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?

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DUE START DATE:

- March 2002

DUE FINISH DATE:

- June 2002

OVERALL PROGRESS

1 This is the final report.

DEFINITIONS

2 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

3 In this report, we often grouped uncultivated Broad Habitat types according to the definition of the Environmental Impact Assessment[1] 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

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

5 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 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

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

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).

6 In parallel, governments have recently had to implement the Environmental Impact Assessment[2] 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[3] 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".

7 Uncultivated lands identified in the consultation exercises were:

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.

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

8 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.

9 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

Haines-Young and McNally (2001) http://www.cs2000.org.uk/Final_reports/M14_final_report.pdf

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

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

[3] *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

Approach 1

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

10 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

11 Analysis of the CS databases showed that newly Arable & horticultural parcels came from the conversion of a range Broad Habitat types (Table 2.2). A large proportion of newly Arable & horticultural came from the conversion of Permanent grassland (BH6,7 and 8). The proportion of Permanent grassland converted to Arable & horticultural between 1990 and 1998 was estimated to be between 1 and 5%. Those were mostly Neutral grassland with an estimated 2 to 8% of the 1990 stock lost to conversion to Arable & horticultural between 1990 and 1998. Less than 1% of the 1990 stock of Acid grassland was converted to Arable & horticultural.

12 It was difficult to interpret estimates for the least represented Broad Habitat types (Calcareous grassland and the Heathland & moorlands category of the EIA) as the 95% confidence intervals were usually large and included zero.

13 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 1990 stock and the amount of Broad Habitat converted into Arable & horticultural in GB between 1990 and 1998 ('000 ha).

	Stock in 1990	**Area converted between 1990 and 1998**
Improved grassland	**5053-5989**	**540 – 741**
Neutral grassland	***479 – 659***	***12 – 49***
Calcareous grassland	***30 – 147***	***0 – 7***
Acid grassland	***1186 – 1737***	***2 – 21***
Total Permanent grassland	**1695 - 2543**	**14-77**
Heathland & moorlands	**3935 – 5712**	**0 – 6**

14 Table 2.3 presents the amount of area that was converted to Arable & horticultural per Environmental Zone and per country. This further desegregation of the dataset meant that regional estimates were derived from very few occurrences of conversion hence the large confidence intervals.

15 Conversion of Neutral Grassland to Arable &horticultural between 1990 and 1998 occurred almost exclusively in the three lowland zones of GB, the largest amount being recorded in the Westerly Lowlands of England & Wales (Environmental Zone 2). These conversions affected an important proportion of the 1990 stock of Neutral grassland in the lowlands of GB - Environmental Zone 2 (between 1 and 19%), Environmental Zone 4 (between 1 and 12%) and Environmental Zone 1 (between 1 and 8%).

16 Regional estimates for conversions from Acid grassland, Calcareous grassland and Heathland & moorlands to Arable & horticultural were low, with the exception of conversion of Acid grassland the Scottish Intermediate uplands and Islands (Environmental Zone 5).

17 The turnover between Improved grassland and Arable & horticultural varied across zones. It was the highest in Environmental zones 2 and 4 (between 10 and 20%) and the lowest in Environmental Zone 3 (between 0 and 5%)

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.

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

Conversion to Improved grassland

18 New Improved grassland came from a range of Broad Habitat types (Table 2.4). A large amount of converted area came from the Permanent grassland category, mainly Neutral and Acid grassland. Results showed that between 7 and 21% of the 1990 stock of Permanent grassland was converted to Improved grassland between 1990 and 1998. The proportion of Neutral grassland converted to Improved grassland was estimated to be between 19 and 34% and the proportion of Acid grassland between 5 and 14% .

19 It also appears that up to 1% of the 1998 Improved grassland came from the conversion of the Heathland & moorlands category, mostly Bracken (BH9) and Fen, Marsh, Swamps (BH11). Such conversions led to a loss of less than 1% of the 1990 stock of Heathland & moorlands.

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

	Stock in 1990	Area converted between 1990 and 1998
Arable & horticultural	**4782 - 5680**	**428 - 607**
Neutral grassland	***479 – 659***	***93 - 161***
Calcareous grassland	***30 – 147***	***1 – 24***
Acid grassland	***1186 - 1737***	***86 - 164***
Total Permanent grassland	**1695 - 2543**	**180 - 349**
Heathland & moorlands	**3935 - 5712**	**14 - 55**

20 When analysing conversions to Improved grassland at the country level (Table 2.5), it appeared that in England & Wales, between 19 and 32% of the 1990 stock of Neutral grassland has been converted to Improved grassland between 1990 and 1998, and between 6 and 29% in Scotland. For Acid grassland, it was estimated that between 8 and 18% of the 1990 stock had been converted to Improved grassland in England & Wales, while in Scotland this proportion was

estimated to be between 2 and 8%. Heathland & moorlands were more affected in England & Wales than in Scotland, with respectively between 1 and 3% of the 1990 stock converted to Improved grassland in England & Wales and less than 0.5% in Scotland.

21 Examining estimates at the Environmental Zone level (Table 2.5) revealed differences in trends between the lowland Environmental Zones (1, 2 and 4) and the upland ones (3, 5 and 6). In the upland zones, a high proportion of new Improved grassland came from the conversion of Permanent grassland, i.e. Acid grassland and Neutral grassland in Environmental Zone 3 or Acid grassland in Environmental Zones 5 and 6. In contrast, , 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 trends at the country level, with no difference between England & Wales and Scotland.

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 ('000 ha).

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

Overlap with designated areas

22 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.

23 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.

24 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.

Approach 2

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).

Primary codes and use of parcels

25 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.

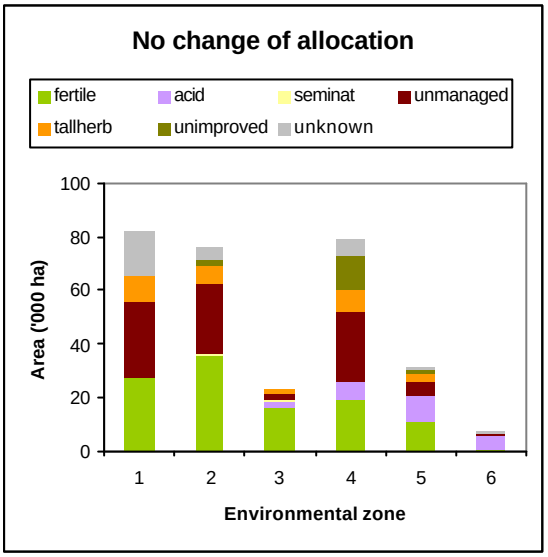
26 Figures 2.1 and 2.2 present primary codes and use of Neutral grassland and Acid grassland that either did not change allocation, were converted to Improved grassland or were converted to Arable & horticultural (Calcareous grassland are not presented given their low representation in the dataset). 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).

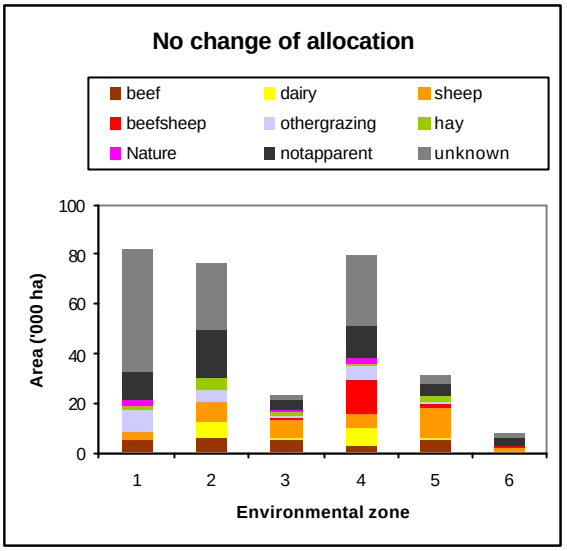
27 It appears that the parcels converted to cultivated land were not representative of the total pool of Acid grassland in term of primary codes. Parcels of Acid grassland with a 'Fertile' primary codes were significantly less likely to remain Acid grassland ($Chi^2 = 144.5$, $df = 4$, $p < 0.0001$) 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.

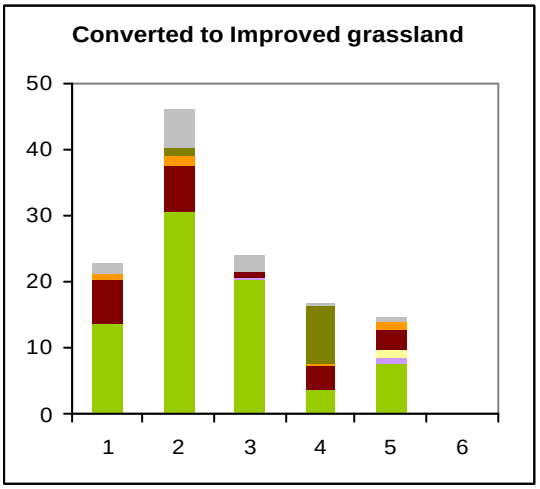
28 Neutral grassland were used in a fairly diversified way (Figure 2.1) while Acid grasslands were primarily grazed by sheep (Figure 2.2). Both Neutral and Acid grassland being used for dairy were significantly more likely to be converted to Improved grassland than parcels with other use (Neutral $Chi^2 = 27.6$, $df = 16$, $p < 0.05$; 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 $Chi^2 = 33.4$, $df = 16$, $p < 0.05$).

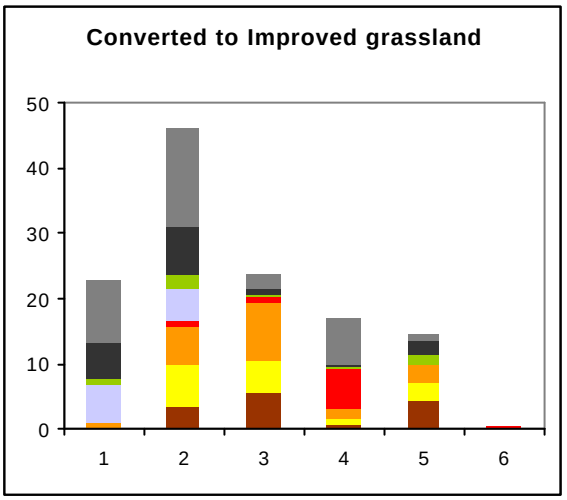
29 Areas of Heathland & moorlands converted to cultivated land were negligible compared to the area that remained the same between 1990 and 1998 and therefore statistical analyses could not be performed. As shown in Figure 2.3, converted areas tended to be more fertile with primary codes such as 'Fertile', 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.

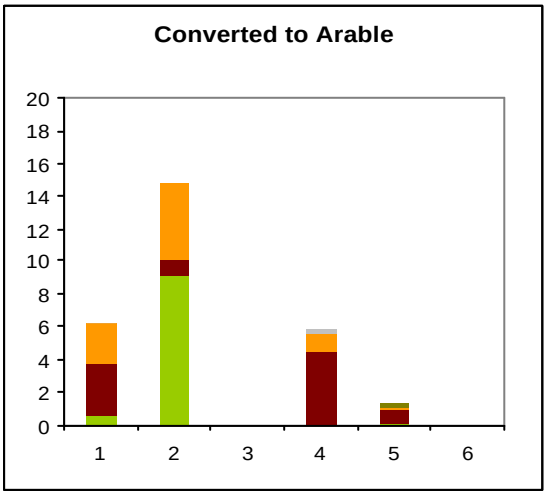
Figure 2.1: Primary code and use of Neutral grassland in 1990 that either did not change allocation, were converted to Improved grassland or were converted to Arable & horticultural between 1990 and 1998, per Environmental Zone.











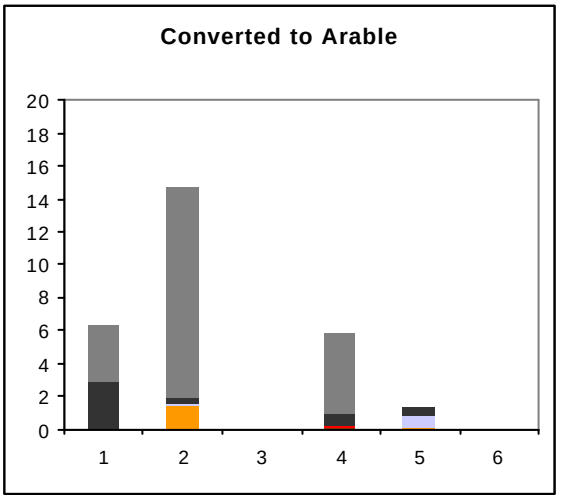
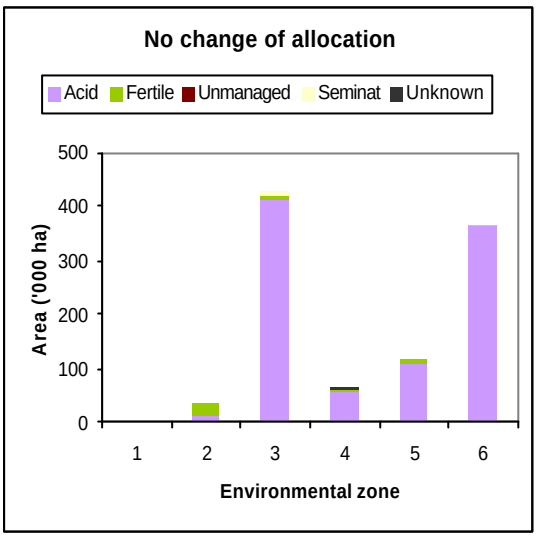
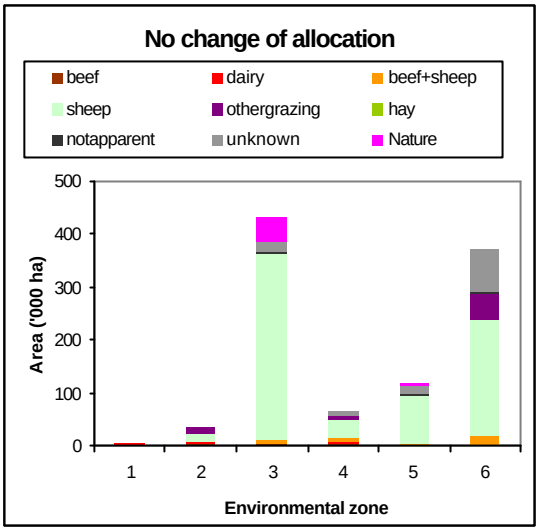
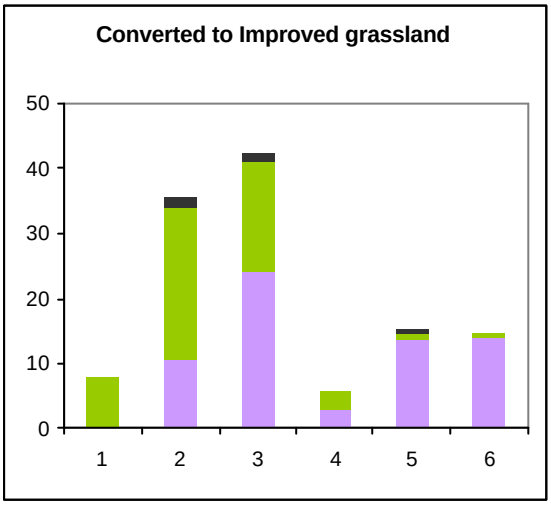
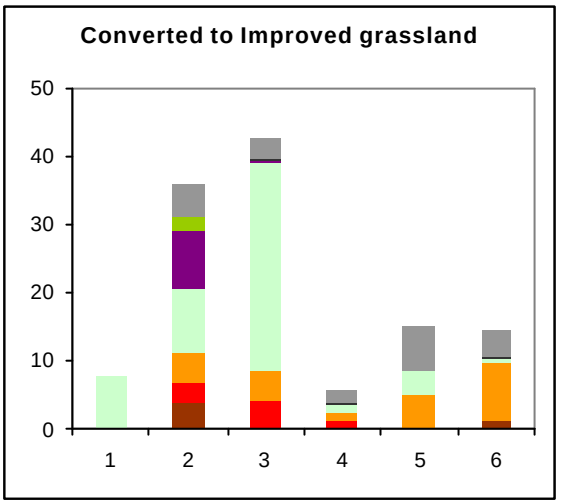


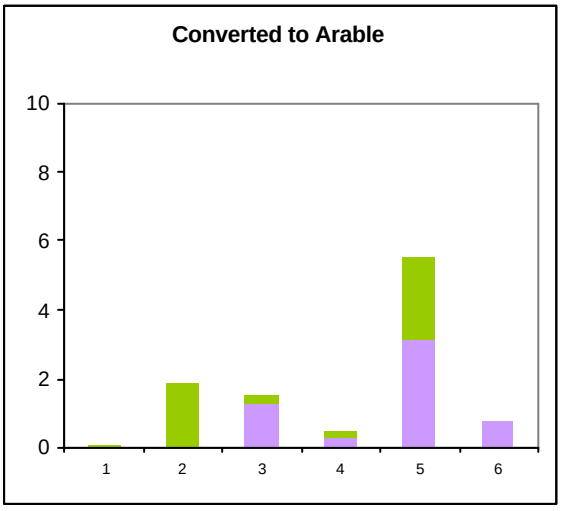
Figure 2.2: Primary code and use of Acid grassland in 1990 that either did not change allocation, were converted to Improved grassland or were converted to Arable & horticultural between 1990 and 1998, per Environmental Zone.











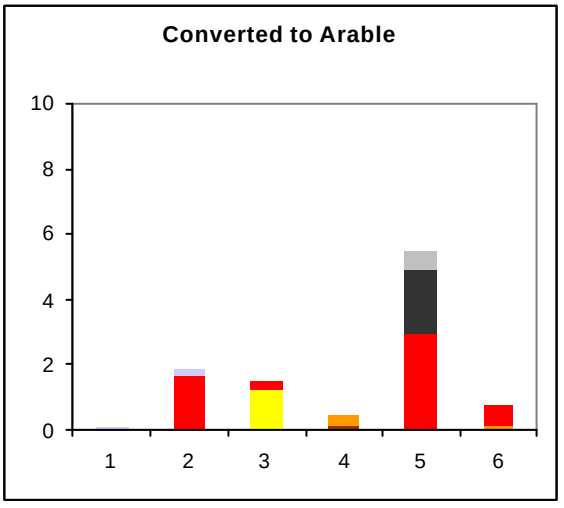
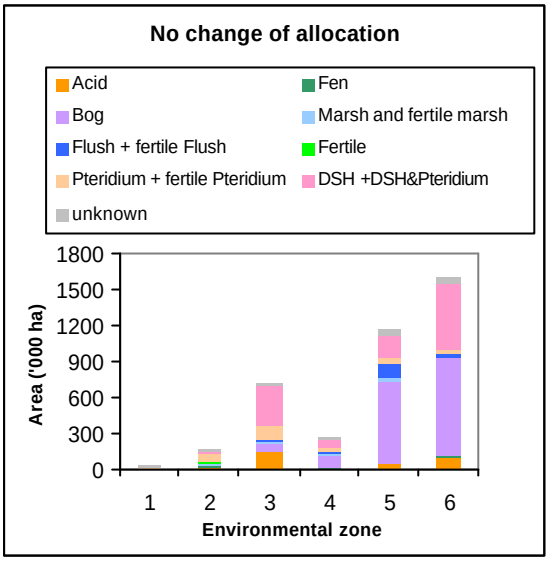
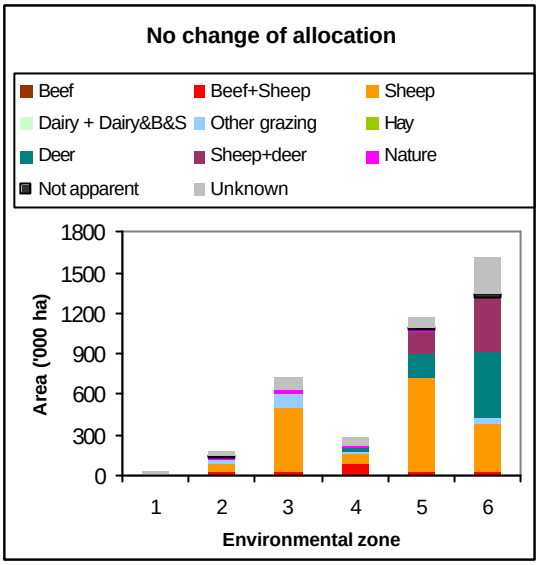
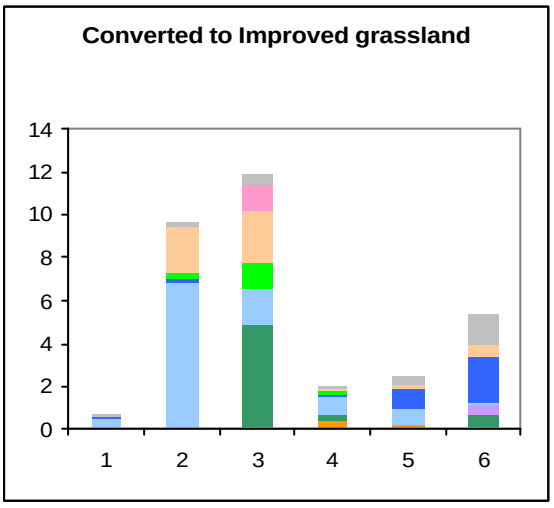
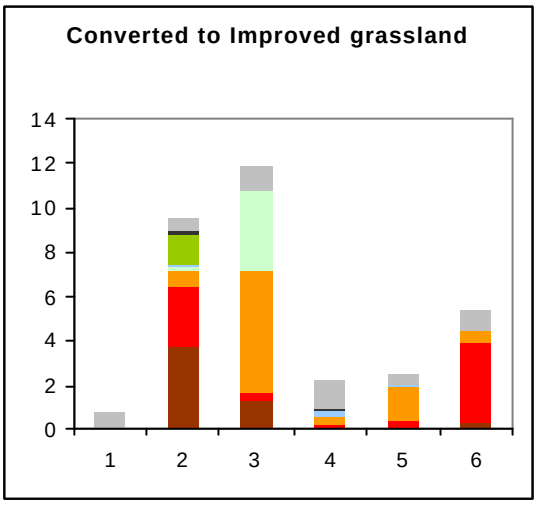


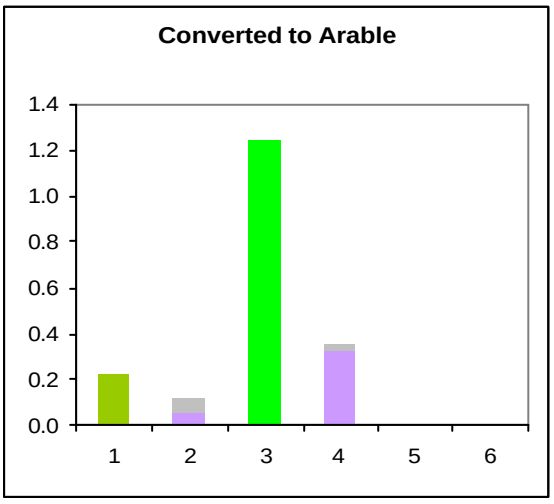
Figure 2.3: Primary code and use of Heathland & moorlands in 1990 that either did not change allocation, were converted to Improved grassland or were converted to Arable & horticultural between 1990 and 1998, per Environmental Zone.

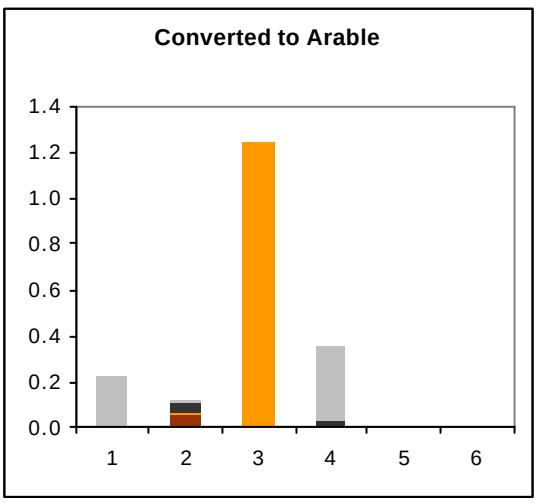












Characteristics of the vegetation

30 Vegetation plots that were recorded in 1990 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.

31 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.

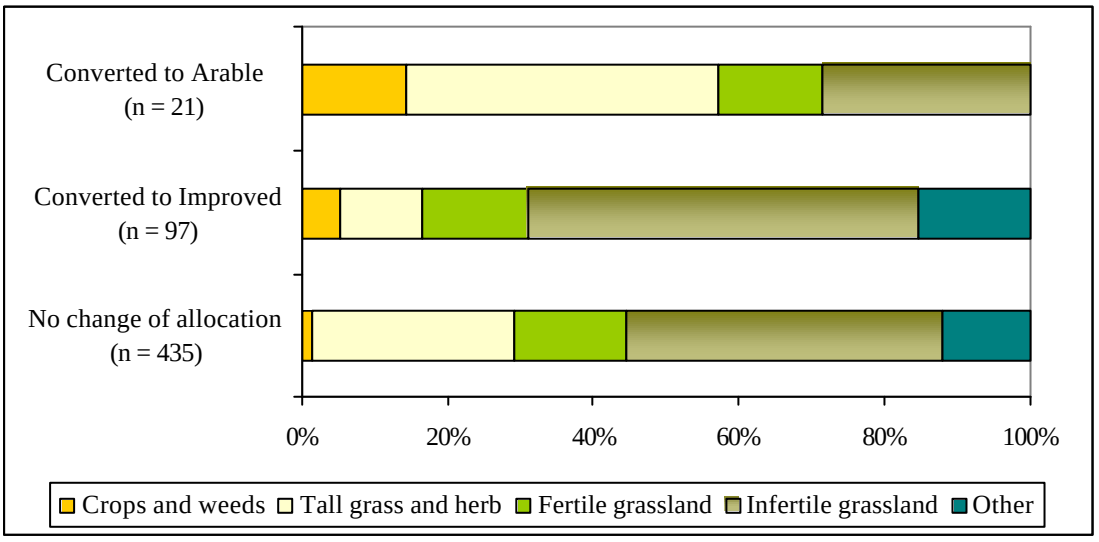
BH90	To BH98	No plots	Fertility	Wetness	pH
Neutral grassland	To Neutral grassland	435	5.36 (1.01)	5.71 (0.66)	6.02 (0.72)
	To Improved grassland	97	5.10 (0.90)	5.81 (0.75)	5.82 (0.66)
	To Arable & horticultural	21	5.81 (0.73)	5.33 (0.34)	6.26 (0.51)
Calcareous grassland	To Calcareous grassland	37	4.0 (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)

32 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.

33 The conversion of Neutral grassland to intensive agriculture meant that a substantial number of parcels characterised by the Infertile grassland vegetation class were lost (Figure 2.4). It was estimated that more than half of the parcels converted to Improved grassland were characterised by a vegetation of Infertile grassland, and only 12% by a vegetation of Fertile grassland. There was no apparent difference in the distribution of vegetation types between parcels that were converted to Improved grassland and parcels that stayed the same, i.e. a majority of Infertile grassland and to a lesser extent Tall grass herb and Fertile grassland vegetation types. This is in line with the fact that the Ellenberg scores of vegetation communities of Neutral grassland that stayed the same or were converted to Improved grassland were similar (Table 2.6)

34 The parcels of Neutral grassland converted to Arable & horticultural differed in their vegetation from parcels of Neutral that stayed the same or were converted to Improved grassland (Figure 2.4). The Crops and weeds class and the Tall grass and herb class tended to be more represented (in accordance with the over-representation of the Tall herb vegetation primary code for those parcels, see previous results). In contrast, only 25% of the parcels converted to Arable & horticultural were characterised by the Infertile grassland vegetation type. This however did not lead to a massive difference in the Ellenberg fertility score of these parcels (Table 2.6)

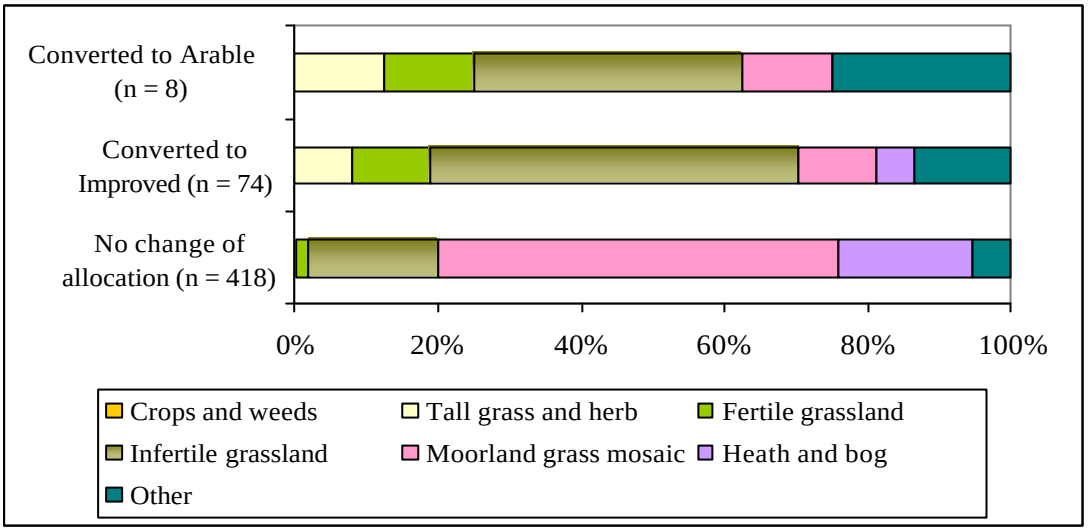
Figure 2.4: Frequency distribution of the vegetation types of the CVS in 1990 plots recorded in Neutral grassland for parcels that either did not change allocation or were converted to Improved grassland or Arable between 1990 and 1998. n = number of vegetation plots.



35 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 presented in Table 2.6 (parcels that remained unchanged were more acid and less fertile).

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



36 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.

37 Neutral grassland that were converted to Improved grassland and those that stayed the same had similar conservation value, which confirms previous results on vegetation types and Ellenberg scores. Parcels converted to Arable & horticultural had the same species richness and bird food plant species than parcels that remained unchanged. It is however clear that the composition of species will be different (see Figure 2.4).

38 If the vegetation composition of Acid grassland that remained unchanged was clearly different from the vegetation recorded in parcels that were to be converted to agriculture (Table 2.6 and figure 2.5), the number of plant species and their value to birds and butterflies are comparable in both types.

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)

Approach 3

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.

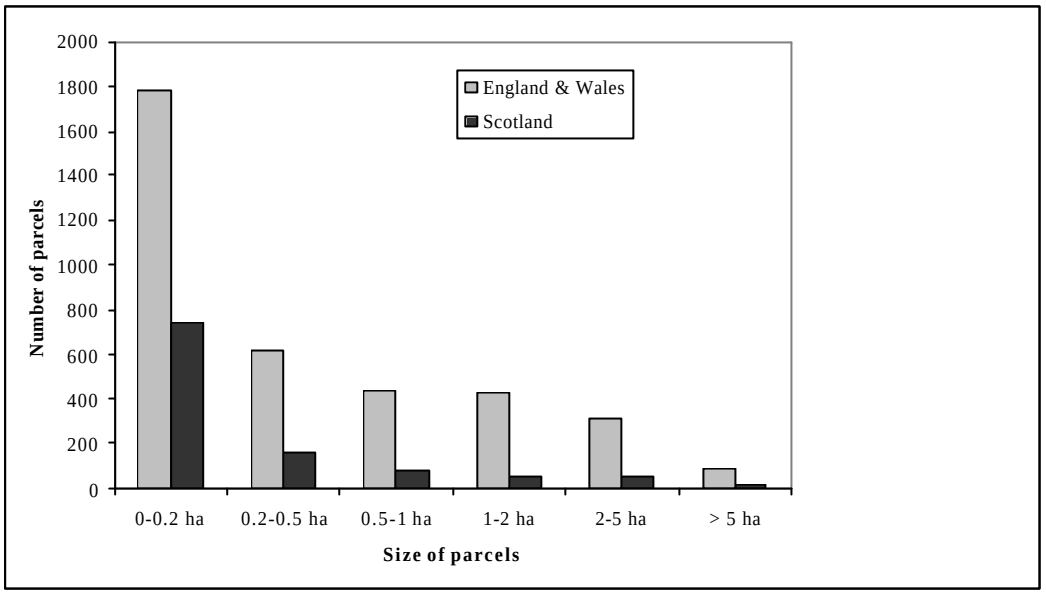
Analysis of the distribution of parcel size

39 We first examined the distribution of size of parcels there were not intensive agriculture in 1990 and were converted to intensive agriculture in 1998 (Figure 2.6)

40 Respectively 48% of parcels converted to intensive agriculture in England & Wales and 66% in Scotland were smaller than 0.2 ha (Figure 2.1) although these conversions account for only 4% of the total area converted in England & Wales and 7% in Scotland. These parcels are too small to represent management units and are likely to be strips of land located along existing fields or improved grass or small pieces of land located at the corner of existing management units.

41 Respectively 23% of converted parcels in England & Wales and 12% in Scotland were larger than 1 ha – these conversions account for 75% of the area that was converted to intensive agriculture for both countries. Of those, 20% in area were converted to *Arable and Horticultural* in England & Wales while this percentage is higher in Scotland, i.e. 38% in area.

Figure 2.6: Frequency distribution of parcels of land converted to intensive Agriculture in England & Wales and in Scotland between 1990 and 1998 per size of parcels.



42 We then examined the average parcel size per square of Permanent grassland, according to the change of allocation observed between 1990 and 1998. It appears that in GB overall, the average size per square of converted Permanent grassland tended to be larger than the mean size per square of parcels 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).

43 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 average parcel size per square 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

44 To clarify results presented in Table 2.8, we examined per country and Environmental Zones the frequency distribution of different classes of size for individual parcels that were in 1990 Neutral grassland (Table 2.9), Calcareous grassland (Table 2.10) or Acid grassland (Table 2.11). Results are presented according to the fate of parcels between 1990 and 1998, i.e. i) converted to Arable & horticultural , ii) converted to Improved grassland or iii) stayed the same.

45 It appeared that conversion to intensive agriculture was not restricted to very small or very large parcels and that the distribution of size of converted parcels was often similar to the distribution observed for parcels that were not converted. There were however notable exceptions such as the relatively large size of parcels of Calcareous grassland converted to Improved grassland in Environmental Zone 5 (Table 2.8), the large size of parcels of Neutral grassland converted to Improved grassland in Environmental Zones 2 and 3, and finally the large size of parcels of Acid grassland converted to Improved grassland in Environmental Zones 2 and 6 (Table 2.10).

Table 2.9: Distribution of parcels of Neutral grassland in 1990 into 5 size classes and according to changes between 1990 and 1998. n = number of parcels.

Zone	Change 90-98	n	% of parcels in size classes				
			<0.2 ha	0.2-0.5 ha	0.5-1 ha	1-2 ha	>2 ha
1	***C. Arable***	**37**	54	27	8	11	0
	C. Improved	**104**	58	20	9	10	4
	Stay-same	**523**	62	22	9	5	2
2	***C. Arable***	**42**	69	12	7	5	6
	C. Improved	**227**	51	25	13	7	5
	Stay-same	**709**	72	17	7	4	0
3	***C. Arable***	**0**	-	-	-	-	-
	C. Improved	**88**	56	15	8	16	5
	Stay-same	**210**	71	15	6	8	0
E&W	***C. Arable***	**79**	62	19	8	8	3
	C. Improved	**419**	53	22	11	9	5
	Stay-same	**1442**	68	19	7	5	1
4	***C. Arable***	**41**	68	20	2	5	4
	C. Improved	**111**	68	18	5	5	5
	Stay-same	**838**	73	17	5	3	2
5	***C. Arable***	**14**	57	36	0	0	7
	C. Improved	**206**	80	12	2	2	1
	Stay-same	**321**	73	18	5	2	2
6	***C. Arable***	**0**	-	-	-	-	-
	C. Improved	**5**	80	20	0	0	0
	Stay-same	**78**	68	23	5	4	0
Sc.	***C. Arable***	**55**	65	24	2	4	5
	C. Improved	**322**	76	14	4	3	3
	Stay-same	**1237**	72	18	5	3	2

Table 2.10: Distribution of parcels of Calcareous grassland in 1990 into 5 size classes and according to changes between 1990 and 1998. n = number of parcels.

Zone	Change 90-98	n	% of parcels in size classes				
			<0.2 ha	0.2-0.5 ha	0.5-1 ha	1-2 ha	>2 ha
1	***C. Arable***	**1**	-	-	-	-	-
	C. Improved	**26**	62	23	12	4	0
	Stay-same	**90**	58	14	13	10	4
2	***C. Arable***	**0**	-	-	-	-	-
	C. Improved	**20**	65	5	5	5	20
	Stay-same	**90**	57	17	12	9	5
5	***C. Arable***	**40**	73	18	6	5	0
	C. Improved	**27**	30	41	15	15	0
	Stay-same	**324**	71	17	7	2	3

Table 2.11: Distribution of parcels of Acid grassland in 1990 into 5 size classes and according to changes between 1990 and 1998. n = number of parcels.

Zone	Change 90-98	n	% of parcels in size classes				
			<0.2 ha	0.2-0.5 ha	0.5-1 ha	1-2 ha	>2 ha
1	***C. Arable***	1	-	-	-	-	-
	C. Improved	6	17	17	0	33	34
	Stay-same	19	58	21	0	16	5
2	***C. Arable***	9	56	11	22	0	11
	C. Improved	178	58	19	9	9	5
	Stay-same	306	69	17	8	3	2
3	***C. Arable***	4	50	25	0	25	0
	C. Improved	250	62	15	10	9	5
	Stay-same	2105	65	17	9	5	4
E&W	***C. Arable***	14	58	14	14	7	7
	C. Improved	434	60	17	9	9	5
	Stay-same	2430	66	26	9	5	3
4	***C. Arable***	4	50	25	25	0	0
	C. Improved	47	72	11	9	4	4
	Stay-same	620	73	14	6	4	1
5	***C. Arable***	8	38	0	13	0	50
	C. Improved	101	74	13	6	3	4
	Stay-same	1336	80	11	4	3	2
6	***C. Arable***	2	33	33	0	33	0
	C. Improved	32	22	19	38	13	9
	Stay-same	1678	63	18	10	5	4
Sc.	***C. Arable***	15	40	13	13	1	27
	C. Improved	180	65	13	12	5	5
	Stay-same	3634	71	15	7	4	3

Effect of adjacent land uses found in the 1 km square

46 At the GB level, there were a number of strong significant relationships between the proportion of Permanent grassland converted to cultivated land and the Broad Habitat composition of the 1km square.

47 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 2.12). 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 2.12: 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

48 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 2.13). 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 2.13: 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	- 0.501**	0.380**	0.284**
% Heath. & moor. in square	0.460**	- 0.375**	- 0.214**
% Woodland in square	0.01	-0.018	0.013

49 We then examined, per country and Environmental Zone, the Broad Habitat composition of the squares in 1990 where different proportions of Permanent grassland had been converted to intensive agriculture. We differentiated squares where either less than 10% of the 1990 stock of Permanent grassland was converted, where between 10 and 50% was converted and finally where more than 50% of the 1990 stock was converted.

50 Table 2.14 presents the 1990 Broad Habitat composition of squares with different proportions of Neutral grassland that were converted to Improved grassland between 1990 and 1998. In Environmental Zones 1 and 2, the Lowland zones of England & Wales, squares where the proportion of conversion was low were squares where few Permanent grassland were available and where most of the square was already occupied by intensive agriculture in 1990. This could indicate that in these regions, most of agriculture intensification has already been achieved with few Permanent grassland left to be converted. In contrast, in Environmental Zones 3, 4 and 5, the highest proportions of Neutral grassland converted to Improved grassland between 1990 and 1998 occurred in squares which presented the highest proportion of intensive agriculture.

51 Table 2.15 presents results of a similar analysis for Neutral grassland converted to Arable & horticultural. In all Environmental zones (expect Environmental zones 3 and 6 where there were too few conversions), the highest proportions of Neutral grassland converted to Arable & horticultural between 1990 and 1998 were found in squares that had the highest proportions of Arable & horticultural and intensive agriculture in 1990. This trend is less pronounced in the arable landscape of Environmental Zone 1.

52 The proportion of Acid grassland converted to Improved grassland was higher than 10% only in a few squares, mainly in Environmental zones 2 and 3, and to a lesser extent Environmental Zone 4 (Table 2.16). In Environmental zones 3 and 4, the highest proportion of conversion was observed in squares already composed of a large amount of intensive agriculture.

Table 2.14: BH square composition (as % of square) per Environmental zone for squares where (a) 0 to 10%, (b) 10 to 50% and (c) 50 to 100% of Neutral grassland were converted to Improved grassland

Zone	% converted	n squares	Neutral grassland	Intensive agriculture	Permanent grassland	Woodland	Semi-natural
1	**0-10**	52	1	80	2	8	0
	10-50	24	4	75	5	6	1
	50-100	27	3	70	4	14	0
2	**0-10**	37	3	64	3	8	5
	10-50	33	5	59	8	9	4
	50-100	40	4	59	7	10	3
3	**0-10**	5	1	20	43	20	15
	10-50	6	4	51	14	11	16
	50-100	15	5	54	17	8	13
4	**0-10**	24	5	41	9	19	16
	10-50	19	5	64	9	7	5
	50-100	11	11	58	15	8	11
5	**0-10**	15	5	22	12	16	32
	10-50	6	8	52	13	18	7
	50-100	5	9	40	16	17	16
6	**0-10**	8	2	11	24	37	24
	10-50	2	1	6	33	13	46
	50-100	0	-	-	-	-	-

Table 2.15: BH square composition (as % of square) per Environmental zone for squares where (a) 0 to 10%, (b) 10 to 50% and (c) 50 to 100% of Neutral grassland were converted to Arable and Horticulture

Zone	% converted	n squares	Arable	Intensive agriculture	Permanent grassland	Woodland	Semi-natural
1	**0-10**	82	54	75	3	9	0
	10-50	13	58	80	3	10	0
	50-100	8	62	80	2	9	2
2	**0-10**	91	16	59	6	9	4
	10-50	12	27	68	4	7	2
	50-100	7	33	72	10	7	1
3	**0-10**	26	4	47	22	11	14
	10-50	0	-	-	-	-	-
	50-100	0	-	-	-	-	-
4	**0-10**	40	13	46	11	14	13
	10-50	9	44	73	7	8	4
	50-100	5	49	66	7	9	8
5	**0-10**	21	5	31	11	16	27
	10-50	4	7	43	12	21	10
	50-100	1	22	26	58	0	0
6	**0-10**	10	1	10	26	32	29
	10-50	0	-	-	-	-	
	50-100	0	-	-	-	-	

Table 2.16: BH square composition (as % of square) per Environmental zone for squares where (a) 0 to 10%, (b) 10 to 50% and (c) 50 to 100% of Acid grassland were converted to Improved grassland

Zone	% converted	n squares	Acid grassland	Intensive agriculture	Permanent grassland	Semi-natural
1	**0-10**	6	1	55	4	2
	10-50	0	-	-	-	-
	50-100	3	5	78	6	0
2	**0-10**	13	3	47	5	13
	10-50	9	11	53	20	2
	50-100	18	3	47	8	11
3	**0-10**	22	33	9	34	45
	10-50	6	42	33	43	15
	50-100	13	11	42	14	22
4	**0-10**	18	9	37	16	30
	10-50	3	13	34	20	25
	50-100	8	6	64	10	12
5	**0-10**	43	5	9	8	53
	10-50	4	13	17	15	51
	50-100	4	15	18	20	34
6	**0-10**	47	17	3	18	59
	10-50	1	31	2	31	49
	50-100	3	43	9	44	37

SUMMARY

- Most of the conversions to cultivated land occurred on previously Neutral grassland and Acid grassland. It was estimated that between 100, 000 and 200,000 ha of Neutral grassland and the same amount of Acid grassland was lost to intensive agriculture between 1990 and 1998.
- CS also recorded conversions from Calcareous grassland 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.

Neutral grassland

- It was estimated that relatively large proportions of the 1990 stock of Neutral grassland had been converted to intensive agriculture between 1990 and 1998, respectively between 2 and 8% to Arable & horticultural (geographically limited to the lowland zones) and between 19 and 34% to Improved grassland (occurring in all zones but the Scottish Highlands).
- A comparison between parcels of Neutral grassland 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, parcels that would be converted to Improved grassland tended to be larger than those which stayed the same nationally, although this trend is only apparent in Environmental Zones 2 and 3. Nationally, conversions occurred significantly more in squares where cultivated land was already well represented. However, this trend is not true in Environmental Zones 1 and 2, probably because the proportion of intensive agriculture in the squares is already very high .

Acid grassland

- The proportion of the 1990 stock of Acid grassland that had been converted to intensive agriculture between 1990 and 1998 was estimated to be respectively less than 1% to Arable & horticultural and between 5 and 14% to Improved grassland. These conversions occurred mainly in Environmental Zones 2, 3 and 5. The proportion of 1990 Acid grassland lost to Improved grassland was larger in England &Wales (8 to 18%) than in Scotland (2 to 8%).
- Analyses of CS survey codes and vegetation plot data both indicated that converted parcels of Acid grassland 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.
- Nationally, the size of average size of parcels per square was the same for Acid grassland that were converted and those that stayed the same, although converted parcels tended to be larger in Environmental Zones 2 and 6. Nationally and in each Environmental Zone, conversions were significantly more likely to occur in squares where cultivated land was already present.

FURTHER WORK AND RECOMMENDED CHANGES TO CS METHODS

53 Targeting of survey if we are to provide information on unlikely conversion.