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?

Simon Smart & Sandrine Petit

DUE START DATE:

- March 2002

DUE FINISH DATE:

- June 2002

OVERALL PROGRESS

1 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]

2 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 Indicators[2]

3 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.

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

Environmental Impact Assessment

5 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

6 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.

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

---

[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.

THREAT	Neutral Grassland: Lowland meadows	Neutral Grassland: Upland hay meadows	Calcareous Grassland: Lowland calcareous grassland	Calcareous Grassland: Upland calcareous grassland	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			✓		✓

<u>Selected key actions from each Priority Habitat Action Plan</u>[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 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 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 integrated approach to environmental, agricultural and socio-economic policy through

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

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]

8 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

9 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 (Fuller 1987; 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).

10 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 recognised 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 grassland[6]

Change in extent

11 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.

12 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

[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."

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.

<u>Change in condition</u>

13 An increase in mean Ellenberg fertility score across the GB plot sample was only seen for Y plots 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 characteristic 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 hence, 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]

<u>Change in extent</u>

14 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.

15 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.

<u>Change in condition</u>

16 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.

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

[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."

Calcareous grassland[8]

Change in extent

18 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

19 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.

20 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).

References:

Bunce, R.G.H., Barr, C.J., Gillespie, M.K., Howard, D.C., Scott, R.A., Smart, S.M., van de Poll, H.M. and Watkins, J.W. 1999. Vegetation of the British countryside - the Countryside Vegetation System. Department of the Environment, Transport and the Regions, London.

Fuller, R.M. (1987) The changing extent and conservation interest of lowland grasslands in England and Wales: a review of grassland surveys 1930-1984. *Biol.Cons.* 40, 281-300.

Gibson, C.W.D., Brown, V.K. (1991) The nature and rate of development of calcareous grasslands in southern England. *Biol. Cons.* 58, 297-316.

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.

HMSO (1975) *Food From Our own Resources*. Cmnd. 6020.

Hopkins, A., Hopkins, J.J. (1994) UK grasslands now: agricultural production and nature conservation. In: (R.J.Haggar & S.Peel eds.) *Grassland Management and Nature Conservation*. BGS Occasional Symposium no.28, pp10-19.

Hopkins, A., Bunce, R.G.H., Smart, S.M. (2000) Recent changes in grassland management and their effects on botanical composition. *J.Royal.Agric.Soc.Eng.* 161, 210-223.

[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

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.

Jefferson, R.G., Robertson, H.J. (1996) Lowland grassland: a strategic action plan. English Nature Research reports no.163. EN, Peterborough.

McGowan, G.M., Palmer, S.C.F., French, D.D., Barr, C.J., Howard, D.C., Smart, S.M. (2001) Trends in Broad Habitats in Scotland 1990-1998. CEH Banchory.

North, J. (2000) Changes in agricultural structures in the 20th century. *J.Royal.Agric.Soc.Eng*. The Millennium Journal 29-40.

Rodwell, J.S. (1992) British Plant Communities. Vol 3, grassland and Montane Communities. CUP.

SCIENCE OUTPUTS

21 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

22 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)

23 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

24 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. Note that 156 refers to dense Bracken. Other codes are explained in Table 1.2.

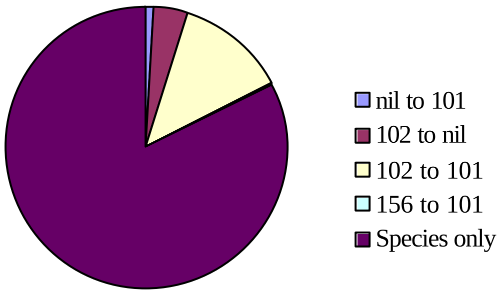
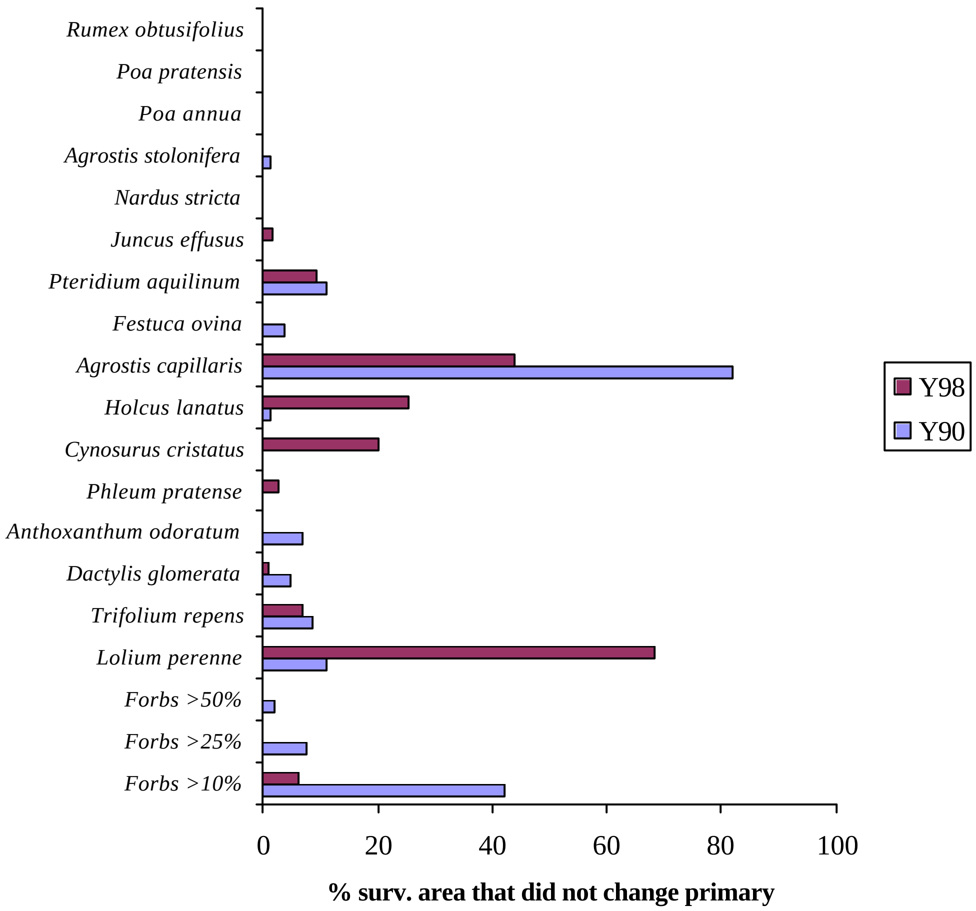


Figure 1.2 Contribution of change in species and other minor codes to the change in Broad Habitat. Proportions based on the surveyed area that did not see a change in Primary code.

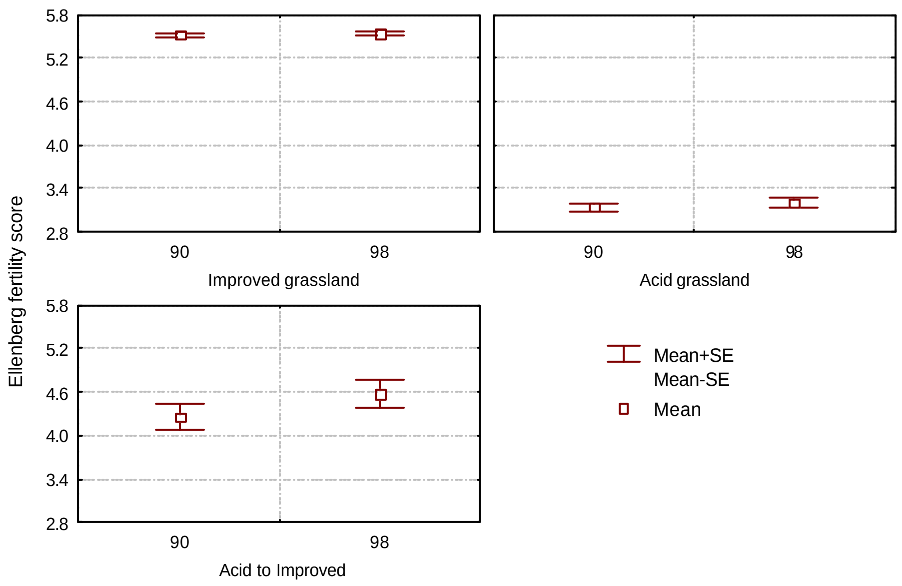


25 Changes in species codes were also largely consistent with the shift from acid to improved grassland with increases in recording of *Lolium perenne* suggesting sward improvement (Figure 1.2). However the decreases in *Anthoxanthum odoratum*, *Festuca ovina* and *Agrostis capillaris* but absence of 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. Hence, in NVC terms U4 (bent/fescue grasslands) have been affected more than U5 (*Nardus*) or U2 (*Deschampsia fexuosa*) grasslands.

Results – change in condition measures

26 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.



27 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.

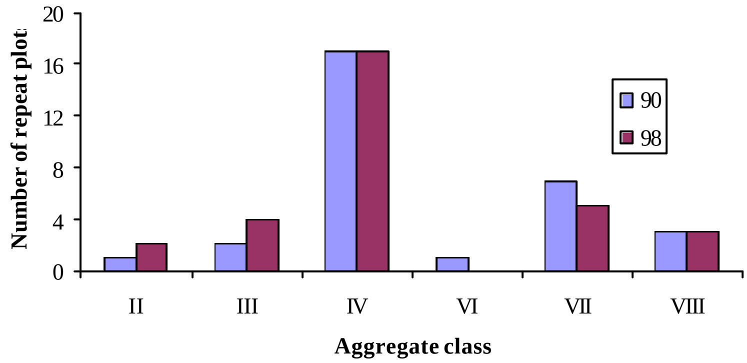
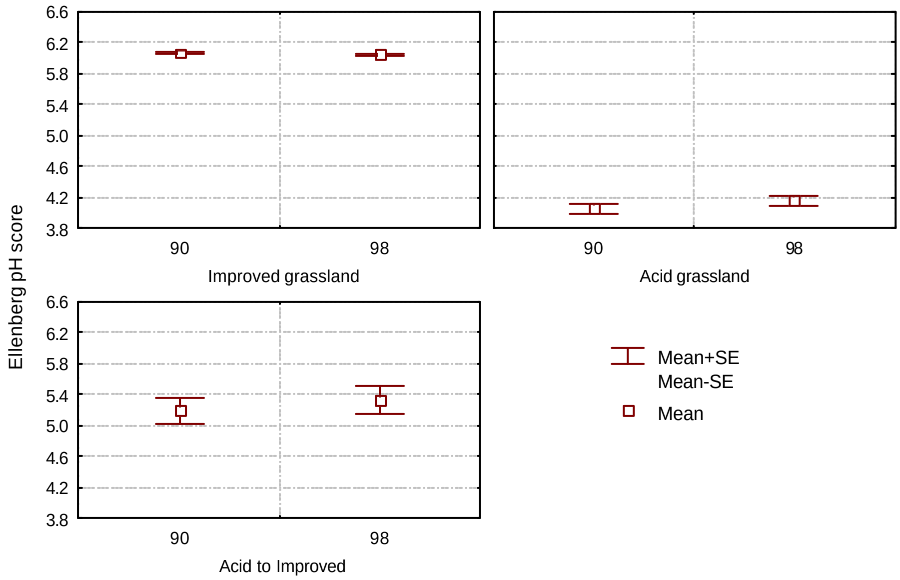


Figure 1.5 Mean Ellenberg pH score for vegetation plots in mapped parcels that either remained in Acid or Improved grassland Broad Habitat between surveys or moved from Acid to Improved grassland.



Conclusions

28 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.

29 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

30 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 1998 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 calc areous 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.

31 34% of the surveyed area did not change primary code or species code.

Results – change in condition measures

32 No plots were available for analyses of condition.

Conclusions

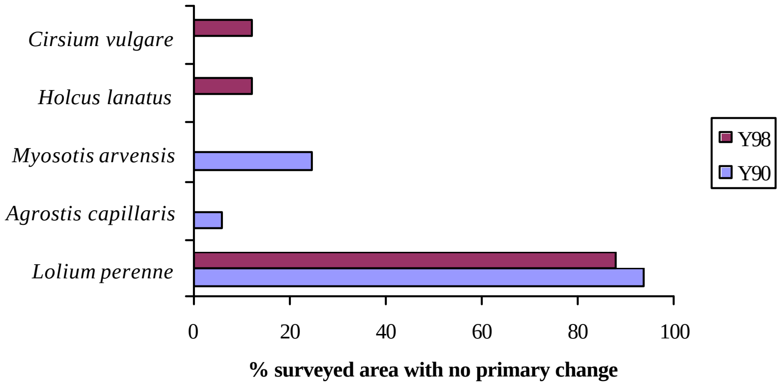
- Change was confined to one sample square.
- Although about half of the changing area remains unsupported by available mapping code data, there has been consistent primary code change in other parts of the square.
- The vegetation involved was restricted to calcareous, dune grassland.

Calcareous to Improved grassland

Results – change in mapping codes

33 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.



<u>Results – change in condition measures</u>

34 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.

<u>Conclusions</u>

- 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.
- Surveyed change within zone 2 remains doubtful and the vegetation appears to have been unimproved or semi-improved grassland in both years. Surveyed change in zones 1 and 5 does appear to reflect real agricultural improvement.

Calcareous to Arable

<u>Results – change in mapping codes</u>

35 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.

<u>Results – change in condition measures</u>

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

<u>Conclusions</u>

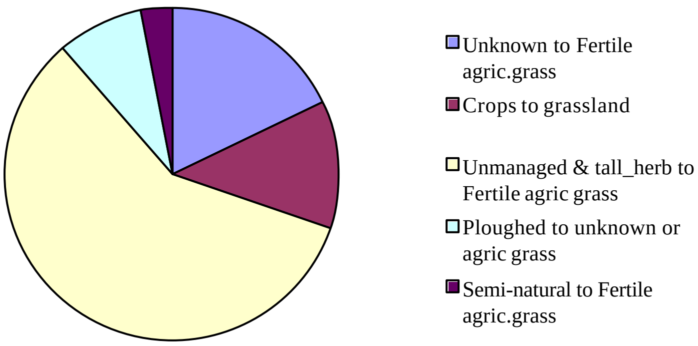
- Although very limited in extent the change in Broad Habitat is entirely consistent with mapping code data.

Neutral to Improved

Results – change in mapping codes

37 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). 3% of surveyed land (7ha) also moved from semi-natural habitat types (Fen, Acid grassland and Bracken) to Fertile agricultural grassland.

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



38 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

39 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.

40 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.

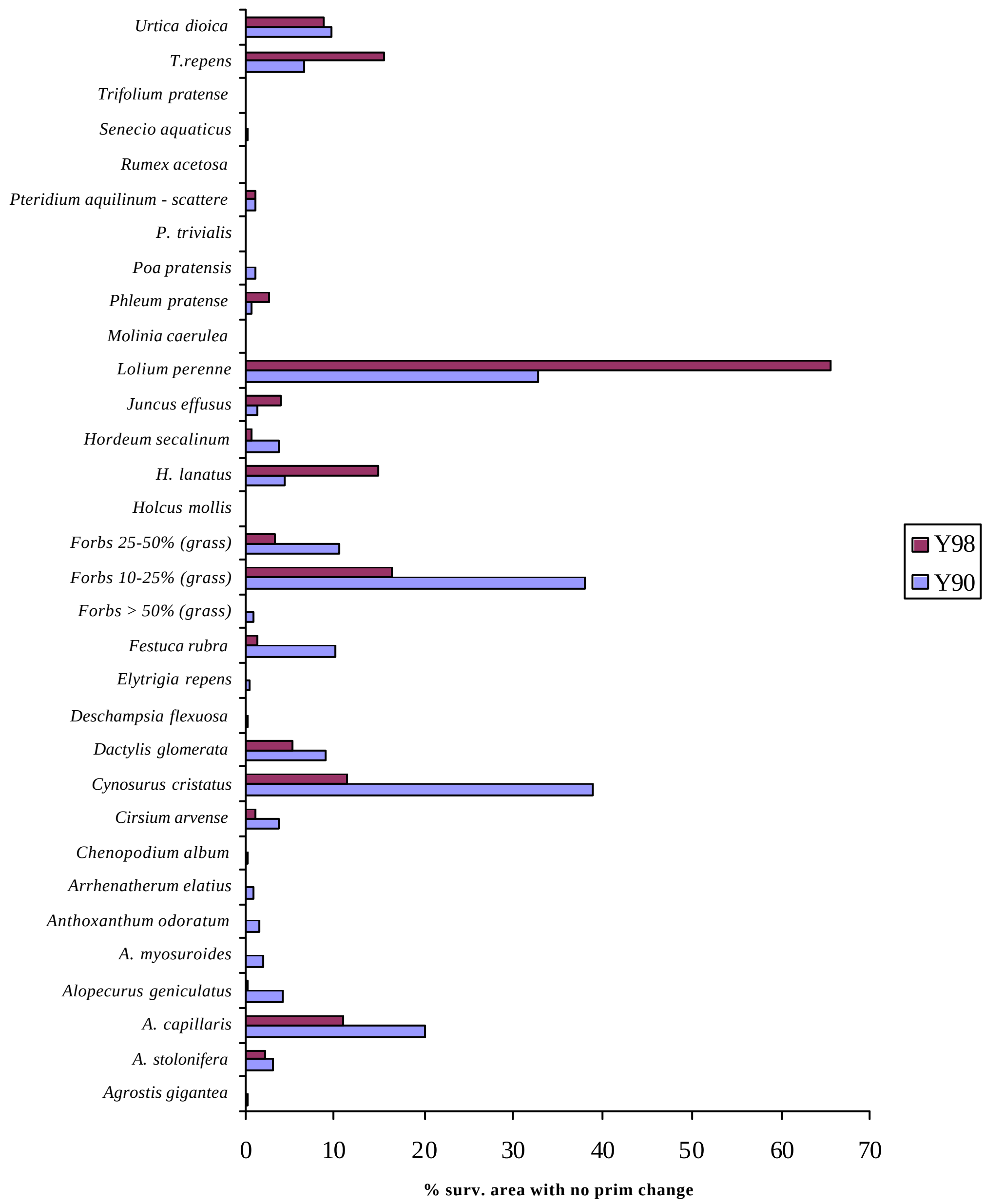


Figure 1.9 Aggregate class membership of plots in 1990 and '98 from parcels that moved from neutral to improved grassland Broad Habitats.

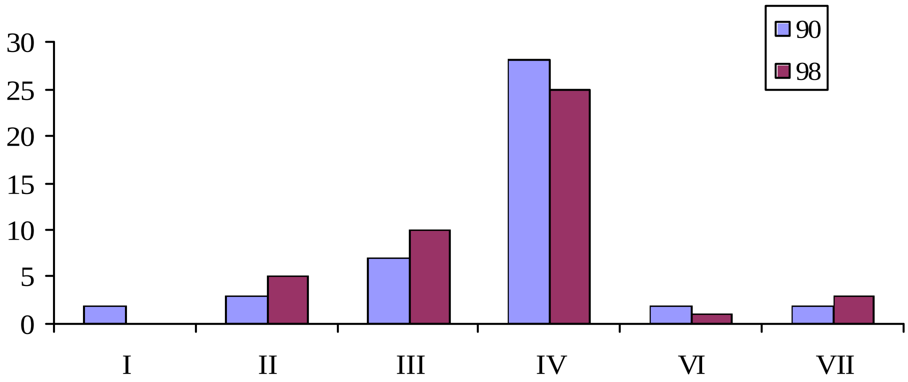
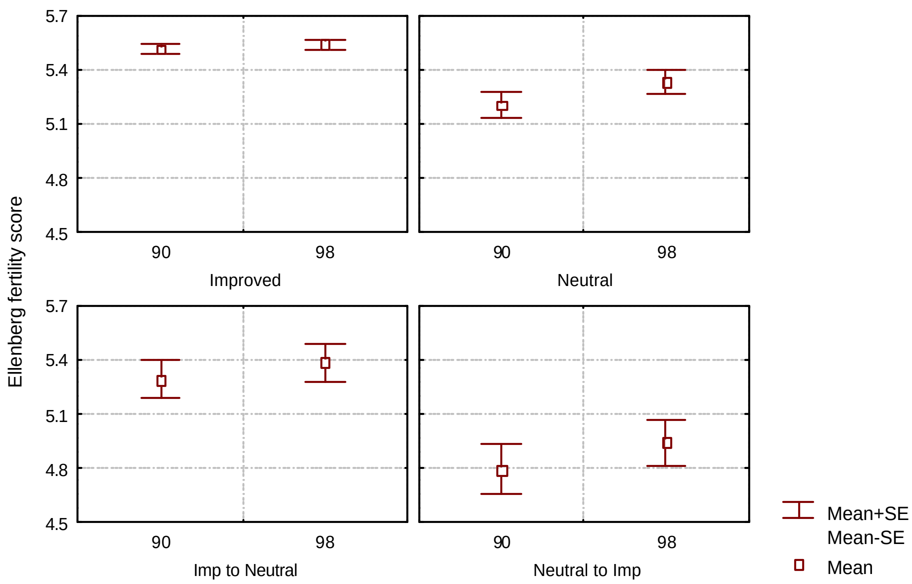


Figure 1.10 Mean Ellenberg fertility score for vegetation plots in mapped parcels that either remained in Neutral or Improved grassland Broad Habitat between surveys or moved between the two.



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 also supportive but suggested that floristic change had been slight and in most plots had not been large enough to result in a floristic change in aggregate class.
- In spite of evidence for local improvement, plot data from a subset of parcels that changed to improved grassland in 1998 still had a much lower score than the stable core of neutral grassland in 1998.

- A small proportion (7ha) of semi-natural habitat surveyed in 1990 (Fen, Acid grassland and Bracken) was lost to Improved grassland but the majority started as unmanaged and tall-herb in 1990. These swards appear to have had more in common with set-aside than established unimproved or semi-improved grasslands.
- Therefore in policy terms, 56% of the change in surveyed area is ecologically less significant regarding loss of extent and condition of established neutral grassland. 49% of the change in surveyed appeared to reflect increased abundance of *Lolium perenne* in semi-improved grassland parcels.

Neutral to Arable

<u>Results – change in mapping codes</u>

41 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 (Neutral to Arable) that saw primary code changes between 1990 and 1998.

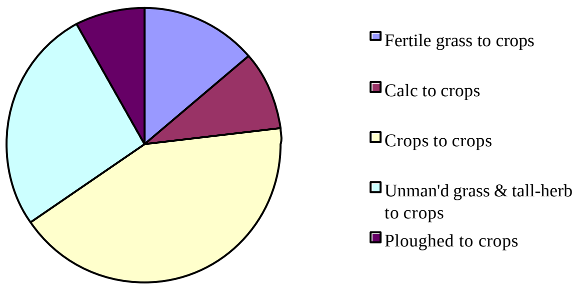
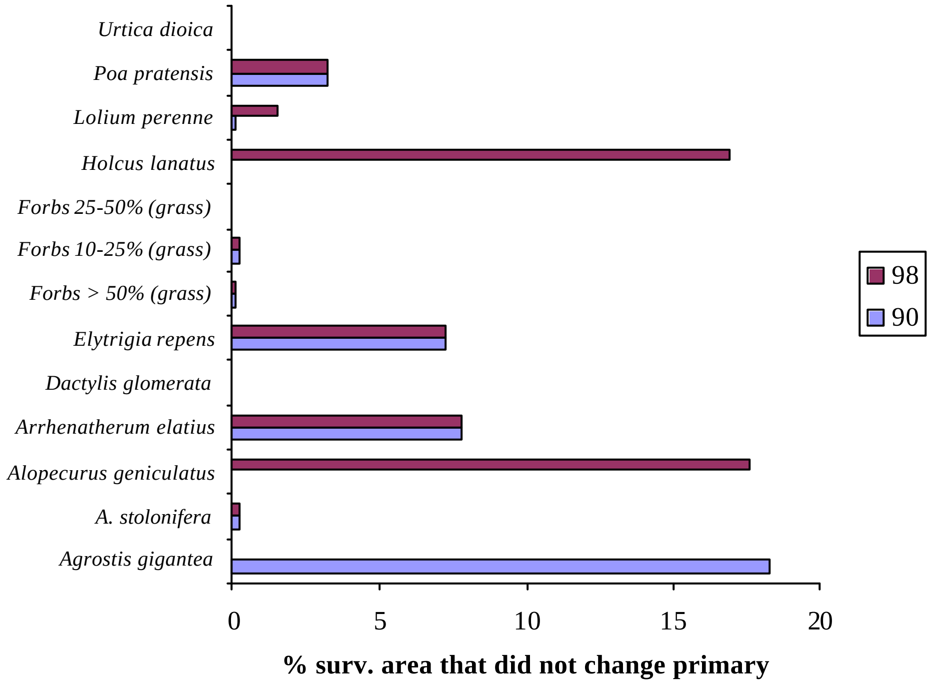


Figure 1.12 Species occurrences as a proportion of surveyed land (Neutral to Arable) that did not change primary code between 1990 and 1998.



42 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.

<u>Results – change in condition measures</u>

43 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.

<u>Conclusions</u>

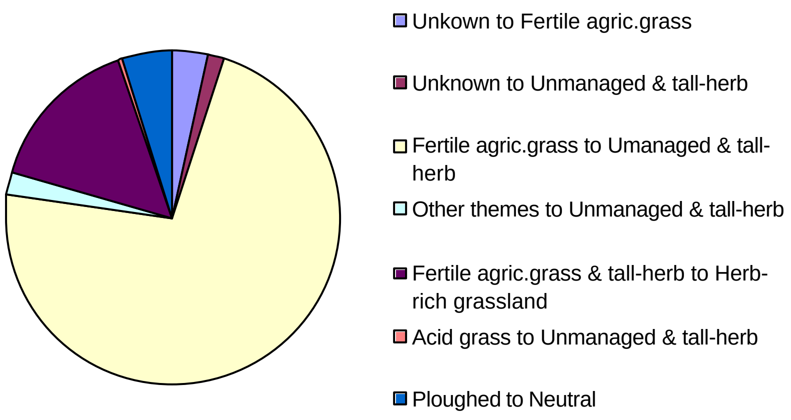
- The change on surveyed land from Neutral to Arable is not generally supported by available mapping code data for parcels that changed.
- Plot condition data was very limited. What little there was indicated floristic stability at the aggregate class level.

Improved to Neutral

<u>Results – change in mapping codes</u>

44 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.



45 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

46 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 Broa d Habitat comprised parcels with vegetation plots.

47 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 di d not change primary code between 1990 and 1998.

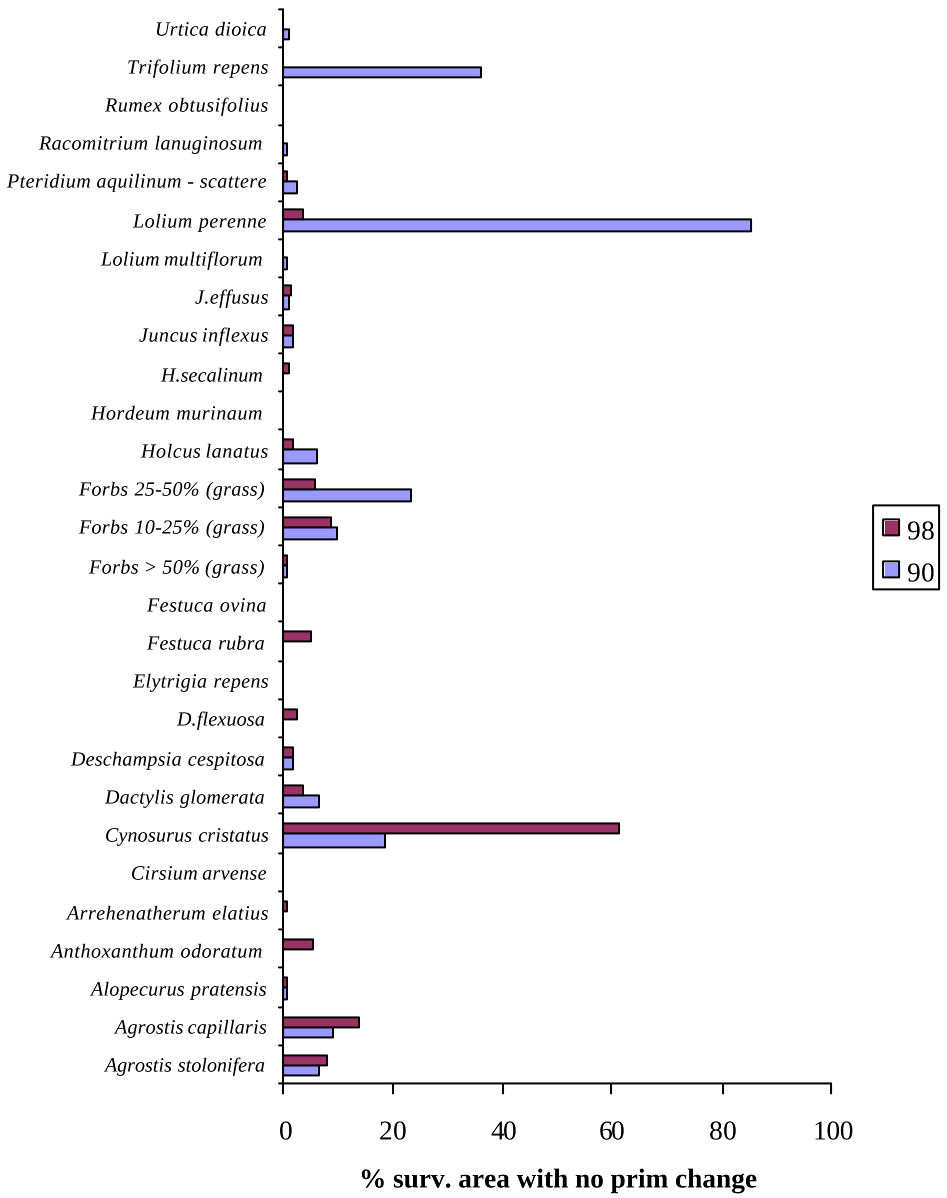
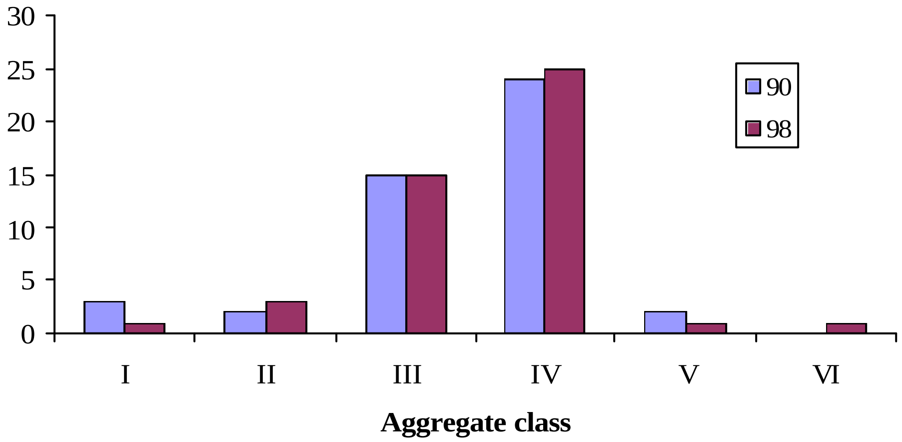


Figure 1.15. Aggregate class membership of plots in 1990 and '98 from parcels that moved from improved to neutral grassland Broad Habitats. N=46.



<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

48 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.

49 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 Neutral Grassland vegetation plots against Priority Habitat reference data

50 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

51 A total of 334 plots were selected from the ESA archive (Table 1.4a). Similarity coefficients between plots from within the same ESA field (ie. validation method) were exluded so as to avoid artificially inflating similarity between ESA plots. 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	154
MG8	131
MG5	66
MG4	3
Total plots	334

52 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 (0.173, SE+/0.0004) was significantly lower than the mean similarity within each group (0.260, SE+/0.0004). Similarity values were therefore low overall and serve to highlight the heterogeneity within ACIV and within the ESA reference data. However, when

this internal variability was taken into account CS plots were significantly different from the priority habitat plots taken from ESA Neutral Grasslands

53 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. Not surprisingly, ESA data was significantly dissimilar to this subset of improved and semi-improved plots (average similarity between ESA and CS plots was 0.074 SE+/-0.0005).

54 The results from both analyses have shown that a) Even those neutral grassland plots that could be classified as unimproved grassland still differed significantly in their species composition from a known reference sample of priority habitat neutral grasslands. b) Over a third of the neutral grassland plots sampled during the 1998 were floristically very different to priority habitat neutral grasslands and are clearly best considered as semi-improved or improved grassland.

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. The test statistic equals 1 if the smallest difference between groups is larger than every difference within groups (see Clarke, 1993).

Comparison	Test statistic (Clarke's R)	Significance level
II & III v. ESA	0.720	0.001
IV v. ESA	0.383	0.001

55 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).

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

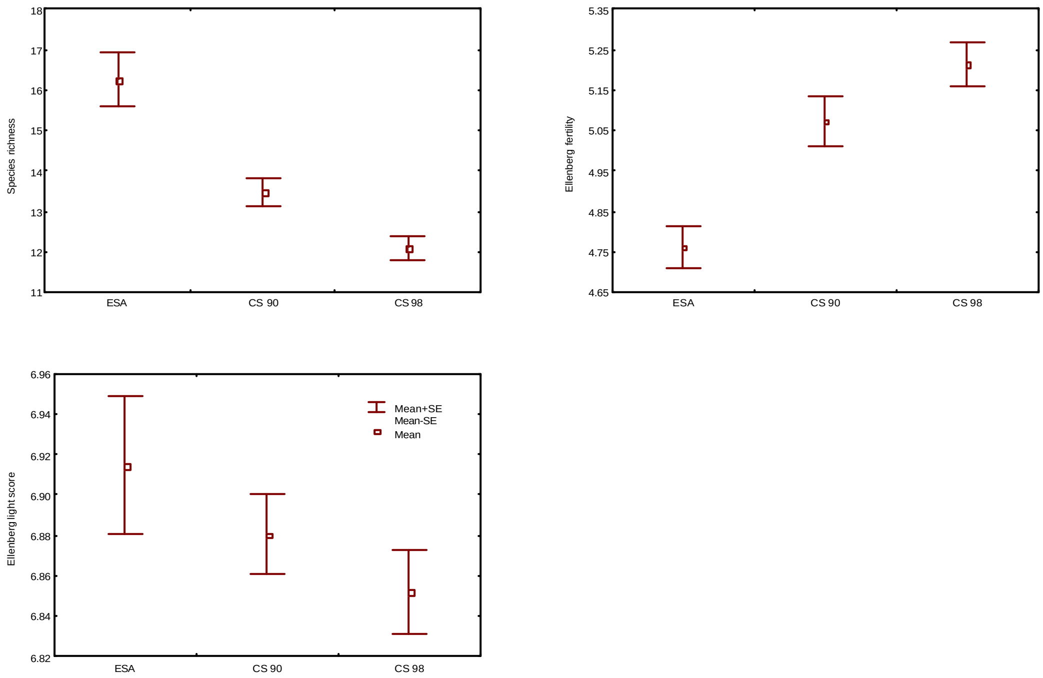


Figure 1.17 A comparison of Ellenberg fertility scores between CS plots in the neutral grassland Broad Habitat and ESA reference plots for neutral grassland priority habitats plus 52 ESA plots sampled in semi-improved MG6. CS plots have been broken down by aggregate classes II, III, IV and VII.

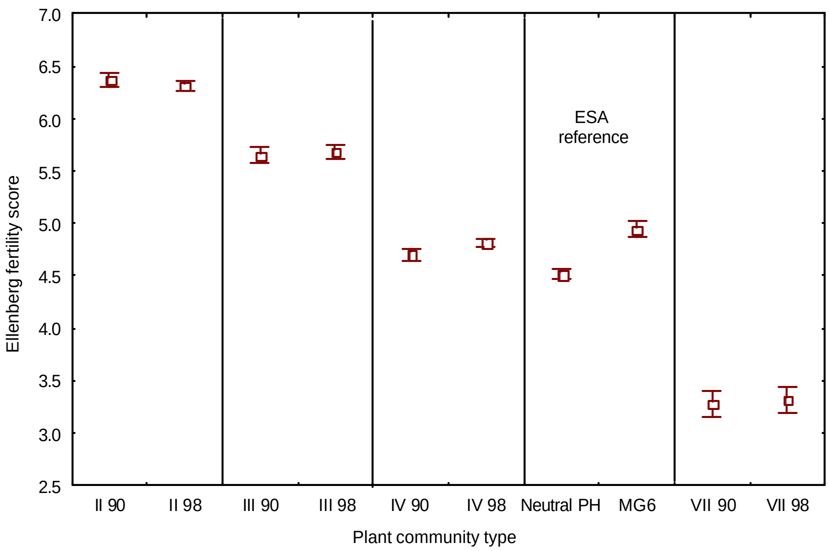
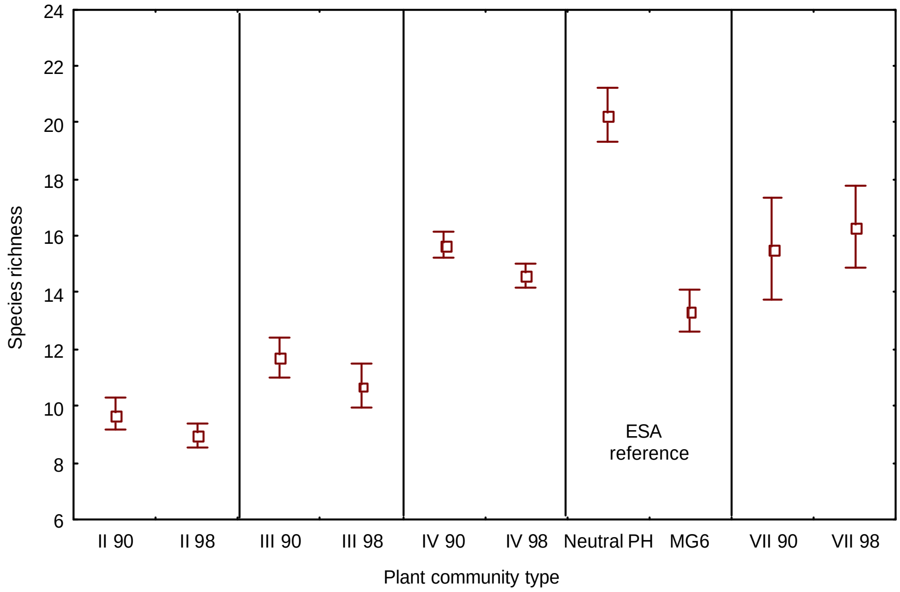


Figure 1.18 A comparison of species richness values between CS plots in the neutral grassland Broad Habitat and ESA reference plots for neutral grassland priority habitats plus 52 ESA plots sampled in semi-improved MG6. CS plots have been broken down by aggregate classes II, III, IV and VII.



56 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 MG6 from the ESA database. This is significant since we assume that the MG6 included in the ESA sample must represent the better quality end of the range of variation if fields were to have been justifiably allowed into the scheme

Results – ESA versus CS calcareous grassland Broad Habitat

57 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. The comparison still has limitations because of the focus on CG2 only but this reflects data availability in the AEMA archive.

58 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.

59 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)

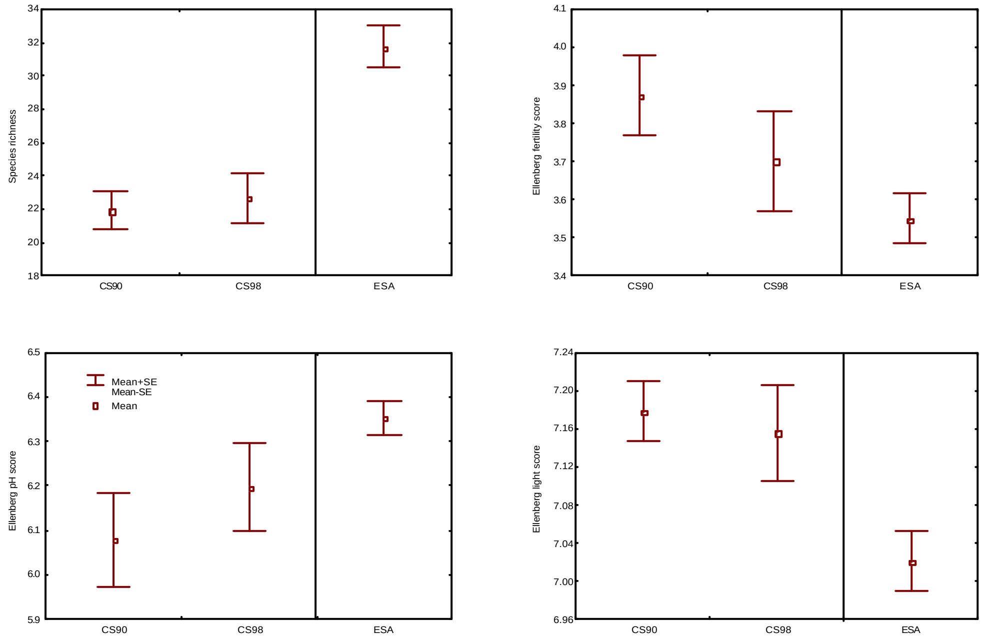
NVC community	N
CG2	50

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

60 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

61 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. This reflects the fact that the improvement gradient is a continuous one. Delimiting areas of neutral and improved grassland is therefore difficult and mapped areas may show considerable internal variation.
- 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

62 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.

63 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 1992), 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.

64 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.

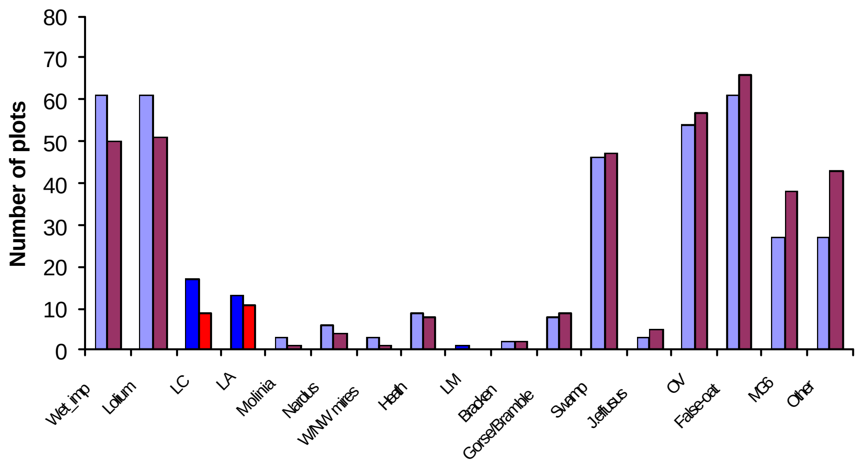
Group name	NVC communities and priority habitats
J. effusus	M23 *Juncus effusus-Cirsium palustre* rush pasture
Molinia	M25 *Molinia caerulea-Potentilla erecta* mire
Swamp	All swamp communities
Heath	All heath communities
Wet_imp	*Seasonally wet, mesotrophic grasslands: MG9 Holcus lanatus-Deschampsia 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

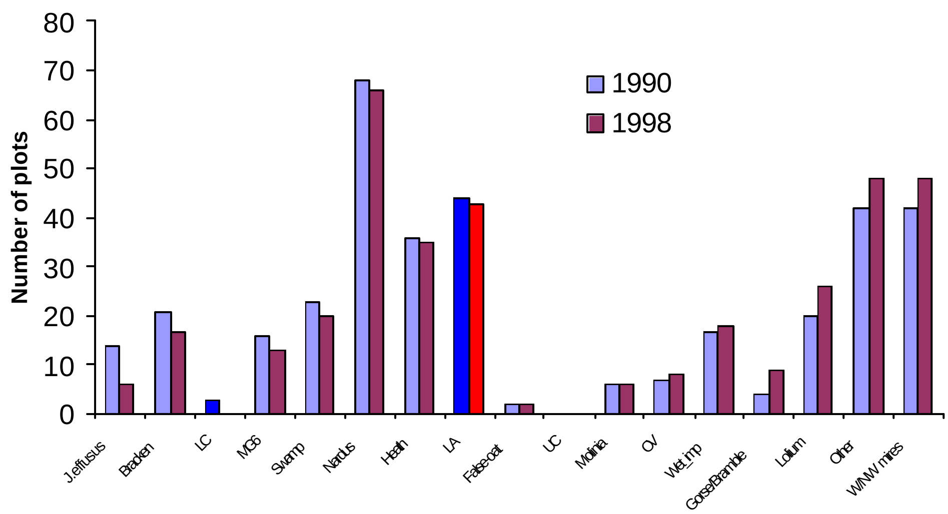
65 All the grassland priority habitats are extremely scarce in CS plot data that coincide with the semi-natural grassland Broad Habitats. Lowland meadow plots were the scarcest of the priority habitats in the lowland subset (Figure 1.20a) while upland calcareous grassland and upland hay meadow were both absent from the upland subset (Figure 1.20b). Since at least two of the NVC communities included in the lowland acid grassland Priority Habitat (U2 and U5) are abundant in upland landscapes it is not surprising that 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)



66 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 where 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

67 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.

68 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

69 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).

70 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.

71 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.

72 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.

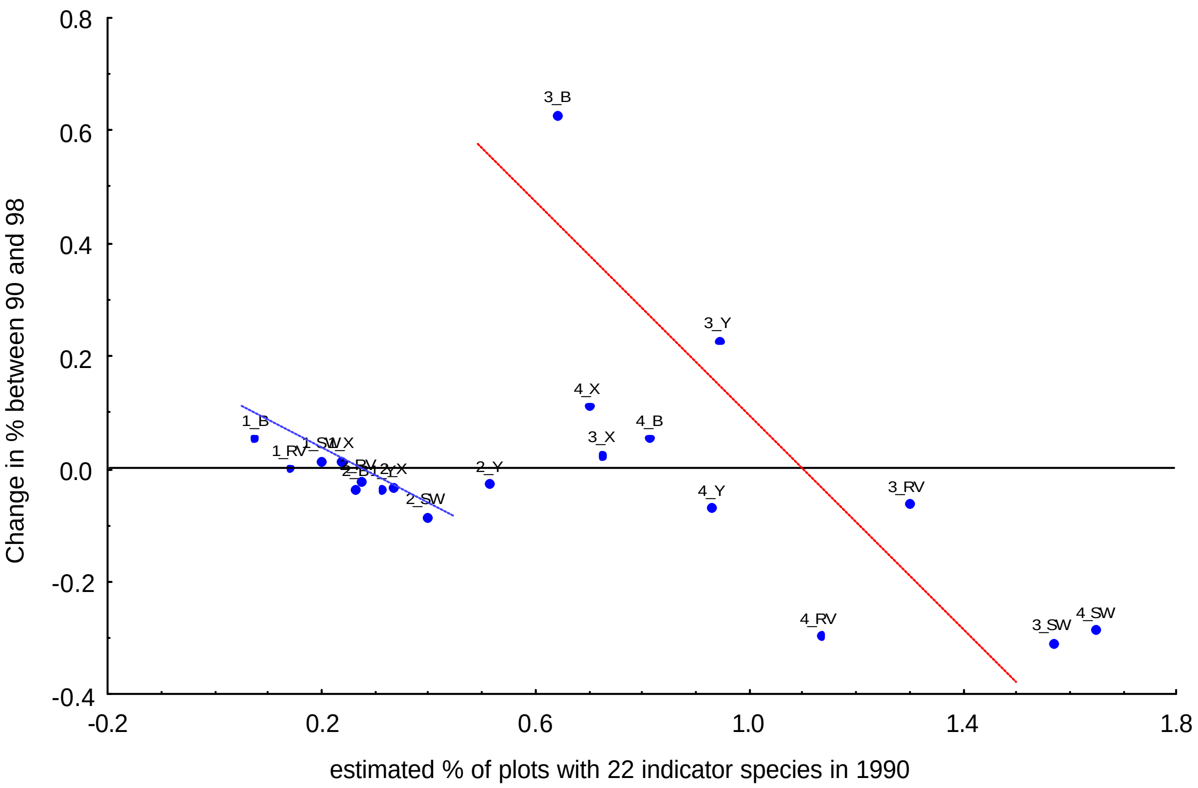
73 Estimation was carried out by firstly generating a linear regression equation of $\log_{10}$ (% of plots in the plot Environmental Zone combination) onto $\log_{10}$ (richness of indicator species per plot) for each plot Environmental Zone combination. This equation was then used to derive the proportion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

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

Results

75 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. These reflect the apparent separation of landscape locations into a lowland group (zones 1 and 2) and an upland group (zones 3 and 4).



76 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.
- These results are consistent with earlier work carried out for the Ecofact project (Bunce et al 1999) in indicating that species of lowland unimproved grasslands are on average sarce in the wider countryside and are in fact more likely to be located on landscape interstices less impacted by in-field management (see aso Smart et al 2002). Linear and targeted plot data may therefore prove useful in estimating the likely richness and abundance of residual pools of target species in different regions of GB. Such information could be used to estimate likely variation in the responsiveness of areas funded under the new 'broad, shallow' agri-environment initiative to be rolled out in 2003. This would help inform baseline and future assessments of the success of the scheme in different places.

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 7% 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

77 *The significance of change:* Large scale agri-environment 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.

78 In light of the new agri-environment scheme, ongoing commitments to BAP and HAP objectives and the new Water Framework Directive it might also be worth considering

revisiting some or all key habitat squares (Hornung, 1997) in parallel with the next Countryside Survey. Since squares were targeted on, among others, Coastal, Waterside and Calcareous grassland landscapes, a resurvey might provide valuable additional information on wider changes in extent and condition of Priority Habitats included in the neutral and calcareous grasslands. Since these squares are not part of the CS series, they might also offer the opportunity for gathering detailed management information.

79 *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.

REFERENCES

Bunce, R.G.H. et al (1999). *Measuring Change in British Vegetation*. *ECOFACT volume 2*. London: Department of the Environment, Transport and the Regions.

Clarke, K.R. (1993) Non-parametric multivariate analyses of change in community structure. *Australian Journal of Ecology* 18, 117-143.

Critchley C.N.R et al. (1999) Sensitivity and calibration of plant community variables for grassland monitoring in English ESAs. Unpublished report to MAFF.

Carey P.D. et al (2002) A comparison of the ecological quality of land between an English agri-environment scheme and the countryside as a whole. *Biol. Cons.* 108,183-197.

Haines-Young, R.H. et al (2000). Accounting for nature: assessing habitats in the UK countryside. Department of the Environment, Transport and the Regions, London.

Hornung, M. (1997) Current status and prospects for threatened habitats in England: Overview. ITE Merlewood, Grange-over-Sands.

Palmer, M. (1992) Trial of MATCH and TABLEFIT computer programs. JNCC report 20. Joint Nature Conservation Committee: Peterborough.

Rodwell, J.S. (1992) British Plant Communities. Vol 3, grassland and Montane Communities. CUP.

Smart, S.M. (2000). Ecological assessment of vegetation data from a nature reserve using regional reference data and indicator scores. *Biodiversity and Conservation* 9, 811-832.

Smart S.M. et al (2002) Do field boundaries act as refugia for grassland plant species diversity in intensively managed agricultural landscapes in Britain? *Agric.Eco.Env.* 91, 73-87.

Smart S.M. et al (in press) National-scale vegetation change across Britain; an analysis of sample-based surveillance data from the Countryside Surveys of 1990 and 1998. *J.Env.Man.*

Phillipi T.E. et al (1998) Detecting trends in species composition. *Ecol App.* 8, 300-308.

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[9]

	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	✓				

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