Assessment of the representation of Priority Habitats in 1990 and 1998 stock (this report).

DEFINITIONS

- The Fen, Marsh & Swamp Broad Habitat is defined as "..vegetation that is ground water fed; and permanently, seasonally or periodically waterlogged peat, peaty or mineral soils where grasses do not predominate. It also includes emergent vegetation or frequently inundated vegetation occurring over peat or mineral soils. This type includes neither areas of carr that are greater than 0.25ha which should be included in the "Broadleaved, mixed and yew woodland" Broad Habitat type nor include wet grassland (with the exception of purple moor grass, reed, or sweet-grass dominated vegetation) which should be included in the "Neutral grassland" Broad Habitat type." (Jackson 2000).
- 'Botanical characteristics' includes several plot level and parcel level attributes. We include condition measures as analysed in the CS2000 Module 1 report (Haines-Young et al 2000) and species cover codes used for describing mapped parcels of Broad Habitat. In addition plot level botanical data recorded in 1990 and 1998 can be assigned to community units of the National Vegetation Classification and hence, to the three Priority Habitats included in the Broad Habitat.
- Note that plot level data will only apply to a subset of the total parcels mapped while information on change in species mapping codes will often be unavailable for parcels mapped in an unenclosed, upland setting.

POLICY CONTEXT STATEMENT

376 *The Policy Context Statement was drafted in May, and takes account of comments made by attendees at the May FOCUS Workshop.*

Recent changes in area and condition of Fen, Marsh & Swamp(FMS)[20]

Changes in area

377 In 1998 FMS was estimated to make up 2.3% of GB land cover with 66% of this being in Scotland (CS2000 web-tables). CS2000 reported three statistically significant changes in area of FMS between 1990-'98 (Haines-Young et al 2000). A 27% increase in England with Wales, an 18.7% increase in Scotland and an 18.6% decrease in Northern Ireland. As a proportion of the 1990 stock by Environmental Zone, the largest increase was seen in Environmental Zone 1 in England & Wales (123%) although in area terms the estimate was relatively small (13,000ha with a 95%CI of 1,700ha to 27,400ha). In Scotland the national increase in extent was largely a consequence of increases in the upland Environmental Zones 5 and 6. The different landscape locations of these changes suggest that the identity and vegetation condition of Broad Habitats gaining or losing stock to FMS are likely to differ considerably; so too might the causes of these changes.

378 Patterns of flow between Broad Habitats at the GB level indicated that the increase in area amounted to 39% of the 1990 stock. This was largely gained from parcels mapped as Improved, Neutral or Acid Grassland, Bog or Conifer in 1990. These types of shift imply the involvement of increased seasonal flooding, clear-felling and possibly rush expansion in wetter grasslands. Of the 18% of GB stock that was lost from FMS, most was gained by Improved, Neutral or Acid Grassland and Bog (Haines-Young et al 2000). Further exploration of the robustness and causes of parcel-based change in FMS area forms a core component of this topic question.

Change in condition

379 Existing analyses of change in vegetation condition between 1990-'98 were carried out on three subsets of repeat plots and each type of analysis can help address a different type of question about change. 'Stay-same' analyses examined change in vegetation condition in plots that remained in the same Broad Habitat over the eight year period ie. stock carried over. 'Stay-same' results for FMS showed that there had been a statistically significant reduction in light score in Scottish X plots implying reduced disturbance and greater shade in larger stands. In addition, increases in substrate fertility were implied by Ellenberg fertility score increases in Scottish Y plots (ie. small fragments of FMS) and in Y plots in the western, lowland Environmental Zone 2 in England & Wales. No significant changes in wetness score were detected, suggesting an absence of change in patterns of seasonal inundation in FMS stock carried over despite possible change in fertility and disturbance regime (CS2000 web-tables).

380 '90-based' analyses focussed on change from a common Broad Habitat starting point but plots could have changed BH over time. Results for FMS tended to show the same pattern as the 'stay-same' analyses. Most statistically significant changes were seen in smaller habitat fragments (Y plots) and these shifts suggested reduced disturbance and increased fertility. As would be expected if some stock had been lost to typically drier BH, wetness score significantly declined across the GB population but again, only in Y plots (CS2000 web-tables).

381 The 'turnover' analyses contrasted the condition of new stock in 1998 with stock present in 1990 but absent in 1998. For FMS the only significant difference in Ellenberg scores was for higher fertility scores in Y and X plots in 1998 based on the total GB population (CS2000 web-tables).

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[20] **CS2000 mapping definition (Jackson 2000; CS2000 Field Handbook):** "This habitat occurs on ground that is permanently, seasonally or periodically waterlogged as a result of ground water or surface run-off. It can occur on peat, peaty soils or mineral soils. It covers a wide range of wetland vegetation including fens, flushes, marshy grasslands, rush-pastures, swamps and reed-beds."

382 Two further points are worth adding with regard to the additional analyses of FMS vegetation planned under this FOCUS topic. Firstly, profound floristic change can rapidly occur in fen vegetation without this resulting in a change in BH. For example, soligenous rich-fen can change into a species-poor reed-bed following lowering of the groundwater table and lack of management (Harding 1993). Hence, lack of change in BH is not necessarily an indicator of vegetation stability or even of a smaller magnitude change in species richness or ecological conditions. Secondly, FMS incorporates three priority habitats that between them cover a wide range of floristic variation and conservation interest. Indeed, these three PH are each associated with their own particular threats, history of change, threatened biota and geographical extent and these differences are reflected by their separate habitat action plans (see below). Also, the CS sample of parcels and plots may include borderline vegetation such as *Juncus* co-dominated rough grazing, which reflects the difficulty in differentiating clearly between Acid Grassland, Neutral Grassland and FMS in the field. Given this wide range of variation, further characterisation of the FMS sample will be essential in assessing the representation of the three PH and therefore the significance to conservation policy of the detected net increase in extent, patterns of turnover and change in vegetation condition over time.

383 Differentiation between the PH at the plant community level and also the description of most designated fens is typically based on allocation of swards to the communities and sub-communities of the NVC (Rodwell 1991; Jackson 2000). Therefore an assessment of the representation of the PH in the CS sample will be carried out using the NVC.

The policy context for changes in Fen, Marsh & Swamp

DEFRA Public Service Agreement (PSA)[21]

384 The PSA set out the aims and objectives of individual government departments. With the formation of DEFRA in 2001 a new set of PSA statements and targets were drawn up by the ministerial team. The PSA targets are coined as specific actions some of which form relevant policy background to this question. These are:

- PSA Target 6: Bring into favourable condition by 2010 95% of all nationally important wildlife sites compared to 60% of sites currently estimated to be in such condition.
- PSA Target 14: open up public access to mountain, moor, heath and down and registered common land by the end of 2005.
- Remaining CSR 1998 target: Contribute to a more attractive and accessible countryside by increasing the area protected and enhanced under the major agri-environment schemes.

National and international biodiversity policy

385 Most of the largest areas of FMS in Britain are already designated as SSSI and NNR, Special Protection Areas (SPA) or Wetlands of International Importance under the Ramsar Convention. Together these designations under domestic and European driven legislation can cover sites supporting all three of the Priority Habitats that constitute the Broad Habitat.

386 Outside designated sites, obligations for habitat and species conservation fall under the UK Biodiversity Action Plan that sets out a strategy for conservation of specific habitats and species. Under the UK BAP FMS covers three priority habitats, each covered by their own Habitat Action Plans. These are Purple moor grass and rush pastures (also known as Culm Grasslands), Fens and Reed-beds. The biological interest features differ to some extent between the PH and this is reflected in the action plans for each. For example, reed-beds are among the

[21] See www.defra.gov.uk/corporate/busplan/01psa.htm

most important habitats for birds in the UK so that variation in importance of reed-bed tends to vary with size of site and geographic coincidence with the range of resident or visiting bird species. Fens, are associated with a range of scarce plants and invertebrates that can vary greatly in their geographic restriction and ecological preferences. Thus the soligenous fens of the New Forest have a different character and associated biota than the topogenous base-poor fens of the Scottish Insh Marshes (Rodwell 1991; Fojt 1994). Purple moor grass and rush pastures also comprise a particular range of plant communities valued for their botanical as well as bird and invertebrate interest. Again, the largest known extents of these tend to have been designated although in many instances this has not guaranteed protection from threats to the condition of the site (UK biodiversity Steering Group 1995)

Environmental Impact Assessment

387 In 2002 the existing government regulations that required EIA to precede planned development and forestry were extended to cover "..the use of uncultivated land or semi-natural areas for intensive agricultural purposes."[22] These extended measures complete the implementation of the European EIA Directive but also contribute to the wider aims of promoting sustainable agriculture. See policy context for T1 – Q2 for further information on the policy background.

Threats to the FMS broad habitat – past and present

388 more detailed account is available in the UK Steering Group Report (1995) also see Fojt (1994). The following table summarises the main threats by the three constituent PH.

THREAT	Reed-beds	Purple moor grass and rush pasture	Fens
Fragmentation	✓	✓	✓
Drainage (p)	✓		✓
Water abstraction (p)	✓		✓
Catchment eutrophication	✓		✓
Sea level rise	✓		
Lack of management	✓		✓
Afforestation		✓	✓
Agricultural improvement		✓	
Overgrazing		✓	
Peat extraction (p)		✓	✓

p = threat more apparent in the past.

Key actions from each Priority Habitat Action Plan[23]

Purple moor grass and rush pastures

- Secure sympathetic management of at least 13,500 ha of purple moor grass and rush pasture by the year 2000, divided between the four countries as follows: Wales 4,000 ha, England 5,000 ha, Northern Ireland 4,000 ha and Scotland 500 ha.
- Initiate experimental attempts to re-create 500 ha of purple moor grass and rush pasture on land adjacent to, or nearby, existing sites, by the year 2005.

[22] See guidelines at http://www.defra.gov.uk/environ/eia/
[23] Actions taken from each plan at www.ukbap.org.uk/species.htm

- The aim is to secure favourable management for a minimum of 25% of this scarce habitat within the time frame. This is considered to be achievable within the likely resource allocations. Whilst the priority is to secure sympathetic management for the existing resource, where there are real opportunities to reverse fragmentation or to enlarge sites to make management viable, a small figure of 500 ha has been targeted.
- Take account of the conservation requirements of purple moor grass and rush pastures in developing and adjusting agri-environment schemes.
- Consider developing and tailoring new incentive schemes in Scotland and Northern Ireland to benefit purple moor grass and rush pasture, to enable the targets for management and re-creation to be met in these countries.
- Woodland expansion should not be encouraged on the more valuable areas, but some less ecologically valuable sites could be suitable for, for example, new native woodlands.
- Support local initiatives to find and map purple moor grass and rush pasture sites, and seek to protect and conserve them within development plans by 2000.

Reed-beds

- Identify and rehabilitate by the year 2000 the priority areas of existing reed-bed (targeting those of 2ha or more) and maintain this thereafter by active management.
- This target should provide habitat for 40 pairs of bitterns and provide optimum conditions for other reed-bed species and should be targeted primarily in the south-east.
- Create 1,200 ha of new reed-bed on land of low nature conservation interest by 2010.
- The creation of new reed-bed should be in blocks of at least 20 ha with priority for creation in areas near to existing habitat, and linking to this wherever possible. The target should provide habitat for an estimated 60 breeding pairs of bitterns boosting numbers to previous levels. It should be targeted in the south-east of Britain.
- Continue to notify nationally important sites as SSSI/ASSI by 1998.
- Continue the existing programme of designations of internationally important sites as SPA and/or Ramsar and SAC by 2004.
- Develop a clear national strategy for reed-bed creation and management by 1997, cross-relating to coastal management plans, ESAs, set-aside and mineral extraction plans, and ensuring that an effective level of monitoring and inventory is maintained.
- Consider modifying or expanding existing habitat schemes such as Wildlife Enhancement Schemes (WES), Tir Cymen, ESAs, Countryside Stewardship, Nitrate Sensitive Areas and Habitat Scheme to encourage and allow for the creation of 1,200 ha of reed-bed. Priority should be given also to reed-bed creation as a preferred condition of after-use for mineral extraction sites.
- Encourage the development of both sympathetic water abstraction, water level management policies and of appropriate coastal zone management plans in order to protect existing reed-beds.

Fens

- Identify priority fen sites in critical need of, and initiate, rehabilitation by the year 2005. All rich fen and other sites with rare communities should be considered.
- Ensure appropriate water quality and water quantity for the continued existence of all SSSI/ASSI fens by 2005.

- Review water quality and set standards for fens by year 1998 through the appropriate government agencies and departments. Aim to meet these targets by year 2010.
- Review water resource uses by 1998 and aim to meet these targets where they affect fens by year 2010.
- Consider modifying or expand existing habitat schemes and countryside schemes such as the Wildlife Enhancement Scheme (WES), Tir Cymen, ESAs, Countryside Stewardship and Nitrate Sensitive Areas to encourage the protection of fens from agricultural contaminants.
- Prepare and implement water level management plans.

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Jackson, D.L. (2000) Guidance on the interpretation of the Biodiversity Broad Habitat Classification: Definitions and relationships with other habitat classifications. JNCC report, no.307. JNCC, Peterborough.

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The UK Steering Group Report (1995). Vol 2. HMSO. London.

SCIENCE OUTPUTS

Location of increases in FMS.

389 There has been no work on this aspect to date.

Causes of increase in FMS

390 There has been no work on this aspect to date.

Change in extent

391 NTR There has been no work on this aspect to date.

Change in condition

392 There has been no work on this aspect to date.

Describe new stock and other stock elements in terms of NVC and hence, Priority Habitat (PH) assemblages, where possible.

Introduction

393 Significant increases in area of FMS were detected in three partitions of the GB sampling domain; 1) in Environmental Zone 1 (E&W), 2) across all E&W Environmental Zones and 3) at the GB level. This increase is potentially highly significant given long term losses of wetland in Britain since the1940s (Fojt 1990) and the importance of the habitat for a range of plant and animal species (UK Biodiversity Steering Group 1995). Objectives for the large-scale restoration and conservation of the Broad Habitat break down into specific targets for the three

constituent Priority Habitats. Hence a key question is to what extent the detected increase in FMS area includes net gains to plant communities referable to each PH. Addressing this question requires an analysis of botanical data for those plots within parcels that were lost or gained to FMS. However, because not all parcels were sampled only a partial indication of PH representation in the new stock can be gained.

394 The percentage of the total surveyed area of FMS recorded in 1998 that was attributable to parcels in which plots were located is shown in Table 11.1. Overall, 21% of the total 1998 surveyed area can be linked to plot data via the parent parcel and this differs somewhat between Environmental Zones. An additional caveat, when inferring changes in the botanical characteristics of the wider parcel from plot data, is that parcels are heterogeneous and there may be marked differences in the extent to which the species composition of a plot represents the overall character of the parcel.

Table 11.1 Proportion of the total surveyed area of FMS in 1998 located in parcels that coincided with vegetation plots.

Surveyed area '000ha	Zone	Surveyed area of parcels with vegetation plots '000ha	Proportion of surveyed area comprising parcels with plots
0.4	1	0.2	46.3
2.3	2	0.8	36.2
3.2	3	0.5	14.8
2.0	4	0.3	14.0
4.4	5	1.0	21.7
1.6	6	0.2	15.6

Methods

395 Repeat plots that were located in FMS in either 1990 or 1998 were selected. Only area plots (X and Y) were selected consistent with the exclusion of the linear Broad Habitats. Only data from the central 4m2 nest of each X plot was used so as to match dimensions between X and Y plots.

396 Botanical data were allocated to the units of the NVC (Rodwell 1992) using the MAVIS software. Although widely and justifiably recognised as a poor substitute for expert judgement (eg. Palmer 1991), we implemented an objective and hence repeatable rule for selecting a single best-fitting community unit. Each plot was assigned to the community unit that appeared most often in the list of top ten coefficients. If tied, then the top coefficient was chosen.

397 Links between Priority Habitats and NVC communities were based on the table in UK Biodiversity Steering Group report (1995) and expert judgement. NVC communities not assigned to PH were grouped under a series of other headings (see Annex 11.1).

Results

398 Allocations of all plots within parcels mapped as FMS in either 1990 or '98 are shown in Table 11.2. Immediately obvious is the scarcity of plots assigned to the three PHs. As a proportion of the total number of plots, Fen was represented in 3.2% of plots in '90 and 2.8% in '98, Reed-bed in 0.8% in '90 and 0.4% in '98 and Purple Moor Grass & Rush Pasture in 1.2% in '90 and 0.4% in '98.

399 Between 1990 and 1998, there was a change in ranking among the most common groups represented. While 'other' community units ranked first in both years, MG7 and MG1 moved from equal fourth to second and third respectively between '90 and '98. This is consistent with

the 'turnover' analyses of change in condition measures carried out for Module 1 where the only signal detected was a GB-level difference in Ellenberg fertility scores; significantly higher scores being associated with the new stock in 1998 compared to the stock lost between 1990 and '98.

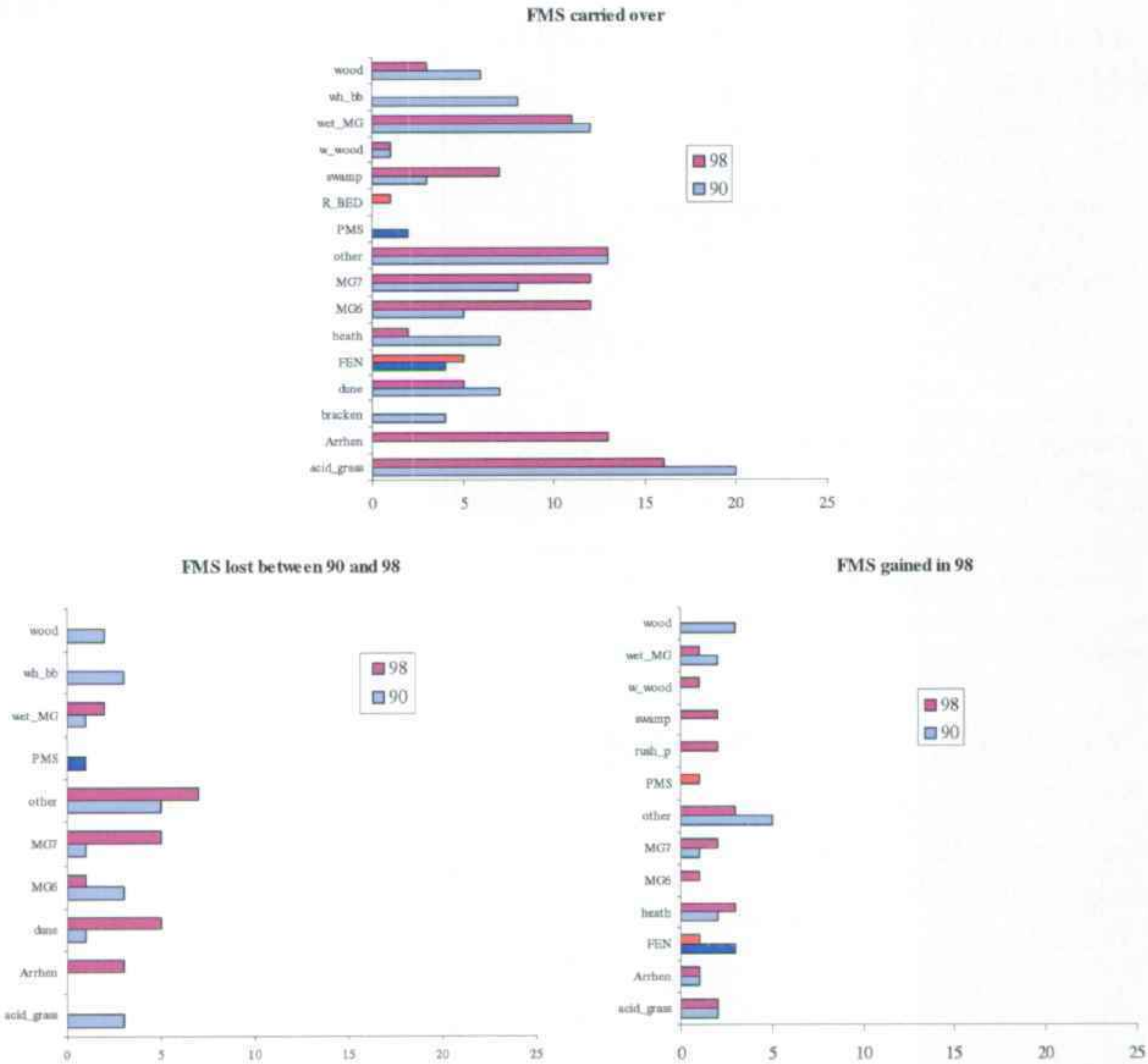
Table 11.2. Counts of repeat plots allocated to Priority Habitats and NVC community groups in 1990 and 1998. All plots were located in FMS in either '90 or '98. Priority Habitats are shaded.

Community groups and Priority Habitats	1990	1998
Other	**41**	**44**
Acid grassland	**35**	**28**
Wet MG	**27**	**22**
Arrhenatherum (MG1)	**22**	**30**
MG7	**22**	**39**
MG6	16	21
Dune	14	17
Wood	14	10
Heath	13	9
Wet heath & Blanket bog	12	1
Fen	8	7
Bracken	7	2
Swamp	6	16
Rush pasture	4	3
Purple M Grass & Rush Pasture (PMS)	3	1
Reed-bed	2	1
Wet woodland	1	3

400 The increase from 6 to 16 plots in the Swamp category hints at local increases in wetland vegetation but the breakdown by parcel change (see below) shows that this was largely a feature of plots in parcels that remained in FMS over the eight year period rather than newly recruited parcels.

401 When the total number of FMS plots are broken down into those associated with parcels newly recruited to FMS, those lost to other Broad Habitats and those that were mapped as FMS in both years (Figure 11.1), it is apparent that most plots were located in stable parcels. Sample sizes are very small for the plots that saw change from and to FMS and little can be confidently inferred from their patterns of change among NVC groups. However, those plots that were gained to FMS do not show any clear indication of shifts to wetter groups consistent with the GB level increase in area.

Figure 11.1 Priority Habitat and NVC allocation of repeat plots that were located in parcels mapped as FMS in either 1990 or 1998. Priority Habitats are shown in bright blue and bright red. X axis=number of repeat plots.



SUMMARY

- A number of aspects of the available botanical data mean that their analysis can give only a weak assessment of the consistency of botanical change with mapped Broad Habitat change.
- However, inspection of the overall pattern of allocation of repeat plots to NVC communities clearly shows that the three Priority Habitats are very scarce in the plot data and therefore likely to be poorly represented within mapped parcels of FMS in both 1990 and 1998.

- The small number of sample of pots located in parcels that were newly recruited to FMS in 1998 did not show any clear indication of having become colonised by wetland vegetation.
- Further assessment of the causes and significance of change in extent of FMS awaits analysis of the mapping code data where this is possible.

FURTHER WORK AND RECOMMENDED CHANGES TO CS METHODS

402 In consultation with EA, attempt an analysis of change in extent and condition of CS parcels and plots in flood plains known to have suffered from major recent flooding episodes ie. is there any coincidence between these areas and the detected increase in FMS?

403 Consider a partial or full re-survey of the Key Habitats waterside squares as part of the next CS.

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ANNEX 11.1

Representation of Priority Habitats and corresponding NVC units in the T4, Q11 Fen, Marsh & Swamp Broad Habitats

NVC community lists for each PH taken from the respective HAP[24]

	Fen, Marsh & Swamp		
NVC unit	Reed-beds	Purple moor grass & rush pasture	Fens
M4			✓
M5			✓
M6			✓
M7			✓
M8			✓
M9			✓
M10			✓
M11			✓
M12			✓
M13			✓
M14			✓
M21			✓
M22		✓	
M24		✓	
M26		✓	
M25		✓	
M27			✓
M28			✓
M29			✓
M30			✓
M31			✓
M32			✓
M33			✓
M34			✓
M35			✓
M36			✓
M37			✓
M38			✓
S1			
S2			
S3			
S4	✓		
S5			
S6			
S7			
S8			
S9			
S10			
S11			
S12			
S13			

[24] See action plan text at http://www.ukbap.org.uk/species.htm

S14	
S15	
S16	
S17	
S18	
S19	
S20	
S21	
S22	
S23	
S24	✓
S25	✓
S26	✓
S27	
S28	
W1	
W2	
W3	
W4	
W5	
W6	

NVC units recorded in plots located in parcels mapped as Fen, Marsh & Swamp Broad Habitat in either 1990 or 1998

Group	NVC
Acid grassland	U1
Acid grassland	U2
Acid grassland	U4
Acid grassland	U5
Acid grassland	U6
Acid grassland	U9
Arrhenatherum	MG1
Bracken	U20
Dune	SD10
Dune	SD17
Dune	SD6
Dune	SD7
Dune	SD8
Dune	SD9
Fen	M27
Fen	M6
Heath	H1
Heath	H10
Heath	H12
Heath	H4
Heath	H7
Heath	H8
Heath	H9
MG6	MG6
MG7	MG7
Other	A11
Other	CG3

Other	CG4
Other	CG6
Other	MC10
Other	MC11
Other	MC12
Other	MC8
Other	MC9
Other	OV19
Other	OV21
Other	OV23
Other	OV24
Other	OV25
Other	OV26
Other	OV27
Other	OV28
Other	OV9
Other	SM16
Purple M Grass & Rush Pasture	M25
Reed-bed	S26
Rush pasture	M23
Swamp	S18
Swamp	S19
Swamp	S28
Swamp	S5
Wet woodland	W4
Wet woodland	W6
Wet MG	MG10
Wet MG	MG11
Wet MG	MG13
Wet MG	MG9
Wet heath & Blanket bog	M15
Wet heath & Blanket bog	M16
Wet heath & Blanket bog	M17
Wet heath & Blanket bog	M2
Woodland	W10
Woodland	W16
Woodland	W23
Woodland	W25

Question 12: What were the environmental and management circumstances under which bracken invaded acid grassland, heath and bog habitats? Is the expansion likely to continue and what are the implications for agriculture and conservation of heaths and bogs?

INTERIM REPORT - ***Simon Smart***

DUE START DATE:

- June 2002

DUE FINISH DATE:

- October 2003

OVERALL PROGRESS

- Policy context completed.
- Techniques and tools developed and trialled for analysis of changes in mapping codes as a result of work on other FOCUS questions – see final report for Q1.
- Assessment of the representation of different NVC plant communities within plots that sub-sampled parcels in the bracken Broad Habitat.

DEFINITIONS

- The bracken Broad Habitat is defined as "..areas dominated by a continuous canopy cover of bracken *Pteridium aquilinum* at the height of the growing season. It does not include areas with scattered patches of bracken or areas of bracken which are less than 0.25ha which are included in the Broad Habitat type with which they are associated. It also does not include areas of bracken under forest or woodland canopy which are included in either the 'Broadleaved, mixed and yew woodland' or 'Coniferous woodland' Broad Habitat types." (Jackson 2000).
- 'Botanical characteristics' includes several plot level and parcel level attributes. We include condition measures as analysed in the CS2000 Module 1 report (Haines-Young et al 2000) and species cover codes used for describing mapped parcels of Broad Habitat. In addition plot level botanical data recorded in 1990 and 1998 can be assigned to community units of the National Vegetation Classification and hence, to the three Priority Habitats included in the Broad Habitat. Note that plot level data will only apply to a subset of the total parcels mapped while information on change in species mapping codes will often be unavailable for parcels mapped in an unenclosed, upland setting.
- 'Extent' refers to the area of surveyed land in each square attributable to a Broad Habitat.

POLICY CONTEXT STATEMENT

404 *The Policy Context Statement was drafted in May, and takes account of comments made by attendees at the May FOCUS Workshop.*

DEFRA Public Service Agreement (PSA)[25]

405 The PSA set out the aims and objectives of individual government departments. With the formation of DEFRA in 2001 a new set of PSA statements and targets were drawn up by the ministerial team. The PSA targets are coined as specific actions some of which form relevant policy background to this question. These are:

- PSA Target 6: Bring into favourable condition by 2010 95% of all nationally important wildlife sites compared to 60% of sites currently estimated to be in such condition.
- PSA Target 14: Open up public access to mountain, moor, heath and down and registered common land by the end of 2005.
- Remaining CSR 1998 target: Contribute to a more attractive and accessible countryside by increasing the area protected and enhanced under the major agri-environment schemes.

The policy context for changes in area of the Bracken Broad Habitat[26]

406 Historical and recent changes in the extent of Bracken in GB have occurred against a shifting climate of opinion regarding the positive and negative values of the BH. During the 1980s the perceived rapid rate of expansion was seen to require aggressive action (Taylor, 1995). At one point even biological control via the irreversible introduction of alien moth species was seriously considered (Lawton 1990). At that time the negative impacts of Bracken expansion included health concerns for both humans and grazing animals, loss of high conservation value semi-natural habitats including dwarf shrub heath and acid grassland, and reduction in the economic value of moorland and grasslands. The apparent difficulty in restoring semi-natural habitat with increasing time after invasion also highlighted the need for expansion to be checked (Marrs et al 1998).

407 Through the nineties, the overwhelmingly negative view of Bracken was balanced by identification of a limited but specific range of positive wildlife values. Pakeman & Marrs (1992) reviewed the conservation value of Bracken-dominated communities in the UK. They marshalled evidence for the role of Bracken stands on more circum-neutral soils as a replacement woodland canopy beneath which a diverse vernal flora was often preserved including abundant *Viola* spp., which are food plants for several scarce butterfly species. Bracken stands can also provide valuable breeding bird habitat being locally favoured over other vegetation types by for example, whinchat and willow warbler (Pakeman & Marrs 1992). On balance however, fewer upland bird species preferred Bracken habitat than upland grasslands and dwarf shrub heath hence replacement of these habitats by Bracken would lead to a net loss of bird diversity including nationally scarce species such as hen harrier, merlin, greenshank and twite (Pakeman & Marrs 1992). Bracken encroachment into heathland, especially in lowland Britain, was also likely to reduce habitat quality for reptiles. Weighing up the positive and negative values of Bracken, Pakeman & Marrs (1992) concluded that "On balance, allowing the continued spread of Bracken will damage more communities and affect

[25] See www.defra.gov.uk/corporate/busplan/01psa.htm

[26] Defined as "areas dominated by a continuous canopy cover of bracken Pteridium aquilinum at the height of the growing season." Does not include bracken in patches <0.25ha or bracken under woodland canopies (Jackson 2000).

more species than control aimed at halting the spread of Bracken or removing it from the landscape."

408 At the present time, conservation and land-management policies to some extent reflect these earlier concerns but the gravity of the Bracken problem, as perceived in the eighties, has not led to the concerted assault on its spread that might have been expected. This is partly because Bracken actually declined in extent between 1984 and 1990 (Pakeman et al 1996), a change that was attributed, at least in part, to the success of control measures during the period. In addition, the census survey of national parks in England and Wales also showed a decrease in dense Bracken cover in the late-seventies to mid-eighties (Countryside Commission 1991). Concerns over the effect of Bracken on human and animal health remain but while evidence for impacts on livestock is clear, proving links to human disease suffers from ongoing methodological problems (Wilson, Donaldson & Sepai, 1998; Taylor 1995).

409 Notwithstanding the recent declines in Bracken extent, current policy reflects the fact that net changes can conceal marked turnover so that Bracken encroachment still poses a serious threat to scarce priority habitats such as lowland and upland heath (Pakeman et al 1996). Since the agri-environment schemes provide one of the main mechanisms for delivering BAP objectives for heathland habitats, it is therefore not surprising that Bracken control measures feature prominently in these schemes. For example, Bracken spraying is funded in eleven of the twenty two English ESA schemes and in the heathland and coastal habitat tiers of the Countryside Stewardship Scheme[27].

410 Although the Bracken Broad Habitat has no published statement or action plan it is valued in those specific situations where the canopy is associated with abundant *Viola* spp. and where Bracken stands coincide with the recent distributions of four nationally rare butterfly species Heath Fritillary (*Melicta athalia*), Pearl-Bordered (*Boloria euphrosyne*), Small Pearl-Bordered (*Boloria selene*) and High Brown (*Argynnis adippe*) (Warren & Oates 1995). Hence, sympathetic management of Bracken mosaics is highlighted in the SAPs for all these species except Heath Fritillary, which depends on Common Cow Wheat (*Melampyrum pratense*) in association with Bracken in a very restricted range of sites on Exmoor (Warren & Oates 1995; UK Steering Group 1995). The particular importance of Bracken for the High Brown has been highlighted in its Species Action Plan. This reported that 80% of extant breeding colonies were associated with Bracken-dominated habitats (Barnett & Warren 1995).

Summary of published results from CS2000

411 The CS2000 report showed that no statistically significant change in Bracken area had occurred in any Environmental Zone or country combination. However, considerable turnover did occur with gains to the Bracken Broad Habitat from Dwarf Shrub Heath, Acid Grassland and Broadleaved woodland and, in other areas, losses from Bracken to the same three Broad Habitats (Haines-Young et al 2000).

412 Although not significant, the largest net gain in Bracken area was seen in Environmental Zone 3. However, the 95% confidence intervals (-13,000ha to +48,000ha) for the average increase of 18,000ha illustrate the considerable uncertainty that surrounds the estimate.

413 Analyses of vegetation change for plots located in the Bracken Broad Habitat showed that stability largely prevailed. An increase in Ellenberg light score within bracken stands characterised by upland woodland plants implied more open conditions (CS2000 web-site data). The environmental and ecological details of this change will be explored as part of this FOCUS question.

[27] See the England Rural Development Programme links at www.defra.gov.uk.

Approach to data analysis

414 The three sub questions highlight ways forward for follow-up analysis of CS change data. Firstly, identification of the environmental and management circumstances surrounding new bracken encroachment need to take account of the known situations in which bracken has historically increased unchecked. This would point to upland and lowland semi-natural habitats and common land particularly in lowland Britain. Additionally, new bracken encroachment might be less expected in National Park, ESA and Stewardship agreement land. However, evaluating the results of these spatial overlays will need to take careful account of the fact that land within an ESA may not necessarily be under agreement. Establishing the designation status of parcels in which bracken expanded will help to address the second question regarding the likelihood of continuing spread.

415 The third question focuses on the significance of bracken encroachment for agriculture and conservation. These issues can be addressed in two main ways. First of all, gains to bracken can be evaluated in terms of the BAP objectives for the habitats that lost extent such as Broadleaved woodland and Dwarf Shrub Heath. Secondly, the fine detail of these changes can be assessed by examination of associated changes in plant species composition for the subset of parcels in which repeat plots were located. As with the questions relating to changes in Dwarf Shrub Heath and Fen, Marsh & Swamp we will convey change among plots in terms of the communities of the NVC.

416 In addition, the significance of bracken encroachment and persistence on linear features has rarely been addressed. Issues include the effect of bracken increase on the diversity of existing plant communities (eg. Smart et al, in press) and the extent to which linear futures operate as corridors or safe havens for bracken in spite of control measures implemented on larger areas of unenclosed land. CS vegetation plot data will be used to quantify recent changes in Bracken abundance on the linear network.

417 Lastly, although the importance of bracken for fritillary butterflies focuses on localised extant populations, the relevant SAPs include actions relating to the favourable management of bracken mosaics on sites where opportunities for recolonisation exist. We can contribute to this issue by highlighting the extent to which existing and newly recruited bracken falls into either W25 *Pteridium aquilinum – Rubus fruticosus* under-scrub or the other major bracken community U20 *Pteridium aquilinum – Galium saxatile* stands. The distinction is significant since W25 is the major locus for fritillary populations while U20, in which Violets are rare, is rarely used (Warren & Oates 1995). This analysis will differentiate between areas inside and outside of the known range of the butterflies concerned.

418 ISSUE: Can we locate GIS coverage for common land across GB?

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SCIENCE OUTPUTS

Assessment of the representation of different NVC communities

Introduction

419 In their assessment of the wildlife value of bracken dominated habitats Pakeman & Marrs (1992) concluded that "On balance, allowing the continued spread of Bracken will damage more communities and affect more species than control aimed at halting the spread of Bracken or removing it from the landscape." One of the few positive benefits of bracken habitats to have been recognised is its value as breeding and feeding habitat for four nationally rare species of fritillary butterfly. Three of these feed on *Viola* spp and these food plants are known to be more abundant in bracken communities referable to the more neutral W25 *Pteridium aquilinum – Rubus fruticosus* under-scrub rather than the other major bracken community typical of more acidic soils, U20 *Pteridium aquilinum – Galium saxatile* community (Warren & Oates 1995).

420 Our aim was to determine the likely representation of these and other NVC community types in the CS plots from bracken stands in the wider countryside. Overlaying this information with the known ranges of the four scarce butterflies should, if sample sizes are sufficient, contribute to an assessment of the likely abundance of the different bracken communities within these regions.

Methods

421 Plots that were located in the bracken Broad Habitat in either 1990 or 1998 were selected. Only area plots (X and Y) were selected, linear plots will be dealt with separately. Only data from the central 4m2 nest of each X plot was used so as to match dimensions between X and Y plots.

422 Botanical data were allocated to the units of the NVC (Rodwell 1992) using the MAVIS software. Although widely and justifiably recognised as a poor substitute for expert judgement (eg. Palmer 1991), we implemented an objective and hence repeatable rule for selecting a single

best-fitting community unit. Each plot was assigned to the community unit that appeared most often in the list of top ten coefficients. If tied, then the top coefficient was chosen.

Results

423 Initial results (Figure 12.1) show that the two major bracken communities are uncommon in CS plots. In fact W25 is only represented in the 1990 data. Also considerable floristic change seems to have taken place. The two fertile mesotrophic grassland communities MG1 and MG7 gained plots as did the group of swamp communities while acid grasslands, *Nardus* grassland (U5), *Molinia* (M25), woodland communities all saw reductions. The significance of these changes and their relationship with changes in the abundance of bracken will be pursued as part of the ongoing research into this FOCUS question.

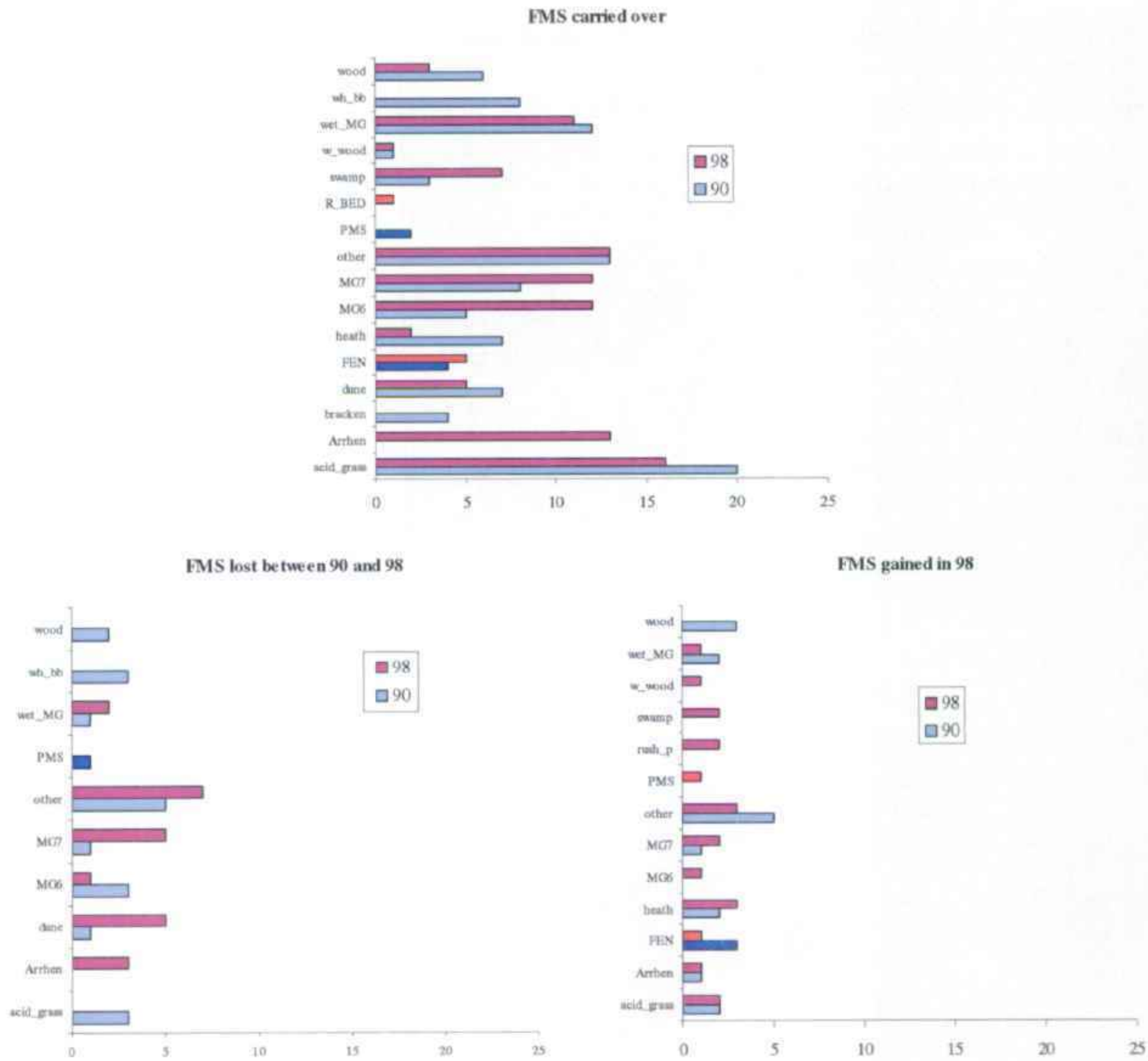
SUMMARY

424 The two core NVC bracken communities appeared to be uncommon in plots located within parcels allocated to the bracken Broad Habitat in both 1990 and 1998.

425 The improved mesotrophic grassland communities MG1, MG7 and MG9-11 were the most common matches in 1998.

426 The results should be treated cautiously because of known problems with the use of matching software to generate the best fit to the NVC.

Figure 12.1 NVC community groups represented in CS repeat plots located in parcels that were bracken Broad Habitat in either 1990 or 1998.



FURTHER WORK AND RECOMMENDED CHANGES TO CS METHODS

427 It is too early in the program of research for this topic question to make any suggestions.

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Question 13: What are the possible causes of more overgrown streamside vegetation? What are the implications for other species groups and associated freshwater habitats?

INTERIM REPORT - ***John Watkins & Simon Smart***

DUE START DATE:

- August 2002

DUE FINISH DATE:

- November 2003

OVERALL PROGRESS

- Contacts are being established to allow discussion between departments and agencies of the issues raise by this question. This has been identified as an important aspect of this question as successional change in streamsides has conflicting consequences for management policies.
- Initial investigation of the River Habitats Survey data has clarified analyses that may be possible to clarify the change identified by CS2000.

DEFINITIONS

- 'River Habitats Survey' – This was included in the Countryside Survey for the first time in 1998. It is a standard assessment procedure for evaluating the physical structure of the watercourse.
- 'watercourse types' – these may be defined by categorisation of the data or taken from existing definitions such those in the River Habitats Survey.
- 'vegetation groups' – these may be taken from the exist Countryside Vegetation Systems used in CS2000 or may be specifically defined for the question.

POLICY CONTEXT STATEMENT

428 *The following policy context statement has been drafted and presented at the May 2002 workshop. Input from relevant Department policy advisers has yet to be made.*

429 The changes in streamside vegetation were among the strongest shown by any of the vegetation plots recorded in CS2000[1]. The signal was most marked in the lowlands of England, Wales and Scotland. Here, the results were consistent with successional changes toward more extensive cover of woody vegetation along streamsides. Species such as hawthorne (*Crataegus monogyna*) and bramble (*Rubus fruticosus* agg.) showed marked increases along streamsides since the 1990 survey. These reported changes may be compared with the results from analyses of the CS1990 vegetation during the ECOFACT programme[2]. These showed that for a range of indicator species for unimproved grassland (supplied by English Nature), acidic and mesotrophic grassland indicators species were recorded in a greater proportion of streamside plots than any other plot type. It was concluded that streamsides formed important refugia for

these indicator species in lowlands as their occurrence was lower in the wider countryside in the lowlands when compared to results in the uplands. Over the same period from 1990 to 1998, changes in the biological condition of streams was measured by CS2000 using and index system called the *Biological Monitoring Working Party* (BMWP) score[3] and the RIVPACS software[4]. When grades of site quality produced by this system are compared between 1990 and 1998, it was evident that there had been a marked improvement in the overall biological condition of sites over the eight year period. The improvement was apparent across the country in all regions and supports finding of an earlier national study carried out between 1990 and 1995[5]. The Environment Agency report an improvement in the chemical grade of rivers in England and Wales and sharp decrease in pollutant load over the same period[6]. As well as these changes, the management of streamsides asmeans buffer strips has been researched[7] as a means to reduce sediment, fertiliser and pesticide inputs. Mature buffer strips may provide a valuable habitat for sustaining and allowing migration of freshwater and terrestrial wildlife.

430 The perceived ecological gains from development of more woody riparian buffer strips may conflict with the lost of habitat for plant species that are being threatened in the wider countryside and for whom streamside have formed an important refuge. There is a need to define habitat and conservation objective in the riparian zone so that appropriate management regimes can be developed. These may need to balance different ecological functions of the riparian zone in what is clearly a dynamic period for this habitat.

SCIENCE OUTPUTS

A preliminary investigation of data will be undertaken before any particular line of analysis is chosen. This will include consideration of River Habitat Survey data.

431 It has been noted that the poorest vegetation condition measures recorded by CS2000 may coincide with the best River Habitats Survey (RHS) score. This would demonstrate a clear conflict between the two assessment systems. The 50 metre check points of the RHS transect would be useful additional data for comparison with the streamside plot and land cover information from CS2000. There may also be use for the adjacent land cover information collected in the RHS.

Depending on (2) above, further exploration of the streamside vegetation may be used to categorise areas of the data for analysis, e.g. defining different watercourse types or vegetation groups. This will include some analysis of spatial data such as fencing off of streamsides.

432 Additional information from the RHS transect check points may be integrated with the spatial analysis of a riparian buffer strip. These spatial buffers will be interrogated for CS2000 land cover and management codes but may also be populated by the adjacency information from the RHS land cover data. The exact approach here has yet to be determined.

Analyses will then partition the changes occurring within different areas of the data to focus on the causes of specific changes. These analyses will explore confounding effects such as additional shading and canopy structure versus additional nutrient input signals. This will include analyses by species percentage cover to explore evidence of succession change.

433 Not yet started

The importance of changes identified by the previous analyses will be assessed in consultation with freshwater, bird and mammal ecologists and linked to current issues in streamside management.

434 Not yet started

Will involve further integration and interpretation of some aspect of the spatial and freshwater data sets to enable partitioning of effects. Some development of specific analyses may be required to take *into account species strategies when testing change hypotheses.*

435 It seems likely that having categorised changes and identified corresponding attributes of the riparian zone and any associated spatial buffer that a mixed general linear model will be constructed to identify specific significant effects and possible interactions between effects. The construct of such models will start when the structure of the analytical data set has been constructed.

SUMMARY

436 This question has recently started and is still in preliminary stages of analysis. However, in is clear from discussions and feedback at the FOCUS workshop that the issues raise cross organisational boundaries. By integrated analysis of the CS2000 and RHS data a better understanding of relationships in the riparian zone should be possible but this will require new spatial integration of the data sets to take place.

FURTHER WORK AND RECOMMENDED CHANGES TO CS METHODS

437 During the 1998 survey, the River Habitats Survey and CS survey were carried out by different survey teams. If better information is to be gathered on possibly conflicting management in the riparian zone, the assessments may need to be carried out in parallel or by one team.

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Question 14: What were the characteristics and locations of the new ponds recorded in 1998? How do the 1996 figures on pond numbers and condition relate to changes in 1998?

INTERIM REPORT - ***John Watkins & Rick Stuart***

DUE START DATE:

- October 2002

DUE FINISH DATE:

- January 2003

OVERALL PROGRESS

- [to be completed].

DEFINITIONS

- 'Pond – defined as a body of standing water 0.25 ha to 3 ha in area, which usually holds water for at least four months of the year.
- 'Lowland' – Is defined in CS as Environmental Zones 1, 2 and 4 and excludes garden and farmyard ponds. For the Lowland Pond Survey, 'Lowland Britain' was defined as the area of the ITE pastural or arable landscape types. This area covered about 64% of the land in Great Britain.

POLICY CONTEXT STATEMENT

438 *The following policy context statement has been drafted and presented at the May 2002 workshop. Input from relevant Department policy advisers has yet to be made.*

439 As part of the CS2000 programme, a detailed analysis of changes in number of all standing water bodies surveyed between 1990 and 1998 was carried out1. These analyses indicated that an over all increase in numbers was concentrated on water bodies of less than 20 x 20 m in area in the westerly lowlands of England and Wales. Changes in these small water bodies or ponds were reported as an update to the Quality of Life Counts indicators2. These results showed that the losses of lowland ponds that occurred in the 1980s had been reversed by the late 1990s. Specific analysis of changes in lowland ponds used a definition of ponds introduced in 1996 , which included seasonal ponds. This definition was used in a the Lowland Pond Survey in 19963, which used a restricted sub-sample of 150 of the 1 km x 1 km CS2000 sample squares. The direct comparison of these squares for 1990, 1996 and 1998 showed a net increase of 6% for this period with a losses occurring between 1990 and 1996 being reversed by increases between 1996 and 1998.

440 Further analysis is required to elucidate type and location on new ponds and whether the gain in ponds masks a net change in the ecological character of ponds. This should inform questions of

whether creation new ponds can compensate for earlier losses in ponds and clarify the use of the Quality of Life Counts indicators.

SCIENCE OUTPUTS

Preliminary work will produce initial categories for ponds in survey squares.

441 Not yet started

The CS2000 data for changes in pond will be further analysed to allocate the type of new pond occurring in survey squares to particular categories. These analyses will incorporate the 1996 Lowland Ponds Survey data.

442 Not yet started

The results for different categories of pond will be interpreted in a national context in consultation with pond ecologists.

443 Not yet started

The work will involve revisiting each record for pond change and allocating to change categories. The categories may be revised as the data is processed.

444 Not yet started

SUMMARY

445 Data collation and analysis has not yet started for this question . Comments from the FOCUS workshop indicated the importance of the additional information collected in the 1996 Lowland Pond Survey that is not collected as part of the CS surveys. This information is will only clarify changes for lowland pond. The necessary data will be sought from The Ponds Conservation Trust: Policy & Research c/o Oxford Brookes University.

FURTHER WORK AND RECOMMENDED CHANGES TO CS METHODS

446 The information collected as part of the Lowland Pond Survey is more detailed than that collected by CS surveys. However, to include such detailed information during CS surveys would require specialist surveyors. Better information of change is ponds may require a parallel survey in future though it would need to be more extensive than the Lowland Pond Survey to provide true national estimates.

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Question 17: How are agri-environment schemes represented in the CS2000 field survey sample? What evidence is there that agri-environment schemes have contributed to the changes in the Broad Habitats and landscape features recorded in CS2000?

DRAFT FINAL REPORT - *Dr Lisa Norton & Lindsay Maskell*

DUE START DATE:

- March 2002

DUE FINISH DATE:

- June 2002

OVERALL PROGRESS

- The work has been completed as far as possible given the limited provision of data sets by relevant government bodies.

DEFINITIONS

- Agri-environment schemes are schemes whereby farmers receive government support for enhancing/maintaining the farm environment for landscape, wildlife and historical interest. Details of particular schemes looked at are given below.
- Broad Habitats are the 21 habitat types as used in CS2000, of the 28 Broad Habitats listed in the UK Biodiversity Action Plan.

POLICY CONTEXT STATEMENT

447 *The following Policy Context Statement was drafted in May, and takes account of comments made by attendees at the May FOCUS workshop:*

448 Agri-environment schemes in the UK are government-funded schemes designed to maintain and enhance the landscape, wildlife and historical interest of areas of the countryside. The first of these schemes to be introduced was the Environmentally Sensitive Areas (ESA) Scheme, which was established in 1987 under the 1986 Agriculture act and originally designated 5 areas in England as ESA's (extending to 22 areas by 1993). Under this scheme farmers and landowners receive annual payments for entering into 10-year management agreements that require them to manage their land according to a set of management prescriptions. The Countryside Stewardship Scheme (CSS), which operates outside the ESA's, was open for applications in 1991 and is the governments main scheme for the wider countryside, under which farmers are paid grants to conserve landscapes and features. Each county has specific targets for landscape features that are important within their area.

449 Other schemes which have been introduced subsequently include the Organic Aid Scheme which ran from 1996-1999 when it was replaced by the Organic Farming Scheme (OFS), the

Farm Woodland Premium Scheme (FWPS) which begun in 1992, the Habitat Scheme which ran from 1994 until it was incorporated into Countryside Stewardship in 2000, the Moorland Scheme which began in 1995 and was later incorporated into Countryside Stewardship, the Nitrate Sensitive Areas Scheme which ran between 1996 and 1998 and the very small scale Countryside Access Scheme which ran between 1994 and 1997 before becoming part of Countryside Stewardship. Since the advent of the England Rural Development Plan (EDRP) in 2000, many previously existing schemes have been re-organised and new ones implemented, however, this question concerns only the schemes described above which were operating during the period 1990-1998.

450 Whilst the schemes described above operated in England, as a result of devolution, schemes operating in Wales and Scotland differed slightly. As well as the above, specific to Wales was Tir Cymen, which opened in Oct 1992 and closed to applications in April 1998 (Tir Gofal, its successor began in April 1999 and will ultimately incorporate many of its predecessors). In Scotland as well as the above the Countryside Premium Scheme ran during the period 1990-1998.

451 The agri-environment schemes are important to the UK government in terms of their contribution towards achieving the objectives of the ERDP and the UK Biodiversity Action Plan (HMSO 1994), which identifies agri-environment measures as one of the key instruments to be used to achieve its goals. For the ERDP, the EU requires information about the nature and extent of scheme uptake, as well as an evaluation of their impact. The evaluation will need to assess the outcomes of the programmes in relation to stated objectives and targets in the ERDP. Biodiversity goals are to be achieved through both the Environmentally Sensitive Areas Scheme (ESA's) and the Countryside Stewardship Scheme (CSS). The extent to which biodiversity has been maintained or enhanced by agri-environmental measures through the protection of species on farmland, the conservation of high nature-value habitats and the enhancement of environmental infrastructure will be considered at both national and regional levels.

452 In addition, a review of Agri-environment schemes is currently being carried out by DEFRA (Department for Environment, Food and Rural Affairs) as a result of concerns about the complexity of the current system. The results from this review will feed into the mid-term review for the ERDP with the main focus on the ESA's and CSS but the review will also consider the FWPS, OFS, and HFA. The scope of this review is broad, it will consider the performance of existing schemes (including methods for monitoring performance), scheme objectives, relationship to other schemes and policy instruments and the basis of payments and will provide a follow up to Hills Task Force & Policy Commission.

453 This question investigates the extent to which Countryside Survey data can be used to explore the impacts of agri-environment schemes on the wider countryside. The starting point is to examine the representation of agri-environment schemes in Countryside Survey samples. Countryside Survey data provides an ideal control dataset representing the 'wider picture' of the British countryside and providing a context with which to compare to land under agreement. The 1km survey squares were randomly chosen and detailed information for landscape features such as hedges, stonewalls, land-cover and the condition of vegetation collected. The same features and habitats are being monitored to assess the effectiveness of agri-environment schemes, and there is a desire to use the Countryside Survey data as reference data with which to compare the monitoring of agri-environment schemes. Although some monitoring of agri-environment schemes has attempted to compare agreement land with non-agreement land there are problems with this. For example, sampling strategies for the ESA monitoring schemes were set up before the land was entered into agreement and subsequently some of the land originally not in agreement came under agreement thereby rendering the comparison invalid. There may also be fundamental differences between agreement and non-

agreement land relating to the farmer's choice to enter the scheme. The recent monitoring of the Countryside Stewardship scheme characterised the ecological quality of land within the scheme by using the same methods as CS and comparing subsequent results in terms of Broad and Priority habitats (CEH 2001). If CS2000 data is to be used as a control data set, it is useful to know to what extent the agri-environment schemes are represented within the CS squares.

454 If CS data can provide valuable information on agri-environmental schemes both as a control data set and as a monitoring tool to assess the performance of land under agreement it will provide a valuable tool for policy makers.

Agri-environment schemes 1990-1998

455 The England Rural Development Plan (EDRP) approved in October 2000 incorporates a range of agri-environment schemes, a number of which pre-date its introduction. Whilst this question concentrates on those schemes which were in place during the period 1990-1998, it is worth observing that the CS2000 database may provide ideal baseline data for land entering into agri-environment schemes which started up shortly after 1998 (e.g. Energy Crops Scheme, Hill Farm Allowance Scheme in England and the Rural Stewardship scheme in Scotland) as part of the EDRP. Table 17.1 shows which agri-environment schemes were in place during the period 1990-1998 and the availability (for our purposes) of spatial data for those schemes.

456 A number of the schemes listed above were on a small scale and included a relatively small area of land and are therefore not appropriate for inclusion in a study of this kind. Spatial data on all the above schemes were sought from The Department of the Environment Food and Rural Affairs (DEFRA), The Scottish Executive Environment and Rural Affairs Department (SEERAD) the Countryside Council for Wales (CCW) and the Welsh Executive.

457 The nature of the data provided (or not provided) has had a significant impact on the progress made under this question. SEERAD were unable to provide any agri-environment scheme data due to the 'significant effort' required and the fact that they 'do not have the resources to meet this type of request' now or in the foreseeable future. DEFRA provided access to data that included spatial data and vegetation data on the two largest schemes operating in England (ESA and CSS). Spatial data are not held for land in any of the other agri-environment schemes running during the period 1990-1998. In Wales, data on agri-environment schemes is held by both CCW (Countryside Council for Wales) and the Welsh Executive. CCW hold the data for the exclusively Welsh schemes Tir Gofal and Tir Cymen. Tir Gofal began after 1998 and is therefore not relevant to the period of time being looked at under this question. Data for the Tir Cymen scheme consisted of point data (with the exception of open access agreement maps) rather than spatial coverage data and was therefore not useful in the context of this question. Welsh ESA data was provided by the Welsh Executive, but has taken some time to acquire (only arriving in mid-September), thereby limiting the amount of analysis that has been done on it.

Table 17.1 Agri-environment schemes in place 1990-1998 and availability of spatial data for this study.

Name of Scheme	Country of operation	Start date	End date	Availability of spatial data
Countryside Stewardship Scheme	ENG & SCO	1991	Ongoing	ENG – ok SCO - None
Environmentally Sensitive Area Scheme	ENG, SCO & WAL	1986	Ongoing	ENG – ok (no dates) SCO – None WAL - ok
Organic Aid Scheme	ENG, SCO & WAL	1996	1999	ENG, SCO & WAL - None
Farm Woodland Premium Scheme	ENG, SCO & WAL	1992	Ongoing	ENG, SCO & WAL - None
Tir Cymen	WAL	1992	1998	WAL - None
Countryside Premium Scheme	SCO	1997	2000	SCO - None
Moorland Scheme	ENG, SCO & WAL	1995	Will be incorporated into stewardship 2003	ENG, SCO & WAL - None
Habitat Scheme	ENG	1994	Incorporated into stewardship 2000	ENG, SCO & WAL - None
Nitrate Sensitive Areas Scheme	ENG	1996	1998	ENG, SCO & WAL - None
Countryside Access Scheme	ENG	1994	Incorporated into stewardship 1997	ENG, SCO & WAL - None

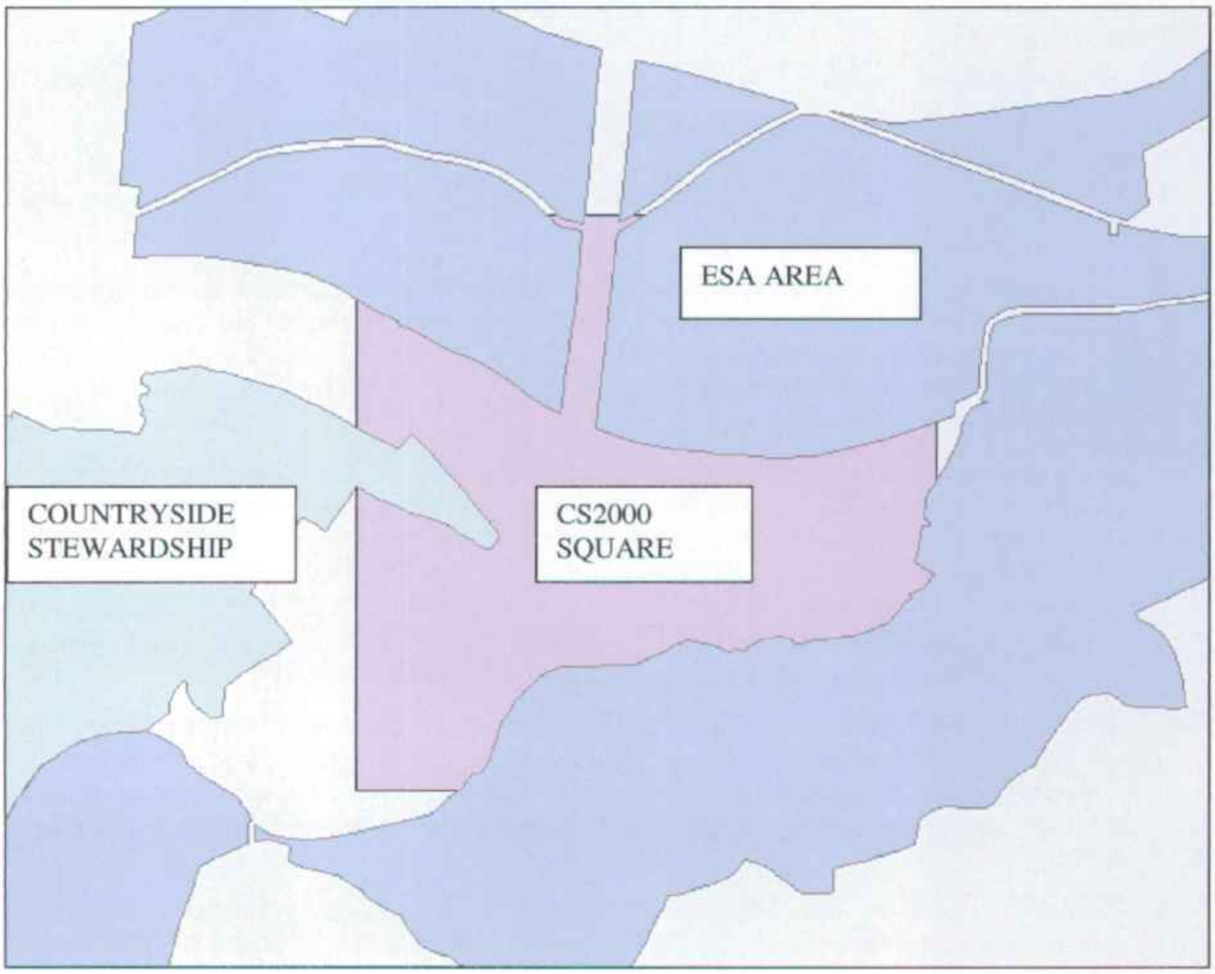
Coverage of agri-environment schemes within the CS dataset

458 Whilst all the schemes listed in the table above were operating during the period 1990-1998, for a variety of reasons, it has not been possible to access spatial data for the majority of the schemes. However, many of the schemes were on a limited scale and therefore unlikely to be represented within the Countryside Survey dataset. However, it has been possible to access the

relevant spatial data for the most extensive of the agri-environmental schemes in England and Wales, i.e. CSS and ESA in England and ESA in Wales.

459 Once data was received from DEFRA and the Welsh Executive, the spatial coverage's of the schemes across England and Wales were overlaid on the spatial coverage of CS squares. Figure 17.1 gives an example of an overlay of spatial coverage's of ESA and CSS schemes onto a CS square. In the case presented (square no 56 in Dorset) and in 5 other squares, land included in both ESA and CSS fell within the 1km survey square). Once the two sets of spatial data were overlaid it was possible to calculate the area of land within each square, which was part of either an ESA or CSS scheme, and to look more closely at the data collected for Countryside Survey in that parcel of land.

Figure 17.1. CS2000 square no 56 (includes land in both CSS and ESA)



460 Table 17.2 shows, 1) the numbers of Countryside Survey squares in which there was/is land under agreement as part of an agri-environment scheme, 2) whether that was the case during the

1990 and 1998 surveys and 3) what proportion that represents of the total number of squares in Countryside Survey in each country concerned. The number of CS plots recorded within the land under agreement is also given where possible.

Table 17.2 Coverage of CS squares by land in agri-environment schemes (CSS –Countryside Stewardship Scheme, ESA – Environmentally Sensitive Area scheme).

	CSS	ESA - England	ESA -Wales
No of CS squares surveyed in 1998 with agreement land	92	41	12
No of CS squares surveyed in 1990 & 1998 with agreement land (a)	79	34	7
(a) With agreements entered into between 1990 & 1998 (b)	47	No data	4
Proportion of all CS squares in England or Wales (b)	15%	No data	6.25%
No of CS plots in 1998 squares with agreements entered into between 1990 & 1998	318	No data	May be done at a later date

461 For the Countryside Stewardship scheme, of the 47 squares with agreement land during the period 1990-1998 which were included in both CS1990 and CS2000, 38% of squares had less than 10% of land under agreement and 79% had less than 50% of land under agreement. The area of CSS agreement land (England) included in CS 1990 & 2000 was 153,600ha or approximately 5% of the CS sample.

462 Due to lack of information on dates of scheme entry, it is impossible to be precise about the amount of land under ESA agreement (in England) between the period of the last two Countryside Surveys, which was in CS squares, as the data probably includes land entered into agreement post 1998. However, the data provided indicates that the area of the squares surveyed for CS2000, which is under ESA agreement is around 34km^2 at the present time indicating that the figure for the period between the last two Countryside Surveys may be of a similar magnitude to that which was under CSS agreement, i.e. <10%.

463 Welsh ESA data does include dates of entry to the scheme and it is therefore possible to work out the amount of land under ESA agreement during the period 1990-1998, i.e. 2.8%. However, it should be made clear that of the 4 squares with land in agreement and in both surveys, 2 of them had land entered into agreement in late 1997, and without that land the figure would be only 0.5%.

464 The lack of significant quantities of data from CS on land in any one agri-environment scheme resulted in the suggestion that it may be advisable to aggregate data from all schemes for which we have appropriate data in order to carry out an analysis of the way in which the schemes impact on the landscape. However, the proportion of land in agri-environment schemes, which is covered by the last two Countryside Surveys, for which we have spatial data and dates of scheme entry, is currently very small. The CSS and ESA schemes cover significant areas of GB, in 1998 the total area covered by both schemes in England was approximately 523,000ha.

The percentage of the land under agreement in agri-environment schemes covered by the CS data is around 0.2% where CS represents a sample of approximately 0.2% of GB.

SCIENCE OUTPUTS

CS measures relevant to features targeted in agri-environment schemes.

465 The agri-environment schemes, which were first implemented in the late 1980's, were a way of ensuring protection and enhancement of the GB landscape by rewarding farmers for beneficial environmental management practices. This question seeks to discover whether it is possible to measure the success of the agri-environment schemes using CS data. The results given above indicate that the area of land in agreement (for which we have data) covered by CS is currently relatively small and therefore to attempt to use that data to draw detailed conclusions about impacts of the schemes on certain aspects of the countryside would be unwise. However, it is possible to look in general at impacts on certain features and to explore possibilities given bigger and better datasets on the agri-environment schemes.

466 The schemes for which we have received data differ in terms of their localities, with English ESA schemes concentrated in 22 areas of particularly high landscape, wildlife or historic value covering some 10% of agricultural land, and Countryside Stewardship covering all areas outside of ESA's. Both schemes are entered into for a 10-year duration and aim to improve the natural beauty and diversity of the countryside. Unlike CSS, ESA schemes may be entered into at one or more tiers of entry with each tier requiring different agricultural practices to be followed. Although, we have access to some information on tier entry level for English and Welsh ESA's, sample sizes are too small at this stage to allow a closer look at differential impacts of tier management.

467 The kinds of landscape benefits which both the CSS and ESA schemes aim at, which may be picked up within the Countryside Survey dataset include; changes in hedges (both quantity and quality), changes in habitat quality (increased diversity) and changes in Broad Habitats (e.g. conversion of arable to grassland on land under agreement).

Are changes in specific features of agri-environment schemes detectable using CS data?

Hedges

468 Data for the quantity of hedgerows in survey squares show that across the 10 squares (recorded in both 90 and 98) in which more than 50% of the land was under CSS at some time there was a loss of 1,006m of hedgerow and a gain of 768m. For those squares in which less than 50% of the land (18 of which with under 10%) was under CSS at some time there was a loss of 3,861m of hedgerow and a gain of 6,774m.

469 It is possible to test whether these results differ from those from a random set of squares, or to pursue a more lengthy option of looking at the actual parcels of land under agreement that fall within the CS squares. However, the dataset is clearly too limited at present to draw any definitive conclusions. High variability in the length of hedgerow in 1km squares dependent on their location and land use mean that there would need to be a substantial amount of data in order to establish a significant difference between land 'in ' and 'out' of agri-environment schemes.

470 Results for squares with land in ESA agreement show similar results with a much larger gain in hedgerows for squares with less than 50% land under stewardship, but as the data does not give dates for entry into the scheme, it is unclear as to whether land was even part of the ESA

scheme at the time of either the 1990 or 1998 CS surveys. If data for both English ESA and CSS are put together (ignoring the lack of date information for English ESA) there are still only 24 squares with more than 50% land in agreement and those agreements will include a whole range of management options including restoration of historical features, access, field boundary, hedge maintenance, low input land etc.

471 Undoubtedly, changes in lengths of hedgerows in all squares with land in an agri-environment scheme will be due both to a number of factors including the nature of the particular stewardship or ESA agreements, the year of entry to those agreements and, of course, any changes in the land in the square that was not under agreement. In order to pick up changes that are due to management under agri-environment schemes, it will require both an increase in the amount of land under agreement as well as access to detailed data on all national schemes.

Broad Habitats

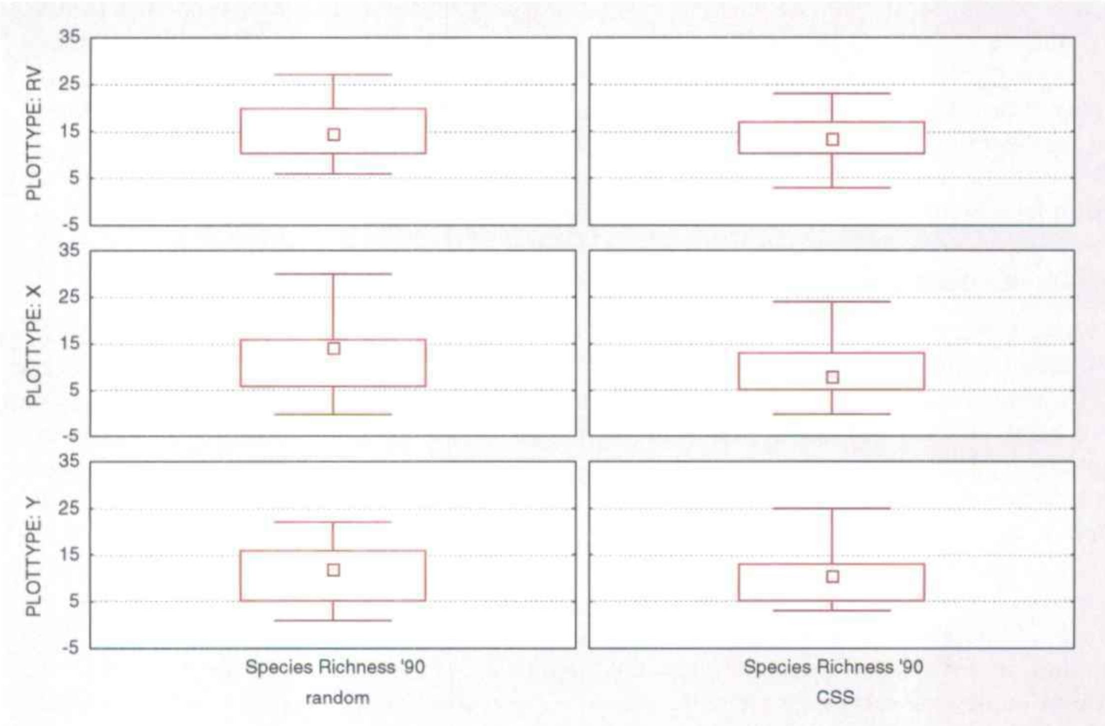
472 To investigate whether land in agri-environment schemes has altered in terms of Broad Habitat, changes in Broad Habitat within the land under CSS agreement was looked at. On average approximately 13% of the land in schemes for some of the period between 1990 and 1998 changed Broad Habitat between the two surveys. This compares with a figure of around 14.2% change between Broad Habitats across England as a whole, indicating that using the data we have, it appears that land within agri-environment schemes is no more likely to change Broad Habitat than land outside of schemes. It is possible to go further and look in detail at what the changes in Broad Habitats are within scheme land, in order to discover whether those changes can be seen as improvements. However, given the limited quantity and quality of data available at present it would be impossible to detect any significant changes or even reliable trends.

Vegetation quality/ plant diversity

473 Using the Countryside Stewardship data it is possible to look at the vegetation within plots that have been part of the stewardship scheme and compare the vegetation of those plots with the vegetation of random plots of the same type to identify whether any changes have occurred as a result of being part of the stewardship scheme. In order to do this, vegetation condition data from plots surveyed in both 1990 and 1998, which were in Countryside Stewardship for at least 2 of the years between 1990 and 1998, were compared to random plot data.

474 Comparisons were carried out using data from Main (X), Targeted (Y) and Roadside verge plots (RV), with the total number of plots within stewardship land used being 88. Analysis of Variance (ANOVA) was carried out to investigate the effect of being part of CSS on condition measures across all three plot types. Initial comparisons between data from random plots and from CSS land (prior to its inclusion in the scheme) were carried out by looking at differences in condition measures in 1990 for random plots versus those located on land that later went into the CSS. These results showed that species richness was significantly lower in the land that was later to become part of the Countryside Stewardship scheme, than in the random plots ($F_{1, 174}$ = 4.16, p<0.05). Figure 17.2 shows box plots of the species richness scores for random plots, and plots, which were later part of the CSS scheme, for each of the three, plot types (X, Y and RV). The C-radius (which is in effect a measure of the proportion of competitive species in the plot) was higher in the scheme plots than in random plots ($F_{1, 168}$ = 9.41, p<0.01). Associated with that, the S radius (which is a measure of the numbers of species in plots which are tolerant to environmental stress) was higher in random plots than in scheme plots ($F_{1, 168}$ = 9.72, p<0.01). These findings point towards a higher nutrient status in the land that was later entered into the scheme and indeed the N score (nitrogen) was marginally significantly higher in scheme plots than in random plots ($F_{1, 174}$ = 6.44, p<0.05) in 1990.

Figure 17.2 Box plots (including 75% of species in boxes, 25% outside, and median) showing species richness in 1990 for main (X), targeted (Y) and roadside verge (RV) plots, in random plots and plots later included in Countryside Stewardship.



475 Comparisons of the same set of random plot data with plot data from land that had been part of CSS for a minimum of 2 years, showed that in 1998 there was no significant difference in species richness, indicating that the numbers of species increased in the scheme plots (from significantly lower to no significant difference). Significant differences between random and scheme plots in C and S radii remained, with more competitive species in the scheme plots in 1998 as in 1990 and more stress tolerators in the random plots.

476 These results could be taken to indicate that the Countryside Stewardship Scheme is raising plant diversity on agricultural land, but the plot types cover a wide range of Broad Habitats within agricultural land and they are not sufficient in number to allow an analysis by Broad Habitat. Species richness is significantly affected by both plot type and Broad Habitat, indicating the importance of looking at differences by both Broad Habitat and plot type as well as just 'part of a scheme' or 'not part of a scheme'. The length of time which land has been part of a scheme is also likely to have a large impact on vegetation condition measures and it may take some time for beneficial effects of schemes to show through in surveys like Countryside Survey. For example, it may take more than 5 years for land to show any benefits of being part of an agri-environment scheme and of the 88 plots used in the above analysis only 34 were in CSS for more than 5 years.

Review of comparisons, use of LCM.

477 It was felt that the CSS Overview Report (Carey *et al.* 2000) had made adequate comparison between land in CSS and land in the wider countryside. The aims of this study differ from the kind of comparisons made by CEH (2001). This study seeks to discover the effects of inclusion in CSS on the landscape by looking at data from both CS90 and CS2000 whereas that of Carey

et al. (2000) sought to identify how land within the CSS scheme differed from the wider countryside at a specific point in time. The importance of entry date information is therefore more pertinent in this study and affects what can be done effectively.

478 The same problem occurs with the use of the Land Cover Map in making broad scale comparisons. It is possible, although a large task, to look at land in and out of schemes using the Land Cover Map (LCM) 2000 to make broad scale comparisons at a single point in time. It is not possible to look at changing aspects of land under agri-environmental schemes using LCM because of the incompatibility of LCM 1990 and LCM 2000. However, given the data that we have received on agri-environment schemes which either does not include date of scheme entry, or includes large numbers of parcels with entry dates in the late 1990's, it is not clear how effective such a comparison would be if it was possible.

Limitations of the study.

479 At present, the amount of overlap between CS data and data on agri-environment schemes is too limited to show how much of an impact those schemes are having on the broader landscape of GB. Undoubtedly, with increases in both the take up of the schemes and in the efficiency and availability of data from the various government bodies running the schemes, it should be possible to get a much clearer picture of scheme impacts. The data collected for CS2000 has the potential to provide excellent baseline data for assessment of changes in landscape features as a result of many of the new schemes being introduced under the EDRP. However, whilst CS2000 covers a representative 0.2% of GB, the 0.2% of agri-environment scheme land that it covers is not part of a stratified random sample and does not therefore represent all scheme options across all landscape types. This is a problem as it means that in order to attain reasonable sample sizes for analysis taking into account the impacts of other factors on the measures made within Countryside surveys, there will need to be a considerable increase in the amount of land under agri-environment schemes within the CS sample.

SUMMARY STATEMENT

480 In order to be able to use the CS database as a means of investigating changes in the wider countryside in relation to agri-environment schemes, there needs to be a substantial increase in the area of land in agreement (from 1998 figures) in combination with considerable improvement in compatible databases from the bodies administrating the schemes as well as easy access to that data.

FURTHER WORK

481 Many of the plot types used in CS already sample important features that form part of the agri-environment schemes. Recommendations for a comparable $1m^2$ quadrat to be used for both the monitoring of all agri-environment schemes and within the CS nested main plot will help to provide directly comparable datasets.

482 Future Countryside Surveys with their random stratified sampling technique are likely to cover a statistically valid sample of farms with land in agreement under Countryside Stewardship (given a substantial increase in agreements on the figures for pre 1998). However, the 22 ESA's are by their nature highly localised and therefore unlikely to be sampled effectively by the CS strategy. In order to use CS to provide information about change in the ESA areas it would be necessary to increase the numbers of sample squares in those areas (and those additional squares would then not form part of the dataset used to look at changes in GB as a whole).

REFERENCE

CEH (2001). Monitoring and evaluation of the Countryside Stewardship Scheme. Module 2: The ecological characterisation of land under agreement.

Task 2: Recommended improvements to survey protocols

483 A database is maintained to which researchers add contributions during the course of their other work. Many of the points raised under 'Recomendations for changes to CS methods' while addressing each question in this report, have come from this databse.

Task 3: Maintaining the CS2000 Website

484 This activity was alwasy intended to start once the CS2000 Module 16 had drawn to a close. Transfer of responsibilities is currently taking place.

CONCLUDING STATEMENTS

485 CEH is pleased to be able to report that work on CS2000 Module 17 is well under way.

486 Draft final reports have been completed on those questions that are scheduled to have been completed (Questions 1, 2, 4 and 17) and work has started on all other questions.

487 Some questions are a little behind schedule but others are ahead. On balance, CEH believes that work is on schedule and that overall completion will be to schedule.

488 CEH looks forward to continuing work on this Module and notes that the next milestone comprises delivery of the final report by the end of February 2003.

[ends].

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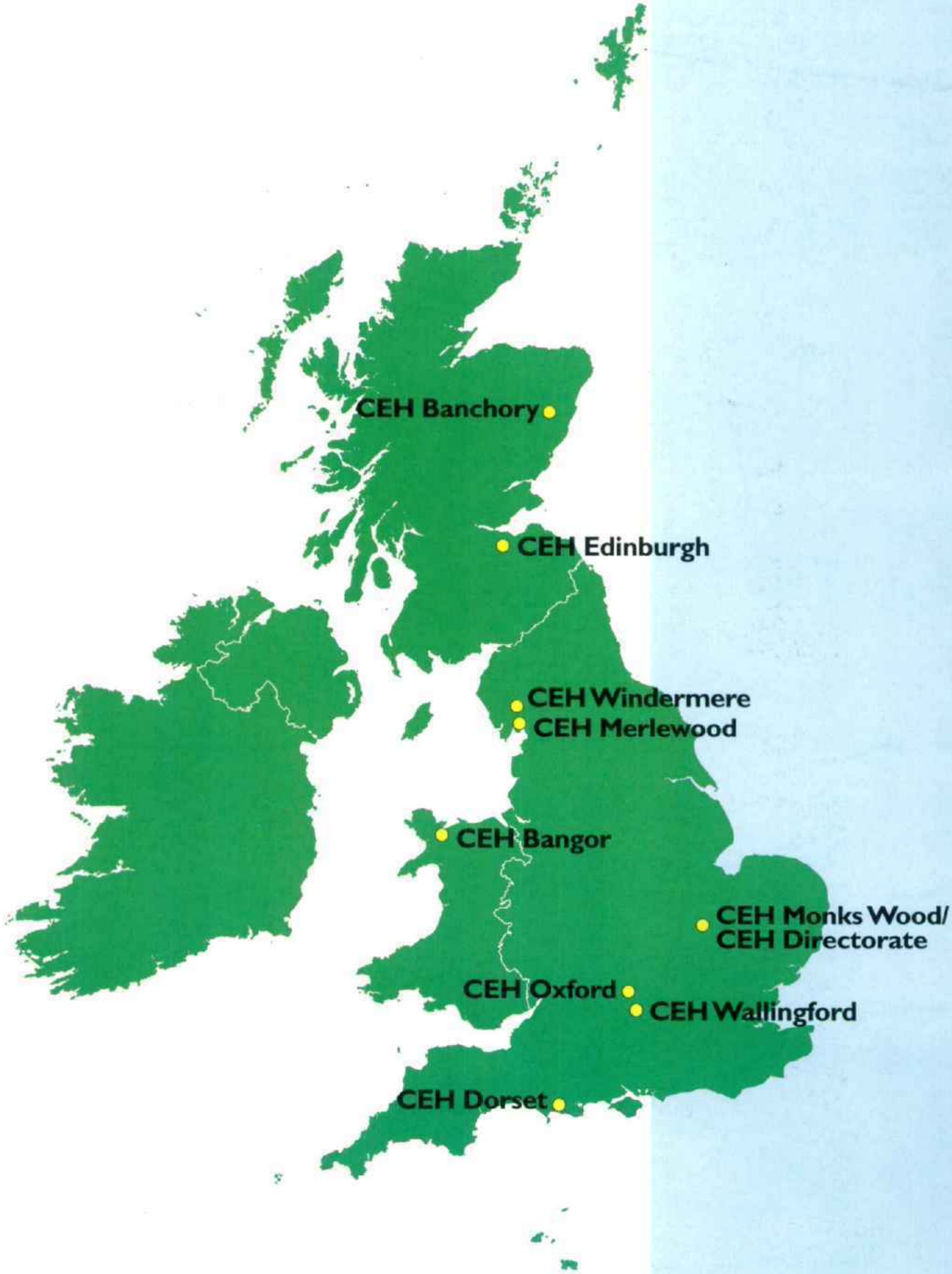

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