Farmland Ecology and the Uptake of Non-Agricultural Activities by Farm Households

Noranne E.Ellis

Ph.D.
The University of Edinburgh
1994

Declaration

I declare that the work presented in this thesis is my own.

ABSTRACT OF THESIS

From the 1940's, British agricultural policies have actively encouraged intensive farming, causing reductions in the extents and numbers of both habitats and species within the countryside. Concern within Europe about the increasing cost of surplus agricultural production reversed further intensification from the late 1970's but has not appeared to reverse the detrimental ecological impact within Britain. However, with a fall in both agricultural production and support, farm households have been passively and actively encouraged to turn to supplementary sources of income. Associated with less intensive land management, would this have noticeably beneficial repercussions for biodiversity? The link between the socio-economic forces which affect land-use and hence the ecological characteristics of the land were therefore examined.

A socio-economic survey visited 295 Grampian farms in 1991 to determine the extent of involvement in non-agricultural activities by farm households, a phenomenon known as 'pluriactivity'. Pluriactivity includes work off the farm as well as non-agricultural activities on the farm (e.g. Bed & Breakfasts, caravan sites, farm shops *etc.*). The uptake of pluriactivity was found to be increasing, having trebled between 1980 and 1990 and doubling between 1987 and 1990.

Seventy-one farms were selected for field survey work from the socio-economic sample. This smaller sample was stratified along a range of environmental conditions and according to their non-involvement or type of involvement in pluriactivity - whether off the farm, on the farm or both. A field survey obtained data on the extents of different vegetation cover types within each farm group and on the species composition of their grasslands. Data on grassland management were also obtained through an interview with the farmer.

Although each farm group varied, pluriactive farm households were generally younger, better educated and were generally associated with greater diversities of habitats and grassland species. However, the life history strategy composition (*sensu* Grime, 1974) of grassland communities indicated only small variations in land management intensity although the quality of ingressing grassland species varied between the farm groups. Multiple regression analyses and correlations indicated that the underlying socio-economic differences between the groups were as likely as the involvement in pluriactivity to account for the variations in grassland species diversity.

Predictions on future changes on Grampian farmland indicate that both habitat and species diversities will increase but that this will be more a reflection of changing socio-economic structures of farm household populations rather than an increasing uptake of and involvement in pluriactivity.

Acknowledgments

For the initial conception of this thesis and the constant encouragement and support to its completion, most gratitude goes to my supervisor, Professor Bill Heal of the Institute of Terrestrial Ecology (ITE), Edinburgh.

Secondly most thanks go to the farmers in Grampian who co-operated in allowing both their lives and land to be surveyed, and to Emma Edwards-Jones and Alice Broom who were invaluable in obtaining the field survey data.

Thirdly, thanks go to the 'JAEP' (Joint Agriculture and Environment Programme) project team, led and encouraged by Professor J.B. Dent of the School of Agriculture, Edinburgh, and co-ordinated by Professor J.S. Bibby of the School of Agriculture, Aberdeen: Tim Perkins, who provided tuition in using the Geographic Information System, and Kate Corcoran (Scottish Agricultural College, SAC, Edinburgh), Morag Mitchell (SAC, Auchincruive), Helen Edmonds (Macaulay Land Use Research Institute, MLURI, Aberdeen) and Dr. A.S. Davies (SAC, Aberdeen). Professor J.S. Bibby also provided soil data and a photocopier (!) to obtain data on the air photo interpretation of the land cover of Scotland at the MLURI to which thanks also go to Dr. R.V. Birnie and A.D. Moir of the MLURI who provided access to the data.

At ITE (Edinburgh), I am extremely grateful to Ron Smith who provided help with the analyses and the use of GENSTAT to alter the length of variables between datasets, and the NERC Computing Services (NCS) team: Jane Robertson for helping set up the Oracle database, Ruth Addinall for writing a short computer program converting quadrat datasets into a form suitable for TWINSPAN and DECORANA, and Tim Duffey for indicating how to export data from the Geographic Information System to Oracle.

At ITE (Merlewood), I especially thank Dr. R.G.H. Bunce and Caroline Hallam for pointing out the right direction to investigate the botanical composition of grasslands and the interpretation of the TWINSPAN and DECORANA output. I also thank Dr. D. Howard and Caroline Hallam for helping me obtain data from the ITE 'Land

Classification' database before it was established in its now universal form as the 'Countryside Information Survey' database, and for the permission to its access, Colin Barr.

At ITE (Banchory), I thank David Welch who checked out botanical specimens during the survey work and who pointed out the existence of *Agrostis gigantea* in Grampian!

I am grateful to the advisors at SAC, Edinburgh, who were initially instructive about matters agricultural and, more specifically, to Dr. M. Black and Dr. J. Reid at the Farms Office, Bush Estate (near Edinburgh), who helped in the construction of the Field Questionnaire.

I am also grateful to Dr. A. Reid of the Statistics Department at the Scottish Office, Edinburgh, who provided data on the frequency of farms in the various Scottish Office categories for Scotland and Grampian, and to Dr. J. Hodgson of the Unit of Comparative Plant Ecology at Sheffield University for checking the method of the plant strategy analyses.

Lastly, but not least, I am very grateful for the encouragement and support from all the staff at ITE (Edinburgh) - even from those supposedly more interested in the botany of the Tropics! Particularly: Tom Murray, for his help in sorting out any problem (computer or otherwise), Graham Bell, for his helpful appraisals, and Dr. Jan Dick and husband Drew Coulter for their comments as an example of a farm household in the OFF-FARM group in the Borders Region of Scotland!

Contents

SUMMARY

Background

1. From the late 1970's, agricultural policies have encouraged extensive farming methods in order to reduce the cost of dealing with agricultural surpluses in Europe. The resultant decline in farming incomes in Britain, however, has been associated with an increased uptake of non-agricultural activities by farm households, a phenomenon known as 'pluriactivity'. A socio-economic survey was therefore undertaken in 1991 on 506 farms in three regions of Scotland (Grampian, Fife and Galloway) to determine the nature and extent of involvement in pluriactivity (Dent *et al*, 1993). This was a Joint Agriculture and Environment Programme (JAEP) project involving the Scottish Agricultural Colleges, the Macaulay Land Use Research Institute and the Institute of Terrestrial Ecology (ITE). This study was based at ITE, Edinburgh, to identify and define any impact pluriactivity may have on farmland ecology.

Introduction to the Ecological Investigation

2. The main hypothesis of this study was that pluriactivity would be associated with an increase in the extent and numbers of semi-natural habitats and plant species within farmland. High numbers of habitat and plant species are associated with greater number of wildlife species (e.g. see NCC, 1977). Seventy-one farms were therefore selected from the socio-economic database to collect ecological data through a field survey. The 71 farms were stratified according to their non-involvement or type of involvement in pluriactivity, i.e. whether the pluriactivity was exclusively off or on the farm or both. These farm groups were termed 'non-pluriactive', 'OFF-FARM', 'ON-FARM' and 'BOTH' respectively. Farms within each farm group were also stratified by ITE Land Classes (described in Bunce, Barr & Whittaker, 1981) to ensure against any potential bias related to the physical characteristics of the land.

Field Survey Data Collection

3. The field survey was undertaken by two persons during August to mid-October 1991 and July to early October 1992. Vegetation cover maps for whole

farm areas (i.e. including every holding) were made at a 1:10 000 scale. Using 2 x 2m quadrats within the grass fields and 1 x 10m plots along their boundaries (i.e. fences and stone walls), lists of vascular plant and bryophyte species were recorded with percentage cover. The vegetation cover maps were made and quadrat data collected using the method of ITE's 'Countryside Survey 1990' (Barr *et al*, 1993). Data were also obtained on the use and management of each grass field through an interview with the farmer.

Analyses

4. The vegetation cover maps were digitised into a Geographic Information System, 'Arc/Info', which measured the extent (hectarage) of each vegetation type per farm. The Arc/Info data was transferred into the relational database, 'Oracle', where all data for the study were stored. Data were extracted from the database for analyses which were made in the statistical package GENSTAT (Payne *et al*, 1987). Due to variations in farm areas the cover of each vegetation type within each farm was calculated proportionally. The mean proportions of each vegetation type per farm for the three pluriactive groups were compared individually to those of the non-pluriactive farms using one-way analyses of variance within an angular transformation. The mean number of species per quadrat/plot were calculated likewise but also by each type of grass field use. Mean numbers of 'agriculturally-preferred' species, 'arable weeds', 'semi-natural' species and bryophytes per quadrat/plot were compared only between the farm groups. Multivariate analyses packages ('DECORANA' and 'TWINSPAN'; Hill 1979) were used to interpret species compositions in terms of land management factors.

For each farm group, multiple-regression and correlation analyses were used to identify which socio-economic, land use and management factors (from a selected number of variables) were most influential in determining the number of species found within the grasslands of a farm.

Results

5. *Farm and Socio-economic Characteristics*

Data obtained from the socio-economic survey indicated that non-pluriactive and OFF-FARM groups were mainly livestock (non-suckler beef and/or sheep) whilst the ON-FARM and BOTH groups were mainly arable. The non-pluriactive farms had significantly older ($P<0.01$) and smaller ($P<0.01$) families than each pluriactive group, although those within the ON-FARM and BOTH groups were slightly younger than those within the OFF-FARM group. A greater proportion of farmers within the ON-FARM group had obtained a tertiary level of education.

6. *Vegetation Cover*

The mean proportions of grass per farm for the ON-FARM and BOTH groups were less (although not significantly) than that within non-pluriactive farms. The share of arable and grass within the OFF-FARM group was similar to that on non-pluriactive farms. However all three pluriactive groups had 7-13% more un-farmed land (i.e. moorland, scrub and 'neglected' land) than the non-pluriactive farms; the ON-FARM group had 10% more ($P<0.01$) woodland.

7. *Grass Field Use and Management*

The farmer interview revealed that pluriactive farms tended to have proportionally more grass fields used for sheep than for cattle. The OFF-FARM and BOTH groups had fewer ($P<0.01$) cattle fields than non-pluriactive farms. The ON-FARM group had nearly double the proportion of fields used for other types of grazing (such as pigs, poultry and goats) than any other group. The BOTH group had four times the proportion of fields under the 'cereal set-aside' scheme than non-pluriactive farms; the OFF-FARM and ON-FARM groups had no fields under 'set-aside' but rented out twice the proportion of fields.

The rate of grassland reseeding tended to be slightly less within the OFF-FARM and BOTH groups than within non-pluriactive farms. Although no individual pluriactive group applied significantly less fertiliser nitrogen to their grass fields than the non-pluriactive farms, the pluriactive farms together did ($P<0.05$).

8. *The Species Composition of Grass Field Swards*

One hundred and five vascular and non-vascular species were identified within the open field. In comparison to non-pluriactive farms, farms within the OFF-FARM and BOTH groups had upto five more species for any given $4m^2$ within grass fields depending on the field use. Although this was associated with more ($P<0.05$) semi-natural species within the OFF-FARM group, the BOTH group had more bryophyte species ($P<0.01$). The ON-FARM group was associated with 1-2 more species per $4m^2$, except for fields used for cattle which had fewer ($P<0.01$) species. Pluriactive farms reseeded with perennial ryegrass (*Lolium perenne)* and white clover (*Trifolium repens*) whilst non-pluriactive farms tended to also include cocksfoot (*Dactylis glomerata*) and timothy grass (*Phleum pratense*). The semi-natural species within the swards of the OFF-FARM group were associated with more permanent/slightly wetter pastures ($P<0.05$) whereas grassland species in the ON-FARM group were associated with lower application rates of fertiliser nitrogen ($P<0.01$).

Using the life history strategy model of Grime (1974), grass swards within each farm group indicated that Grampian grasslands are highly disturbed and highly eutrophic. Comparison of the occurrence of plants of each life history strategy within each pluriactive farm group to the non-pluriactive farms showed only the BOTH group to have more stress-tolerant species ($P<0.05$) (i.e. species that are indicative of less disturbance and lower fertility) although stress-tolerant species did not constitute more than 1% of species occurrences.

Using Whittaker's (1960) β-diversity measure, the distribution of species over farms in each group were relatively homogeneous which suggested that management intensity was uniformly distributed over a farm and not localised.

9. *The Species Composition of Grass Field Boundaries*

Although the area surveyed along the field boundaries was 25% greater than the area surveyed within the open field, 73% (70) more species were found along the boundaries than within the field. However, the vegetation composition along the boundaries was similar between farm groups, grass field uses and type of boundary. The number of species per $10m^2$ plot ranged between 10-19 for the non-pluriactive, OFF-FARM and BOTH groups. The ON-FARM group had a slightly greater range in diversity with 9-20 species per $10m^2$, the lowest values associated with cattle which were lower ($P<0.05$) than those within non-pluriactive farms. The life history composition of the boundary vegetation indicated that field boundaries were as eutrophic although less disturbed than the open field. Stress-tolerant species accounted for upto 3% of species.

10. *The Relationships between the Socio-economic, Time Allocation and Land Use/management to the Botanical Richness of Grass Fields*

Within non-pluriactive farms, 26.3% of the botanical richness in grassland was accounted for by the proportion of young (<4 years) grass fields ($P<0.01$), there being fewer species with a greater extent of young grass. Within the OFF-FARM group the less time given to farming was associated with a greater botanical richness in grass fields and explained 47% of the variability in the botanical richness ($P<0.01$). However, the less time spent farming was associated ($P<0.01$) with larger farm households which, in turn, were associated with a greater number of earners off the farm. Since the reseeding and stocking of grass fields in this group is less frequent than in other farm groups, it is believed that off-farm work is partly encouraged by a fall in farm income.

Within the ON-FARM group, fewer species within grass fields was associated with ($P<0.05$) a greater number of employees, accounting for 37.5% of the variability of botanical richness.

The BOTH group was a heterogenous group of farms in terms of their socio-economic characteristics. Only the number of employees significantly accounted for any (18.2%) of the botanical richness in grass fields. However, an increase in the number of employees was associated with increasing numbers of species (although this was not significant in the correlations). From the quadrat analyses, the increase in the botanical richness was known to be caused by an increase in the number of bryophytes. Therefore the *quality* of the employees is important in determining the type of species in the grass swards of the BOTH group.

Prediction

11. Based on the average farmer age for each farm group, it is predicted that in the next decade there will be a reduction in the number of farms in the non-pluriactive and OFF-FARM groups, equating to approximately 7% and 5% of the regional land area respectively. The ON-FARM group appears to be the most stable younger group of farms in terms of farm income. It seems feasible that the ON-FARM group might therefore take on the management of the farms

leaving the non-pluriactive and OFF-FARM groups, possibly extending their current farm areas. If this scenario is to be true, then this would mean an increase in the extents of arable (particularly cereal) and broadleaf woodland, but a decrease in the extent of grassland and particularly the relatively species-rich grasslands associated with the OFF-FARM group. Grass species indicative of slightly less fertile soils (*Agrostis* spp. and *Holcus lanatus*) would be expected to increase their cover within remaining grasslands. The past depletion of stress-tolerant species within Grampian grasslands and their boundaries may mean that traditionally defined 'species-rich' fields (that is, with greater than 20 species per $1m^2$) may not develop naturally.

Conclusions

12. The involvement of farm household members in non-agricultural activities is associated with greater extents of non-agricultural habitats and greater numbers of non-sown plant species within grasslands, although the type of habitat and species varied according to the type of pluriactivity.

The type of pluriactivity also reflected the farm and farm household characteristics and it was concluded that socio-economic characteristics were of equal or greater importance than land management in determining the distribution of plant species in a landscape. Because of this, policies and grants, even when aimed at the same type of farmer (e.g. arable/livestock) were found to have differing ecological impacts upon the farm. It is therefore suggested that schemes that encourage more extensive farming over the whole farm would be more likely to enable a more predictable and uniform increase in non-agricultural habitats and species over a farm than schemes which target the reduction of management intensity in only one or two enterprises which opens the possibility of intensification in other enterprises.

CHAPTER 1

Introduction

"I know a bank whereon the wild thyme blows,
Where ox-lips and the nodding violet grows..."

A MIDSUMMER NIGHT'S DREAM
Shakespeare

1.1 *The Divergent Use of Land and the Requirement for Intensive Agriculture*

The surface of the earth is roughly 51 thousand million hectares but little more than one quarter is classed as land (Stamp, 1968). Only 11% of the total surface (excluding Antarctica) has no serious limitations for agriculture but more than one third of the land surface is used for producing food; livestock grazing accounts for 24% and crops 11% (FAO, 1978). Europe, having the greatest area of land (36%) with no serious limitations for agriculture (FAO, 1978), is predominantly agricultural. The United Kingdom has the greatest proportion of land (78%) used for agriculture (Best, 1981) (Fig. 1.1).

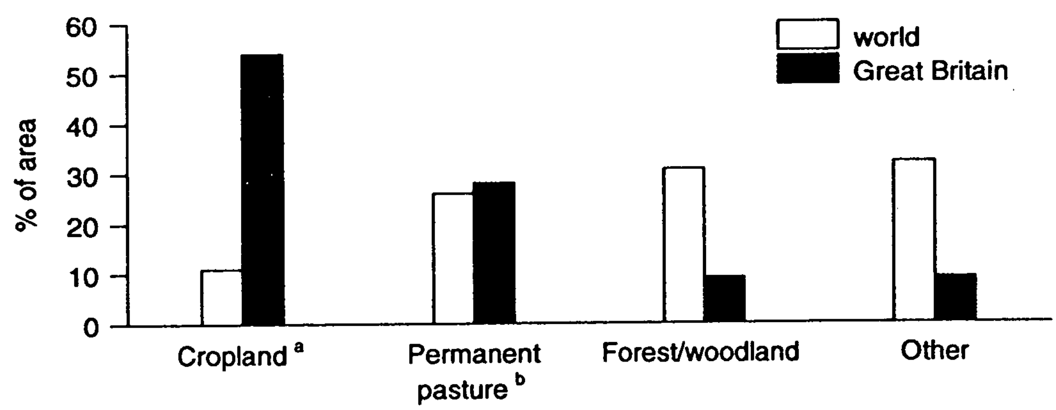


Fig. 1.1. A comparison of the allocation of land in 1990 between crops, livestock grazing and forestry at the world scale and for Great Britain. The land area of the world is 13,079,151,000ha; that for Great Britain (i.e. excluding Northern Ireland) is 24,022,000ha. [a] includes managed grass; [b] includes moorland/heath. Figures are from FAO (1991) and Barr *et al* (1993).

The world population increased by 75% between 1930 and 1990 (Whitaker's Almanac, 1993) and the requirement for increasing areas of land to be used for agriculture intensified worldwide. Despite a high proportion of land already under agricultural use, the UK still had to intensify the use of such land. This increased the tension between the allocation of land between agricultural use, non-agricultural activities (such as forestry and recreation) and semi-natural areas for wildlife conservation. The multiple use of land appears to have slowly developed in Britain (Bunce & Heal, 1984).

1.2 *Intensifying Agricultural Production in the UK and its Affect on the Countryside*

It was not until the Second World War that agricultural production within the UK was intensified, and this was in response to poor self-sufficiency in food production. As agriculture became more science-based, in the 1950's and 1960's a technological revolution occurred - the so-called 'green revolution'. This produced higher yielding crops (including grass), more agro-chemicals and more efficient machinery to improve the timeliness of cultivations. The yield of crops per unit area increased, for example, wheat yields increased from 1-2 tonnes per hectare in 1940 to 7 tonnes by the mid-1980's (MAFF, 1987). As a result, self-sufficiency for temperate food stuffs increased from 30% before the war to nearly 80% in the late 1980's (Green & Burnham, 1989).

Although technological advances enabled agricultural production to increase substantially for any given area of land, UK government policies still encouraged greater agricultural output and therefore increasing extents of land to be farmed. Britain lost 25% of its semi-natural vegetation between 1947 and 1980 (Huntings, 1986). Such losses included:

"Lowland herb-rich hay meadows: 95% now lacking significant wildlife interest...
Lowland grasslands of sheep walks. On chalk and Jurassic limestone: 80% loss...
Lowland heaths on acidic soils: 40% loss...
Ancient lowland woods composed of native, broad-leaved trees: 30-50% loss...
Lowland fens, valley and basin mires: 50% loss...

Lowland raised mires: 50% loss...
Upland grasslands, heaths and blanket bogs: 30% loss..." (NCC Report, 1984; figures are for Great Britain),

and 175,000 km (20%) of hedgerow between 1947 and 1985 in England and Wales (Huntings, 1986). The major cause of habitat loss was attributed to the intensive agricultural methods adopted during this century (Shoard, 1980; NCC Report, 1984).

In Scotland, at least 40% of land cover changed between the 1940's and the 1970's with considerable losses of moorland, ranging from 6-70% for a region (Budd, 1990). The loss of moorland was attributed to tree planting or conversion to agricultural grass (Budd, 1990). Hedgerow loss was also substantial in Scotland; between the 1940's and 1970's, 3000 km (45%) had been removed in the Borders (Budd, 1990) and 5967 km (41%) in Grampian (NCMS, 1988).

Forty-eight per cent of the UK agricultural land in 1981 was grass - the greatest proportion of grass in any European country along with Ireland; the Netherlands had the next most extensive grassland covering 39% of its agricultural area (Best, 1981). However, the extent of grassland (both semi-natural and agriculturally improved) decreased from 7.8M ha in England and Wales in 1937 to 4.8M ha by 1987 (Fuller, 1987). This was partly because land which had been extensively sown as grass during the agricultural depression of the late 1800's and early 1900's was reverted to arable use (Davies, 1941; Marsden *et al*, 1993). In 1939, the government introduced the 'plough-up' grant for grasslands after Stapledon (1939) recognised that greater productivity would follow the reseeding of grasslands he termed 'weedlands'. As the proportion of sown grass increased, the extent of permanent grass decreased from 5.4M ha in 1939 in England by 43% to 2.3M ha by 1959 (from Green, 1974[1]).

Semi-natural grasslands in Britain support about 550 species of flowering plants i.e. about one quarter of the British flora (Wells & Sheail, 1988). Between

---

[1]hectares were calculated from acres

8-40 species may be expected per square metre of permanent grassland (for example, Grime, 1973b) in comparison to newly reseeded swards consisting of a mixture of 1, 2 or 3 species, e.g. perennial ryegrass (*Lolium perenne*), Italian ryegrass (*L.multiflorum*), cocksfoot (*Dactylis glomerata*), timothy (*Phleum pratense*), white clover (*Trifolium repens*) and red clover (*T. pratense*). Perennial ryegrass is the most widely sown species as its seed is easy to produce, the plants develop quickly, yield well and respond well to nitrogen fertiliser (Hopkins, 1979). No grassland had received nitrogen fertiliser before 1938 (Green, 1982), but by 1985 85% of all grasslands had received some, including 79% of all permanent pasture fields (Elsmere, 1985). This has encouraged perennial ryegrass to dominate unploughed and older grasslands, replacing the more species-rich bent-grass (*Agrostis* spp.) dominated swards. Pastures with >30% cover of perennial ryegrass (i.e. the 'first-grade ryegrass pastures' of Davies, 1941) accounted for only 2% of permanent grassland before 1941 (Davies, 1941) but by the mid 1970's, this came to at least 40% (Forbes *et al*, 1980). Further increases have occurred since (Hopkins *et al*, 1985). Generally the proportion of ryegrass indicates the degree of agricultural improvement of the grassland by reseeding, the application of nitrogen fertiliser, soil drainage, increased grazing intensities and the widespread replacement of hay cutting by silage (Hopkins, 1988).

Even with the withdrawal of the plough-up grant in the 1960's, by 1984 only 0.6M ha of unimproved grassland and rough grazings remained in England and Wales, representing 11% of the total grassland area with unimproved pastures (excluding rough grazings) covering 0.2 M ha (or 4%) (Fuller, 1987). Since 1930 the distribution of 117 species out of 1,423 native flowering plants and ferns in Britain have declined by at least 33%, with 34 of these species belonging to grasslands (NCC, 1974).

"the main conservation problem of rare plants lies in the lowlands (of Great Britain) rather than in the Highlands of Scotland. 35 species of lowland grassland and other natural open habitats alone are at present threatened and the total number of lowland species in the Endangered or Vulnerable categories is 120" (my brackets) (Perring & Farrell, 1983).

With only 17.2% of Scotland's agricultural land classed as grassland in 1975 and 72% of agricultural land classed as rough grazings (EDC, 1987) it is not surprising that no detailed studies of Scottish lowland grasslands exist. However, even before the war Stamp (1946) noted that Scottish farmers preferred reseeded to permanent grass; less than 10% of Scottish grassland was classed as 'permanent'. Agricultural grasslands in Scotland are therefore possibly less species-rich than elsewhere in Britain.

The 'green revolution', with the introduction of chemical methods of weed control and varieties of cereal crops that could be planted closer together, also caused serious declines in populations of some arable weeds. Ninety-six per cent of the 23 British rare species are endangered in some way; for example, corn crowfoot (*Ranunculus arvensis*), corn cockle (*Agrostemma githago*) and shepherd's needle (*Scandix pecten-veneris*) (Perring & Farrell, 1983). Although Barr *et al* (1993) noted that the rates of loss of semi-natural habitats had declined in Britain by 1990, there was still an overall decline in botanical diversity.

1.3 *The Agricultural Reform in Europe and its Affect on the British Countryside*

"...whether in North America, Continental Europe or the United Kingdom, the spectre of insufficient food supplies by the end of the century is largely a figment of the imagination. Indeed, the opposite circumstances more nearly applies, and one of the most serious problems facing North American and European agriculture, both now and in the future, is the predicament of surplus production and the related dilemma of too much farmland rather than too little" (Best, 1981).

Britain joined the European Common Market in 1973. Technology continued to enable a more efficient use of agricultural land, with new levels of production support and guaranteed markets under the Common Agricultural Policy (CAP). This encouraged record yields of cereals and livestock products - Britain, once a net importer of cereals, became the sixth largest exporter in the world (MAFF, 1987). Yet policies encouraged the 'improvement' of even more land and surpluses built up (Shoard, 1980; Bowers & Cheshire, 1983), and so did the cost of having to deal with the over-production.

By the end of the 1970's, the CAP reduced subsidies throughout Europe by cutting unit prices and imposing quotas and levies. Specific policies were also introduced to further curtail food surpluses, either:

(1) by encouraging land to be taken out of production,

and/or (2) by encouraging less intensive farming methods ('extensification').

(1) In 1988, the EC introduced the 'cereal set-aside' scheme to compensate farmers for setting land aside from cereal production. In 1989, the UK government introduced a 'Farm Woodland Scheme' which provided supplementary payments to plant trees on agriculturally-improved land, adding to the Forestry Commission's 'Woodland Grant Scheme' introduced in 1988.

(2) The 'Environmentally Sensitive Area' scheme, introduced by the UK government in 1985, encouraged more extensive methods of farming by paying farmers to maintain traditional forms of land management such as hay-cutting. 'Extensification schemes' for beef and sheep were introduced in 1990.

Later, more conservation-orientated schemes were built into UK agricultural policies. In 1990 the 'Countryside Premium Scheme' offering farmers extra conservation payments to the EC's 'Cereal Set-aside' scheme was introduced as were 'Nitrate Sensitive Areas' in which farmers are paid to use less nitrogen. In 1992 the EEC followed suit:

"The agreement secured on reform of the Common Agricultural Policy (CAP) in May this year includes a commitment that all Member States will in future operate programmes to encourage environmentally sensitive farming (the agri-environment plan). The agri-environment plan requires Member States to prepare area programmes covering schemes which encourage reduced use of chemical inputs, extensification of crops or livestock production; other environmentally sensitive farming practices; the upkeep of abandoned land; the setting aside of farmland for at least 20 years for environmental purposes; and the management of land for public access and recreation" ('This Common Inheritance', 1992).

Despite the overall decline in the botanical diversity of the countryside, there were some significant changes in the agricultural use of land (Barr *et al*, 1993). These included a 14.8% decrease in the extent of agriculturally-managed grassland[2], a 127% increase in the extent of weedier swards with more than 25% ryegrass and an 18% increase in the extent of unimproved agricultural grass, i.e. a decrease in short-term grassland management with reseeding and an increase in more extensive pasture management (Barr *et al*, 1993).

The trend of intensive agricultural production started to reverse from the early 1980's. Green & Burnham (1989) cite a number of studies predicting surplus agricultural land; 3-4 million hectares was a 'middle of the road' estimate of agricultural land (approximately 15-25% of the UK's agricultural area) that might be potentially surplus for the year 2000. Between 1977 and 1987, the area of farmed land in Britain decreased by 2% and there was a 10% loss in the workforce (MAFF, 1987).

At the end of the 1980's it remained to be seen how farmers would continue to respond to reduced subsidies i.e. declining farm incomes. Would they abandon land and/or maintain forms of less intensive management as they seek alternative sources of employment? Would this result in former species-rich agricultural habitats being restored?

1.4 *The Uptake of Non-agricultural Activities by Farm Households*

In 1971, farmers were some of the best paid workers in the UK having incomes greater than university lecturers, army captains and Civil Servants (Bowers & Cheshire, 1983). The level of financial support given to farmers through guaranteed market prices and tax exemptions was 5-6 times greater than that given to British Steel or British Rail workers (Shoard, 1980; Bowers & Cheshire, 1983). However reductions in subsidies since 1975 meant that farming income in Britain declined by about 60% in real terms from 1980 with land values also

---

[2] 'recently sown grass', 'pure ryegrass' and 'well-managed grass' (P.47, Barr *et al*, 1993).

falling by about 40% (LGC, 1986; Munton, Lowe & Marsden, 1992). Yet the stipulation agreed in the Treaty of Rome (1976) stated that the EC had a responsibility to maintain the livelihood of the farming community. However, it was not until 1992 that the CAP began to regard the farming community as 'stewards of the countryside' rather than 'food producers' and to make-up short falls in farming income by additional payments in the form of grants for more environmentally-sensitive farming.

Since the early 1980's, then, the decline in farming incomes encouraged the search for new land uses and alternative means of supporting a living on the land (Marsden & Murdoch, 1990). The uptake of non-agricultural activities on and off the farm by farm households increased not only in Europe but also worldwide: in Greece, 29% of farm operators in 1977-78 were reported as having other employment outside agriculture which rose to 35% by 1985 (Efstratoglou-Todoulou, 1988); "...in France, the official figures (under-estimated) of income from other sources ... show an increase of 26% from 1970 to 1983" (Fuller & Brun, 1988); in the United States there was an increase from 15% to 44% between 1940 and 1978 (Albrecht & Murdock, 1984); in the UK, part-time farming increased by 30% between 1974 and 1984 (LGC, 1986).

Although a number of studies emphasise that alternative sources of income to UK farm households have been important throughout this century (Harrison, 1975; Gasson, 1988; Shucksmith *et al,* 1989), the Joint Agriculture and Environment Programme (JAEP) socio-economic survey (Dent *et al,* 1993) revealed that the uptake of non-agricultural activities has increased markedly since the late 1970's. The number of farm household members becoming involved in non-agricultural activities in Grampian doubled between 1987 and 1990 (Fig. 1.2). Examples of non-agricultural activities taken up by farm households in Scotland include: game, forestry, Bed and Breakfasts, caravan and camp sites, farm shops, quarrying, dried flowers and off-farm jobs (Dent *et al,* 1993).

The uptake of non-agricultural activities by farm households has been termed 'pluriactivity' (Arkleton Trust, 1988; Shucksmith *et al*, 1989), 'multiple job-holding', (Hathaway, 1925; Gasson, 1983) and 'diversification' (Dalton & Wilson, 1989) although the term 'part-time farming' has been most used (Rozman, 1930; Arkleton, 1985; Gasson, 1988; Munton, Whatmore & Marsden, 1989). 'Part-time farming' is least favoured since it was first applied to describe farmers who worked off the farm for some part of their working week; about three quarters of the farm households now involved in non-agricultural activities are not the farmer (Arkleton, 1985; Fuller & Brun, 1988). 'Multiple job-holdings by farm households' was the preferred terminology by the Arkleton Research group (1985) but this is a cumbersome description. The term 'pluriactivity' is therefore used within this study.

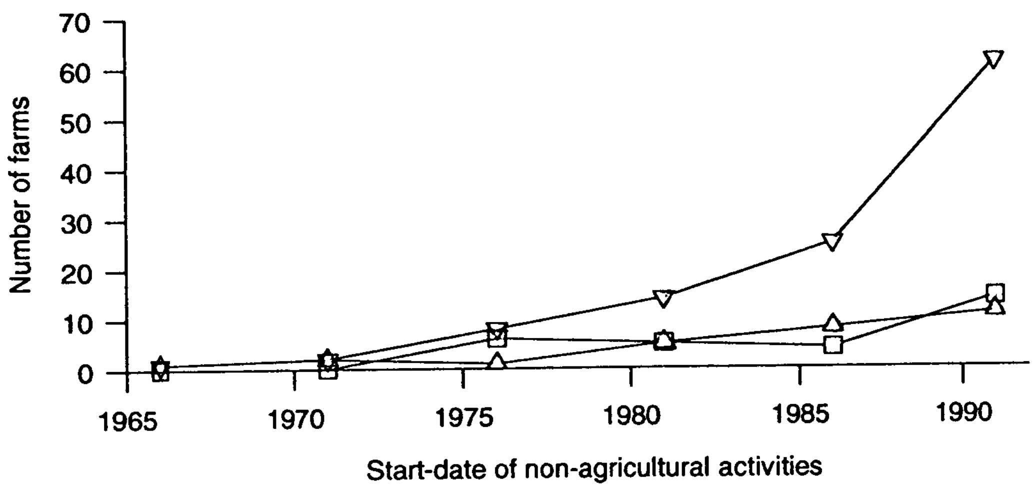


Fig. 1.2. The uptake of non-agricultural activities by farm households in Grampian Region as revealed by a socio-economic survey undertaken in 1991. 174 out of 295 surveyed farm households were able to give a start-date for their non-agricultural activities. The earliest date was used where more than one was given. (▽) at least one member of the farm household is involved in OFF-FARM work; (△) at least one household member is involved in non-agricultural activities ON-FARM; (□) the farm household is involved in non-agricultural activities BOTH off-farm and on-farm. These data were extracted from the socio-economic survey database by Noranne Ellis and is reported within Dent *et al* (1993).

1.5 *Hypotheses on Changes in Management of British Farmland in Relation to Pluriactivity*

Two affects have therefore been simultaneously altering the management of agricultural land during the 1980's:

(1) 'environmentally sensitive' farming policies resulting from the agricultural reform in Europe,

and (2) the uptake of non-agricultural activities by farm households ('pluriactivity').

Both may be encouraging the restoration or creation of former species-rich agricultural and semi-natural habitats. However, this study set out to identify and define the ecological characteristics associated with alterations in land management associated with pluriactivity alone. There would therefore be difficulty in attributing changes on farmland directly to involvement in pluriactivity when simultaneously (if not initially) agricultural policies were aiming to encourage less intensive farming.

However, past studies noted that farms with part-time farmers relied more financially on fewer and simpler enterprises which require less attention, i.e. cereal crops and beef-cattle as opposed to more intensive arable crops like potatoes and more time-demanding dairy-cattle (Gasson, 1966; 1983). Gasson (1966), Sinclair (1983) and Munton *et al* (1989) noted greater extents of grassland, woodland and scrub on pluriactive farms. Lower stocking densities were also recorded on pluriactive farms (Gasson, 1966; Sinclair, 1983) and increases in 'undesired' species within grasslands (Sinclair, 1983). Pluriactivity may therefore affect the farmland vegetation at one or two levels;

(1) by altering the land cover by altering the land use from purely agricultural, either to abandoned land and/or to non-agricultural cover types such as moorland and forestry, and/or

(2) by reducing the level of management and therefore increasing the diversity of species within vegetation cover types.

The uptake of pluriactivity has been found to depend upon farm characteristics, such as size (in hectares and economically), enterprise-mix (arable/livestock), tenancy/owner-occupancy *etc.*, and the characteristics of the household, such as education and age *etc.* (Nalson, 1968; Gasson, 1966, 1983; EDC, 1973; Sinclair, 1983). It was therefore important to recognise how socio-economic factors might affect the type and extent of land management decisions in relation to the uptake of non-agricultural activities. The 'chain of events' to consider in this study are outlined diagrammatically in Fig. 1.3 with decisions within the household affected by socio-economic and agricultural policies leading to changes in the management of the farm and impacting on the ecological characteristics of the farmland.

The Hypotheses

(1) The type and degree of changes at the vegetation cover level were hypothesised to depend upon the type of involvement in pluriactivity, particularly whether the non-agricultural activities were land-based (e.g. golf course, game shooting *etc.*) or not (e.g. Bed and Breakfast, off-farm work *etc.*). The intensity of management had already been recorded to decline as result of involvement in off-farm work (Gasson, 1966; Sinclair, 1983), but would this be so with land-based/non land-based non-agricultural activities on the farm where there might be greater opportunity to be more efficient at allocating time between farming and non-farming activities?

(2) Management is exhibited in a number of different forms; for example, in the application of fertilisers and herbicides, through ploughing and mowing, in the type and density of livestock, the type of crop, and the type and extent of land drainage. Would there be differences in the forms and degrees of reduction in management intensity between farms involved in pluriactivity on or off the farm in comparison to full-time farms? The management of cereal crops is seasonal and more amenable to contract work than that of grasslands so might relatively be the least affected agricultural land cover at the management level. Productive grasslands, however, require to be reseeded, fertilised, grazed

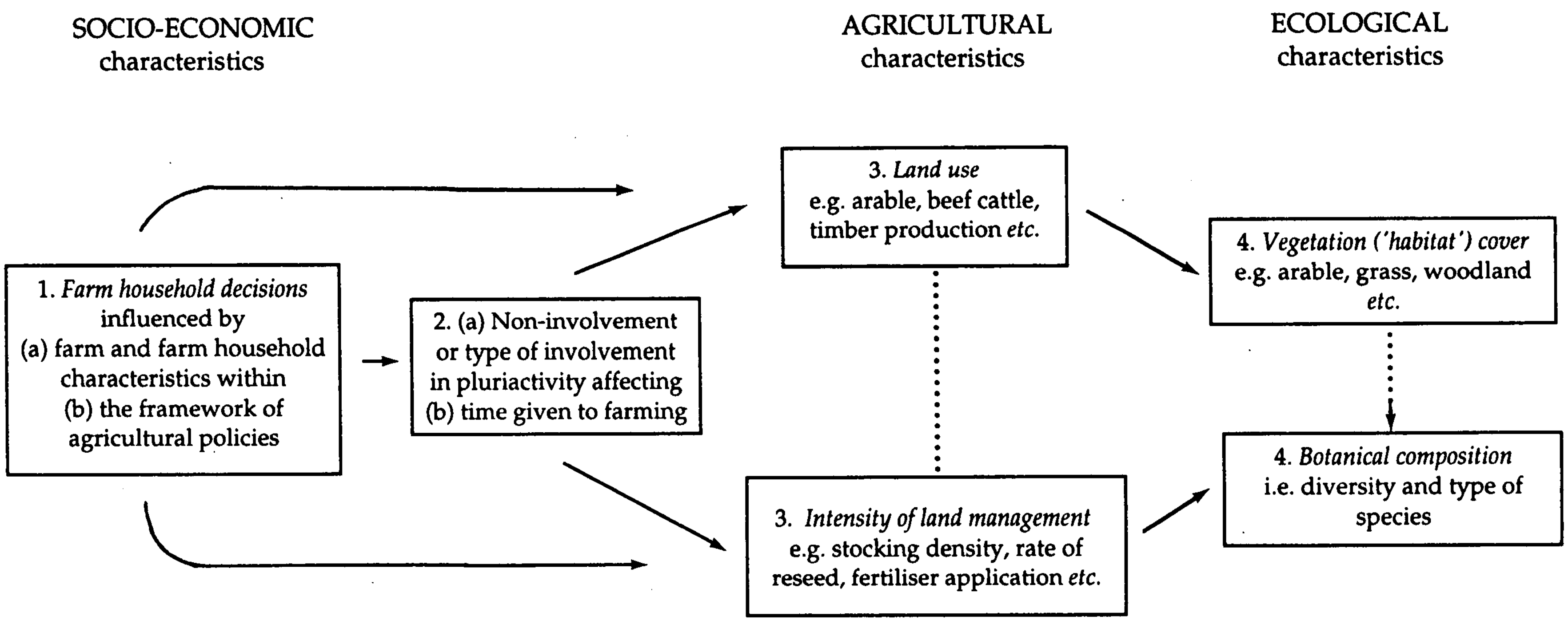


Fig. 1.3. A model of the 'chain of effects' from the decision-making processes of the farm household to farmland vegetation cover and species composition.

carefully, mown *etc.* It was therefore hypothesised that grasslands would be the agricultural habitat most likely to be affected by alterations in the level of management. Of the agricultural habitats grasslands had already been noted by Gasson (1966), Sinclair (1983) and Munton *et al* (1989) to also increase in extent on pluriactive farms.

(3) Scottish upland areas, already managed for non-agricultural activities (such as shooting and stalking) would possibly see little alteration in the intensity of their management although the extent of upland vegetation types (e.g. moorland, semi-natural grasslands and scrub) may increase where the management on land adjacent to them might decline.

1.6 *Possible Alterations in the Botanical Richness and Type of Species within Grassland Swards as a Result of Involvement in Pluriactivity*

The hypotheses above indicate grasslands to be the agricultural habitat type to be possibly most affected by alterations in management due to involvement in pluriactivity. Is it possible to predict the number and type of species which might be expected in the grass swards of pluriactive farms?

Grime (1973) noted that in maintaining or re-constructing "species-rich" communities, the competitive behaviour of some plant species needs to be curtailed. 'Competitive' species have tall statures, growth forms which allow both intensive and extensive exploitation of the environment and high relative growth rates above and below ground. In fertile, undisturbed environments, competitive species therefore reduce the ability of other species to exist with them and therefore reduce species richness. Grime (1974) noted that the affect of competition can, however, be reduced by:

(1) *disturbance*, i.e. mechanisms which limit the plant biomass by causing its partial or total destruction, such as trampling, grazing, mowing and ploughing (also called 'damage intensity'; Grime, 1973); and/or

(2) *environmental stress*, i.e. external constraints which limit the rate of dry matter production of all or part of the vegetation, such as shortages of light,

water, mineral nutrients and suboptimal temperatures.

The type of non-sown species which would re-appear would depend upon whether stress or disturbance was the most influential process. Species adapted to high levels of disturbance[3] are termed *ruderal* (R). Species adapted to high stress (e.g. low soil fertility)[4] are termed *stress-tolerators* (S) (Grime, 1979). Secondary strategists are species which exploit environments experiencing intermediate intensities of disturbance, stress and competition:

"*competitive-ruderals* (CR) - adapted to circumstances in which there is a low impact of stress and competition is restricted to moderate intensity by disturbance;
stress-tolerant ruderals (SR) - adapted to lightly-disturbed, unproductive habitats;
stress-tolerant competitors (CS) - adapted to relatively undisturbed conditions experiencing moderate intensities of stress;
'*C-S-R strategists*' - adapted to habitats in which the level of competition is restricted by moderate intensities of both stress and disturbance" (Grime, 1979).

The relationship between the seven life history strategies are described within a triangular model (Fig. 1.4. Grime, 1979).

Agriculturally preferred species tend to be competitive-ruderal and C-S-R species, weed species are generally ruderals (e.g. Shepherd's purse, *Capsella bursa-pastoris*; chickweed, *Stellaria media*; pineapple mayweed, *Matricaria matricaroides*) whilst 'semi-natural' species are mainly stress-tolerant species (e.g. sedges, *Carices* spp.; harebell, *Campanula rotundifolia*; wild thyme, *Thymus drucei*). Stress-tolerant species are currently of greater conservation interest than other strategists (UCPE report, 1988/9) because they are specialised to unproductive (low soil fertility) and undisturbed habitats which are now scarce within Britain. Stress-tolerants are therefore associated with delicate ecological communities; for example, the decline of the Large Blue butterfly (*Maculinea arion*) was associated with the ploughing of former pastures and the loss of its food plant, wild thyme (*Thymus drucei*), a stress-tolerant (Spooner, 1963).

---

[3] by rapid growth rates, short lifecycles and abundant seed production.

[4] by their slow relative growth rates, long life histories and intermittent flowering.

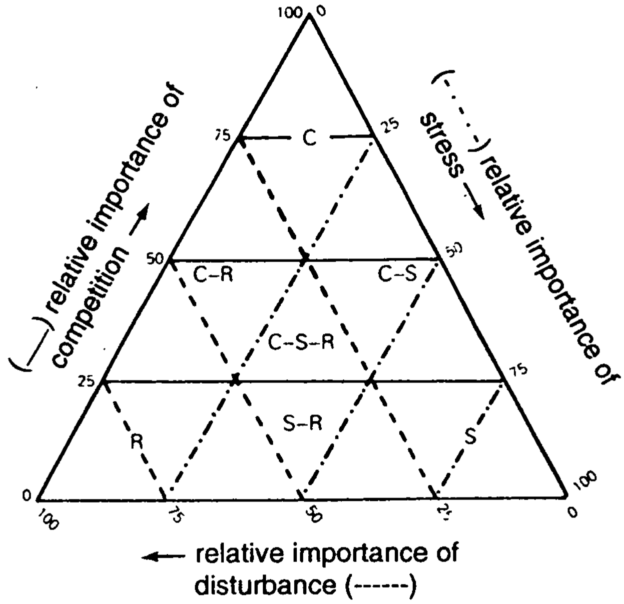


Fig. 1.4. Grime's (1979) model describing the various equilibria between competition, stress and disturbance in vegetation and the location of the primary and secondary strategists. C, competitor; S, stress-tolerator; R, ruderal; C-R, competitive-ruderal; S-R, stress-tolerant ruderal; C-S, stress-tolerant competitor; C-S-R, 'C-S-R strategist' (from Grime, Hodgson & Hunt, 1988).

Moderate intensities of either disturbance, stress or both would therefore increase species diversity by reducing the vigour of potential agricultural dominants, thus allowing subsidiary non-sown species to co-exist (Grime, 1979). However, at the most extreme intensities of stress and/or disturbance, species diversity declines as conditions are created to which only a very small number of species are sufficiently adapted to survive (Al-Mufti *et al*, 1977). The diagrammatic representation of this 'hump-backed' model (Grime, 1979) is shown in Fig. 1.5 which has also been recorded by Whittaker (1977), Huston (1979) and Bond (1983).

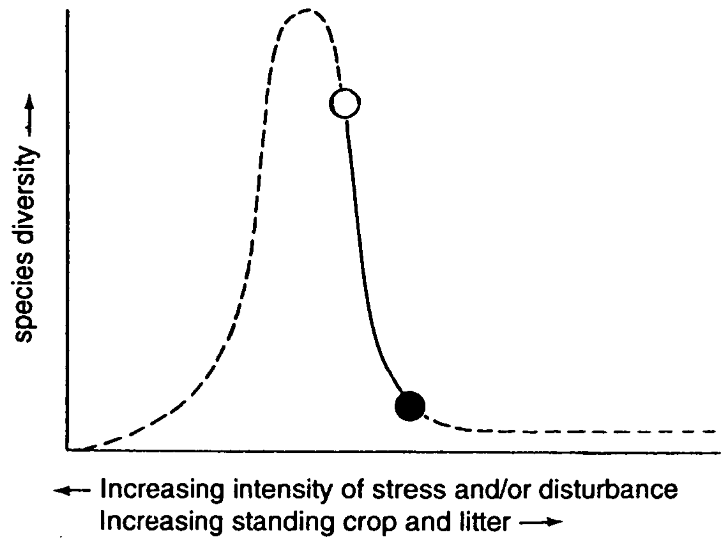


Fig. 1.5. An adaptation of the 'hump-backed' model of Grime (1979) which shows that at moderate intensities of either environmental stress or disturbance or both allows a greater diversity of species by reducing the vigour of potential dominants. ● shows the species diversity within agricultural habitats and ○ shows the number of species which may be found in derelict or rough grasslands (e.g. see Al-Mufti *et al*, 1977).

The proportion of each life-history strategy within grass swards may indicate the main ecological processes resulting from current agricultural practices and may also allow prediction in vegetation change resulting from changes in land management (Grime, Hodgson & Hunt, 1988).

"reference to the potential growth rates, phenologies and established strategies of constituent species may allow prediction of the rate of change and the direction of change in species composition which would occur as a consequence of the removal of grazing animals from pastures" (Grime *et al*, 1988).

Examples are shown in Fig. 1.6 where Grime (1987) hypothesised that succession in swards as a result of reducing the input of fertiliser will decrease the proportion of C-S-R strategists (typical of fertile meadows) and cause an increase in the proportions of stress-tolerant competitors firstly, then stress-tolerant species. Vegetation of moderately unproductive habitats may also follow the same incursion of species type but the succession may extend over a much longer time scale following the reduction in soil fertility (Grime, 1987).

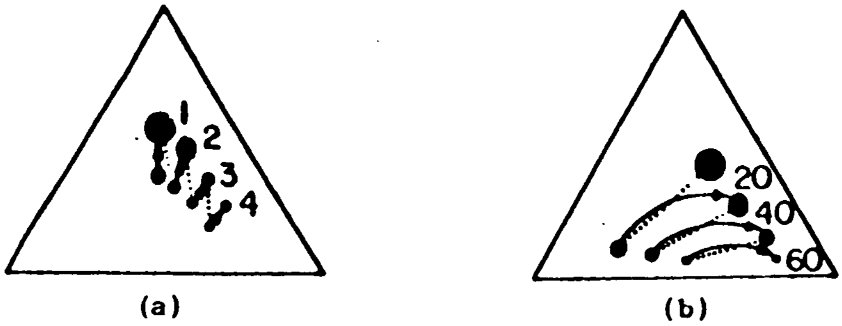


Fig. 1.6. Using the triangular model of Grime to show vegetation succession changes. (a) shows the sequence of events where a meadow is not fertilised and a drift towards lower productivity and incursion by stress-tolerant species; (b) shows the sequence of events where the vegetation of moderately unproductive habitats is subjected to repeated cycles of destruction by burning, browsing or cropping, the declining mineral nutrient capital of the soil may be expected to bring about a series of arcs of progressively lower trajectory in successive cycles of vegetation recovery. The time in years during succession is represented by the numbers on each line and shoot biomass at particular points is reflected in the size of the circles (from Grime, 1987).

It generally takes twenty years from the time of reseeding for the dominance of pastures to alter from ryegrass to species indicative of lower fertility (e.g. *Agrostis* spp. and *Holcus lanatus*) (Morrison, 1979). However, the rate will depend upon the rate in decline of the soil fertility, the richness of the local flora and availability of seed sources (i.e. field boundaries and nearby semi-natural areas; Barr *et al*, 1993; Gibson, Watt & Brown, 1987), and the degree of disturbance and gap generation to allow areas for the colonisation of species (Miles, 1979).

1.7 *Synopsis of the Introduction*

Harvey & Bell (1990) suggest that the era of major environmental damage and habitat loss as a consequence of agricultural practice is now past. Will extensive farming methods, abandonment or both replace intensive agriculture, and, if so, in what proportions? Will there be consequential increases in the extent of non-agricultural habitats i.e. wetlands, semi-natural grasslands, scrub and woodland? Will land-based non-agricultural activities significantly increase the extent of semi-natural habitats (e.g. game cover and tree planting) or destroy them (e.g. through quarrying and motor cycle tracks)? That work off the farm has been associated with increasing extents of grassland indicates that pluriactivity may reverse the considerable loss of grassland since the Second World War (NCC, 1984; Fuller, 1987; Wells & Sheail, 1988). Pluriactivity has also been associated with declines in the intensity of land management which may allow a return of plant species traditionally associated with pastures and meadows to grass fields, and, therefore, associated wildlife species.

Since changes in farmland ecology are possibly also occurring as a result of policies encouraging reductions in agricultural productivity, and this simultaneous to declining farm incomes which are encouraging the uptake of non-agricultural activities, attributing changes directly to pluriactivity may be tenuous. This study therefore investigated changes in farmland ecology *associated with* the uptake of non-agricultural activities by farm households ('pluriactivity') rather than what might be '*the result of*'. The thesis therefore is that: ***the involvement of farm household members in non-agricultural activities is associated with an increase in the extent and number of semi-natural habitats and plant species within farmland.*** This would be associated with increases in the diversity and abundance of faunal species.

CHAPTER 2

Options for Investigating the Ecological Characteristics associated with Pluriactivity

Introduction

This ecological study was part of a larger socio-economic project investigating the nature and extent of various types of pluriactivity in Scotland. This chapter outlines the options and final strategy chosen to obtain ecological data for the types of pluriactivity revealed by the socio-economic survey. At the end of the chapter the structure of the thesis is outlined.

2.1 *The Link to a Socio-economic Survey of Pluriactivity in Scotland*

Between July and December 1991 a socio-economic questionnaire had been taken to 506 Scottish farms to determine the nature and extent of pluriactivity (Dent *et al*, 1993). The farms had been randomly selected from the Grampian, Fife, and Dumfries & Galloway regions by:

(1) farm type, defined by the Scottish Office Agriculture and Fisheries Department (SOAFD),

and (2) British Size Unit (BSU).

Nine 'farm types' are defined by SOAFD using the gross margin of the farm's enterprise mix. The farm type therefore gives some indication of the main land use(s) of the farm; for example, farms are described as 'mainly cattle', 'mainly sheep', 'cropping' *etc*. The BSU is a measure of farm size based on farming income[1] and so indicates the economic status of the farm. All nine farm types were included in the sample but farms below 4BSU were excluded since they

[1] i.e. in terms of the standard gross margin (Farm Account Scheme notes produced by the Scottish Agricultural Colleges, various years).

are small, generally needing less than one person to run them (Farm Account Scheme notes, various years). Farm estates were also excluded since the project was investigating the impact of pluriactivity at the farm level.

The face-to-face questionnaire had been taken to each of the farm households by socio-economists and geographers from the Scottish Agricultural College ('SAC': Glasgow, Aberdeen and Edinburgh) and the Macaulay Land Use Research Institute ('MLURI', Aberdeen). For one week I also took part in this survey. Details were obtained on the farm area, ownership, household members, qualifications, previous employment, attitudes[2], and the number of employed labourers and contractors. More specifically, details were obtained on the location of non-agricultural activities ('pluriactivity') and the time allocated to pluriactivity by each household member. The details of the data to be collected had been agreed during a number of meetings involving myself during the early part of 1991. Therefore the questionnaire also obtained the farm boundary on a 1:25 000 scale map which was crucial to identifying and defining the extent and types of differences in the ecological characteristics between farms not involved pluriactivity and those involved in various forms of pluriactivity. The farm boundary included all holdings[3] managed as part of the farm business. However, data on land use and management were not collected in any detail: the multidisciplinary nature of the project meant that the questionnaire already contained too many questions to enable a 'short' interview with the farm household. It was therefore decided that data on land use and management need only be collected for the farms where the ecological data were to be collected.

Access to the socio-economic data was available for this study to:

(1) select farms for the ecological investigation

---

[2] to farming, wildlife, agricultural policies, ambitions *etc.*

[3] 'holding' is a term given to an area of farmland that is detached from the main farm area but managed as part of the farm. Holdings have often been other farms.

and (2) to later allow for associations between the socio-economic characteristics of the farm and household to the ecological characteristics of the farmland.

The ecological investigation started in October 1990 with the socio-economic investigation. Both were due to finish by April 1993. With the socio-economic survey occurring over the vegetation season of 1991 this posed serious difficulties with the timing of the ecological investigation which are outlined in section 2.6 and in more detail in Chapter 4.

2.2 *Defining the Investigation*

To obtain comprehensive ecological data from farms involved in different types of pluriactivity (as well as non-pluriactive farms) would have been impossible. To narrow the task three main questions were posed:

(1) what aspects of pluriactivity would be most likely to affect the farmland?

(2) would such impacts be mainly at a field (or 'localised') level, or spread more generally over the farm?

(3) would the vegetation cover or its species composition show most change?

Considering question (3), the introductory chapter gave evidence that alterations in the extent of arable and grassland (i.e. the vegetation cover level) occurs with alterations in the state of the agricultural economy. Pluriactivity was also associated with a reduction in the intensity of management which affects the vegetation at the species composition level. Therefore alterations at both levels of vegetation would need to be considered. Question (3) was therefore amended to:

"How would data at both the vegetation cover and species composition levels be most easily and effectively acquired?".

The next two sections deal specifically with (1) and (3), as amended, respectively. With respect to question (2), however, Jenkins (1987) suggested that:

"even in the case of changes to one enterprise affecting only one part of the farm the ecologist should still deal with the whole farm rather than focusing on the localised changes since the 'knock-on' effects may be greater than the direct effects." (Jenkins, 1987).

Pluriactivity has not, so far, been associated with environmental characteristics but, at the same time, no investigation had specifically explored this. It therefore seemed too much to assume that there was no association between the uptake of pluriactivity (or type of pluriactivity) and the physical characteristics of the land. Therefore some form of standardisation of environmental characteristics was considered in comparing the farmland characteristics of pluriactive farms to non-pluriactive farms. These are described in section 2.5.

2.3 *Some Definitions of 'Pluriactivity'*

Various aspects of pluriactivity were considered so that the ecological investigation would include those factors most likely to impact on the farmland. The main aspects were:

(a) whether the pluriactivity was on or off the farm site;

(b) whether the on-farm pluriactivity directly used the land (e.g. golf course, caravan site, shooting *etc.*) or not (e.g. Bed & Breakfast, yoghurt-making *etc.*);

(c) whether the main farmer or another member of the household was involved;

and (d) the overall degree of involvement by the household.

(a), (c) and (d) were based on the hypothesis that the extent of time away from farming would have an immediate impact on farmland ecology. On-farm activities may, however, allow a greater efficiency of adapting the farm and non-farming activities around one another in contrast to off-farm work. The location of the farmer particularly was hypothesised to have a large influence on the farming strategy by altering the time allocated between farming and non-farming activities. A simple classification had already been used by Dalton and Wilson (1989) which was based on (a). Three groups of pluriactive farms were identified:

(1) farms where the only type of pluriactivity was OFF-FARM work;

(2) farms where the only type of pluriactivity was ON-FARM;

(3) farms with BOTH off-farm and on-farm pluriactivities.

The classification of Dalton and Wilson (1989) could, at least, be used as a base classification. However, Dalton and Wilson did not use the three categories exclusively; their analyses included category (3) within both (1) and (2) since farms with BOTH types of pluriactivities constituted an estimated 6.4% of the national (Scottish) total of farms in 1988. If the impact on farmland occurring from off-farm pluriactivity differed contrary to that resulting from on-farm pluriactivity the possibility existed that where both occurred on the same farm there would be a net cancellation of effect. However, by 1991, the proportion of farms with BOTH pluriactivities had nearly doubled (see Fig. 1.1). Therefore the three exclusive categories were used within this study. To emphasise the exclusiveness of each category in this study, they are referred to in the UPPER case: farms with OFF-FARM pluriactivity = the OFF-FARM group,

farms with ON-FARM pluriactivity = the ON-FARM group,

and farms with BOTH pluriactivities = the BOTH group.

The lower case is used if the type of pluriactivity is discussed more generally e.g. 'off-farm pluriactivity' when considering both the OFF-FARM and BOTH groups together.

It had been considered that if the number of farms for the ecological investigation was large enough, categories (b), (c) and (d) could be possible subcategories. However, this possibility was lost due to the way that the socio-economic data became available and the small number of farms selected (discussed in Chapter 4).

The Office for Economic Co-operation and Development (OECD, 1978) classified 'part-time' farmers as those who either depended on farming for a living or were mainly dependant on off-farm occupations. This economic approach was only applicable to farms with off-farm work; on-farm pluriactivity is a supplementary form of income (Olfert, 1992; Dent *et al*, 1993). An economic classification would therefore not have been any better than the location classification.

2.4 *Acquiring both Vegetation Cover and Species Composition Data Effectively*

There were three options to obtaining vegetation data:

(a) to use existing data sets,

(b) to do a field survey,

(c) to use a combination of (a) and (b).

The requirements for the data were:

(1) to be detailed enough to detect change where land cover differences were not extensive or may only be at the species composition level;

(2) to be specific to farm boundaries outlined on a map so that the general affect over the whole farm could be assessed.

Existing data sets for both vegetation cover and species lists were considered before a field survey was considered and are now outlined.

Availability of data at the vegetation cover level included both air photo interpretation and field survey data. Aerial photography had been interpreted for certain regions in Scotland by the National Countryside Monitoring Scheme (NCMS) (Budd, 1990). The NCMS was designed to provide quantitative information on land cover changes for the whole of Scotland using a stratified sample of aerial photographs from the 1940's and the 1970's at a scale of 1:25 000. The NCMS data could therefore not provide complete coverage of Scotland nor was it recent enough for a study investigating changes due to the recent uptake of pluriactivity (see Fig. 1.2). The MLURI was also interpreting aerial photography, recording the 1989 land cover for the whole of Scotland at a scale of 1:25 000, to be released in December 1991 although data for Grampian Region would be released in June 1991 (MLURI, 1990).

The interpretation of vegetation features on air photographs at a scale less detailed than 1:10 000 is, however, difficult; for example, separating different types of grassland can pose difficulties (Fuller, 1986a, 1986b) and broadleaved plantations can be confused with semi-natural woodland (Budd, 1990). Both the NCMS and the MLURI datasets were therefore neither extensive, detailed enough nor of appropriate timing for this investigation.

However, both land cover at the scale of 1:10 000 and species data had been obtained through field surveys by the Institute of Terrestrial Ecology (ITE). The ITE surveys had been based on a random sample of Ordnance Survey kilometre grid squares, stratified according to the thirty-two 'Land Classes' defined using climatic, topographical, geological and human artefact data obtained from maps (Bunce, Barr & Whittaker, 1983). Ecological characterisation of each Land Class was then defined by surveying a number of randomly selected squares within each class.

Eighty-three squares had been surveyed in Scotland in 1978, 128 in 1984 and 195 in 1990 (C.J. Barr, *pers. comm.*). Although the 1978 and 1984 data were computerised, the data generated from the field survey in 1990 would not be available in time to be useful for this project. The data obtained from the 128 one-kilometre squares from the 1984 survey would therefore be the main dataset but only about twenty squares had been surveyed in each of the Grampian and Dumfries & Galloway regions; only three had been surveyed in Fife. It did not seem feasible that complete farm areas would fall completely within these forty-three squares particularly since farm areas could be several hundred hectares (i.e. greater than $1km^2$) and the scatter of holdings could be kilometres apart (SAC farm advisors, *pers. comm.*; later verified by the maps returned by the socio-economic survey). Even if complete farm areas fell within all the forty-three squares the number would hardly be sufficient to form a valid sample size, assuming a considerable degree of variety in farming and environmental characteristics, even before the impact of the different types of pluriactivity.

The option remaining was for a field survey to be carried out. Apart from the disadvantage of expense, the advantages of a field survey were that:

(1) vegetation cover data of the whole farm business (i.e. including all 'holdings') could be collected at a scale of 1:10 000;

(2) species lists could be obtained;

(3) land management (particularly alterations due to pluriactivity) could be noted from the farmer and outlined on the farm map.

Hypotheses outlined in the introductory chapter indicated that grasslands might be the most affected vegetation type with the degree of management intensity more likely to decrease with increasing involvement in pluriactivity. Grass fields were therefore an obvious focus; vegetation cover data collected at the farm scale would quantify alterations in their extent whilst species lists from the grasslands would reveal changes in composition. As the mapping of grasslands required the whole area of the farm to be walked, all vegetation cover types were to be recorded in the mapping allowing a more comprehensive assessment of change related to pluriactivity.

That vegetation adjacent to the field might be of importance in holding a reserve of species for the open field has already been outlined in the introductory chapter (citing Gibson, Watt & Brown, 1987, and Barr *et al*, 1993). Therefore the species composition of the field boundary would also be collected for the surveyed grass fields.

Additionally, a 5-15 minute questionnaire with the farmer at the start of the field survey would:

(1) ensure that the farm boundary was correct before the vegetation mapping exercise. This was necessary to ensure that farm boundaries obtained on 1:25 000 scale maps during the socio-economic survey visit were correctly delimited on the 1:10 000 maps (particularly where other holdings were some kilometres from the main holding) and

(2) provide data on the use and management of each grass field to later aid in explaining variations in species composition between the farm groups.

2.5 *Standardising Environmental Characteristics*

There were two options for defining the environmental characteristics within each farm boundary:

(a) the ITE Land Classification with thirty-two Land Classes defined by climatic, topographical, geological and human artefact data (Bunce *et al*, 1983);

(b) the MLURI Land Capability maps with seven main categories defined by soil and climate data, specifically describing the agricultural potential of the land (Bibby *et al*, 1982).

Although no soil data was used to define the ITE Land Classes, it was argued that soils are the products of the environmental conditions described in the land classification:

"soils are formed by the influence of many agencies, biotic and abiotic, on the weathering of bedrock, with abiotic environmental factors (e.g. temperature and moisture, including frost) additionally controlling the activity of the biotic factors (bacteria, fungi, protozoa, invertebrates including earthworms....). To an extent therefore soils are products of their habitats..." (Bunce & Last, 1981).

The MLURI Land Capability Classification used soils in an analogous fashion, i.e. that the soil would inherently describe the geological and topographical characteristics. In this respect, there was little to choose between the two classifications. However, the ITE Land Class for each kilometre O/S grid square of Great Britain was placed within the ITE database early in 1991. The land type for any farm could therefore be identified quickly and easily using its grid reference(s) in contrast to the lengthy process of having to locate farm boundaries on the MLURI Land Capability 1:25 000 scale maps and then to quantify the areas of each level of land capability.

2.6 *The Resultant Strategy*

Finally the investigation emerged as being a field survey where:

(1) a smaller sample of farms would be randomly obtained from the socio-economic sample, stratified by:

- their non-involvement or type of involvement in pluriactivity (i.e. the non-pluriactive, 'OFF-FARM', 'ON-FARM' and 'BOTH' farm groups) so that the characteristics of each pluriactive group could be compared to those of the non-pluriactive farms;

and ● environmental characteristics defined by the ITE Land classification system to ensure against any potential bias related to the physical characteristics of the land;

(2) vegetation cover would be collected of the whole farm area and that

(3) species composition data and land management details would be collected for grass fields only.

Vegetation surveys are restricted to a 3-4 month growing season (June, July, August, September). From personal experience gained within the ITE Countryside Survey in 1990 (described in Barr *et al*, 1993), it was estimated that a day would be needed to collect the vegetation data for every one hundred hectares. Assuming a mean farm area of about 100ha (on advice from SAC advisors) and an entire growing season, an estimated sixty to eighty farms could be surveyed during 1991. This would therefore result in fifteen to twenty farms within each of the four farm groups. No pilot study could be carried out to assess the statistical viability of these farm group sizes but it was hoped that at least, in the case of very heterogeneous ecological data, the field survey would give indications of the affect of each farm group within the countryside.

2.7 *Restriction to Grampian Region*

The socio-economic survey did not begin until the first week of July 1991 and it seemed unlikely that it would be completed by the end of September 1991. Having discussed the importance of undertaking a vegetation survey during the summer of 1991 with the socio-economists, it was decided that only one of the three regions should be targeted with the socio-economic questionnaire at this time. This would ensure that the survey could be completed as close as possible to the end of September 1991 (as opposed to later). The ecological investigation would then be restricted to this region. This would also theoretically restrict the heterogeneity of the ecological data within each farm group and therefore increase the likelihood of detecting differences between the farm groups.

Grampian contained 295 (58%) of the 506 farms and was therefore chosen. The choice of Grampian was fortuitous because:

- there would be the possibility of using air photo interpretation data on land cover from the MLURI to extrapolate to other regions;
- the region contained the greatest range of ITE land classes of the three survey regions so that there was also scope for using the ITE Land Classification system for extrapolation to other regions.

2.8 *The Structure of the Thesis*

Grampian is described in the next chapter (Chapter 3). The following two chapters then describe the selection of farms for the ecological investigation (Chapter 4) and the field survey methodology (Chapter 5). Due to the structure of the field survey data, the analyses are then presented in three parts:

I the vegetation cover is described in Chapter 6,

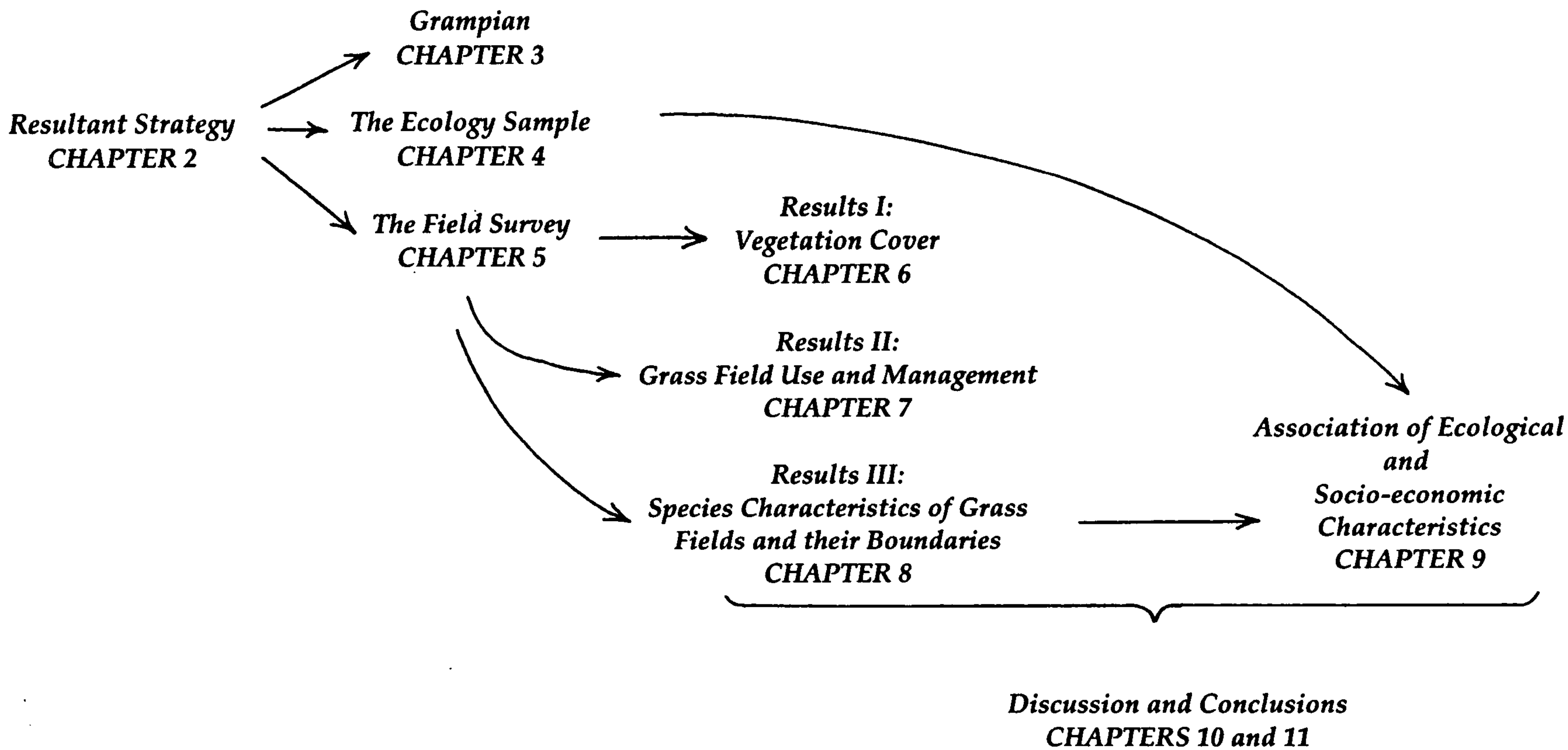
II the use and management of grass fields are described in Chapter 7,

III the species composition of grass fields and their boundaries are described in Chapter 8.

Use of both the socio-economic and ecological data at the farm level is then made to disclose the underlying causes determining the ecological differences between the farm groups in Chapter 9. The results of the three levels of the field survey are discussed together, in the light of the socio-economic associations, in Chapter 10 and future vegetational changes within Grampian are predicted.

The resultant structure of the thesis is summarised in Fig. 2.1.

Fig. 2.1. The Structure of the Thesis



CHAPTER 3

Grampian Region

Introduction

The ecological study was restricted to Grampian (see section 2.7). This chapter therefore describes the characteristics of Grampian using data from published and unpublished sources, particularly that obtained through the socio-economic survey of Dent *et al* (1993). Since I was involved in the setting up of the socio-economic questionnaire and database of the Dent *et al* (1993) study (described in section 2.1) and the socio-economic data presented in this study, this data is referred to as the 'socio-economic survey data'.

The number of farms taking up pluriactivity in Grampian has been rising from the mid-1970's (Fig. 1.2) although the rate of increase has varied with the type of pluriactivity. The extent of land affected by each type of pluriactivity therefore differs and is constantly changing. The landscape, farming and socio-economic characteristics associated with each pluriactivity farm group are therefore described separately to discover any relationships with the type of pluriactivity.

Where possible, Grampian characteristics are compared to those for Scotland and Britain.

3.1 *The Grampian Countryside*

Grampian is the third largest region in Scotland, covering 12%[1] of the 77,279km^2 of the mainland. In comparison to the rest of the Scotland, Grampian is predominantly arable. Intensively-cultivated land covers 38% of the region,

[1] figures quoted in this paragraph are taken from the ITE Land Classification database (Merlewood).

mainly in the lowland toward the north and east coasts. An equivalent area is covered by mountains in the west although this is proportionally less than that in Scotland generally. Predominantly grassland hills extend patchwork-like between the lowland and upland areas, covering 10% of the region. Higher hills, conspicuous with heather and gorse during the summer, cover a further 13% of the region (Fig. 3.1). Hedgerows and lines of trees are conspicuously absent or rare. Wooded areas are often coniferous monoculture plantations. Beech is common but only as small copses or as lines of trees on agricultural land; the native birch, pine and oak (McVean and Ratcliffe, 1962) occur in areas topographically unsuitable for anything else. Grampian therefore contrasts to the moor-grasslands of the west, the peatlands of the north and the less intensive areas of the south-west.

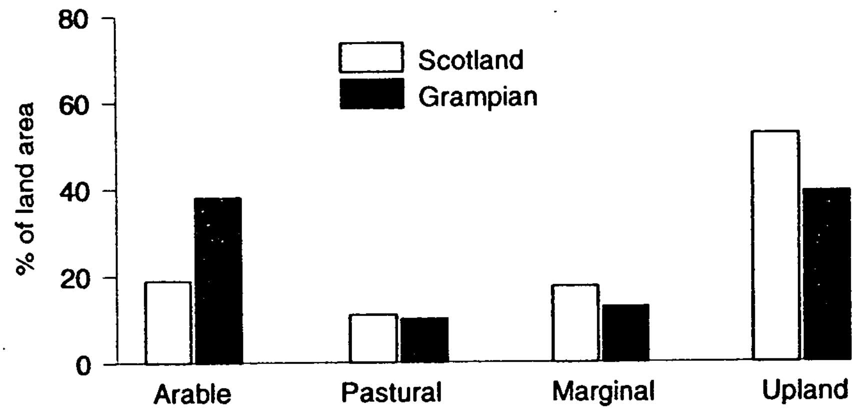


Fig 3.1. Proportions of different landscape types within Grampian and Scotland. arable = arable-growing lowland areas (ITE Land classes 9,12,14,25,26); pastural = lowland grasslands (Land classes 5,6,7,8,10,13,15,16,27); marginal = marginal areas with a mixture of lowland and upland land types (Land classes 17,18,19,20,28,31); upland = upland land types (Land classes 21,22,23,24,29,30,32) (Figures were obtained from the ITE Land Classification database, Merlewood. The landscape types are as defined in Barr *et al*, 1993).

The three agricultural landscape types of Grampian are illustrated in Plates 1-3.

(1) The marginal upland landscape, conspicuous with heather and gorse during the summer, which covers 13% of the region.

(2) The pastural landscape type extending patchwork-like between the marginal upland areas and the lowland arable areas, covering 10% of the region.

(3) The arable landscape type which covers 38% of the region.

Plates 1-3. The three agricultural landscape types (defined by the ITE Land Classification System; see Barr *et al*, 1993), Grampian Region. Taken by Noranne Ellis.

3.2 *Farming Characteristics*

Soils vary from fertile brown soils to less fertile podsols and gleys. However, in the agricultural areas, soils have been ploughed and fertilised for more than 200 years. Pedological differences are therefore now less important than texture and drainage in influencing agricultural capability (J.S. Bibby, *pers. comm.*). The 'Agricultural Land Capability' classes defined for Scotland (Bibby *et al,* 1982), reveal that 52% of Grampian is capable of producing good cereals and grass with a further 7% classed as highly fertile; 23% is hill or mountain capable only of sustaining rough grazing with a further 16% suitable only for grass (unpublished Macaulay Institute of Soil Research data; J.S. Bibby, *pers. comm.*).

All nine Scottish Office (or 'SOAFD'[2]) farm types occur in Grampian. Each has a similar frequency to the rest of Scotland generally (Fig. 3.2). Nearly 50% of farms are small businesses (farm type 9) whilst the rest are generally cattle (mainly non-suckler beef in Grampian) and cropping (arable) farms, even in Less Favoured Areas (LFA's), i.e. areas of poorer agricultural capability.

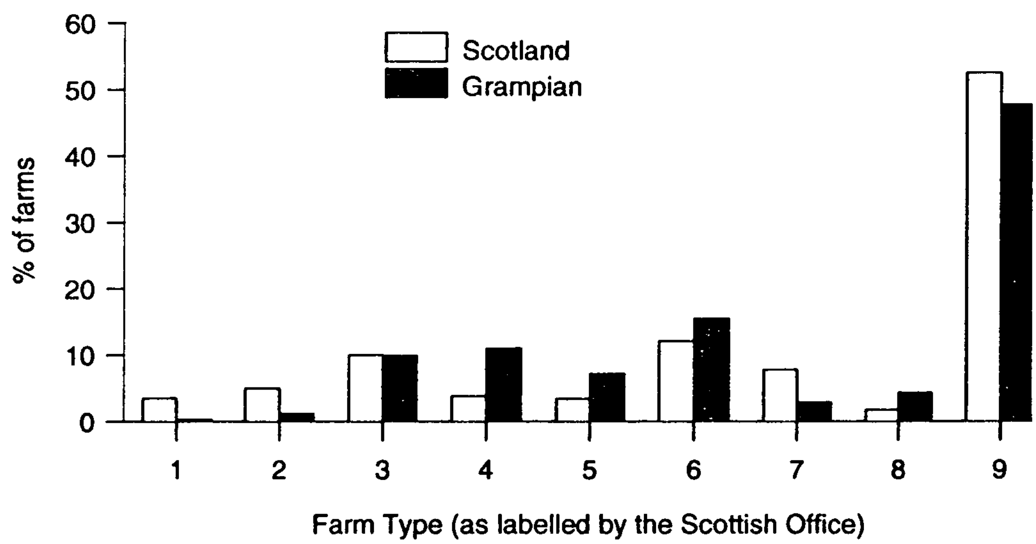


Fig. 3.2. The proportion of Scottish Office ('SOAFD') Farm Types in Scotland and Grampian, 1992 (Scottish Office Department of Statistics; A. Reid, *pers. comm.*). 1 = LFA sheep; 2 = LFA sheep+cattle; 3 = LFA cattle; 4 = LFA with arable; 5 = lowground sheep+cattle; 6 = cropping; 7 = dairy; 8 = intensive; 9 = small units (4-16 BSU).

---

[2] Scottish Office Agriculture and Food Department

However, farms selected for the socio-economic survey excluded small farms, i.e. under the economic size of 4BSU (see section 2.1). As a result, over 25% were cropping farms and only 17% were small units; the SOAFD farm types 3-5 were also about 33% more predominant within the socio-economic survey than within Grampian generally.

The distribution of SOAFD farm types between the farm groups was also not even;

● higher proportions of pluriactive farms were classified as small units (i.e. farm type 9);

● particularly high proportions of cropping farms (i.e. farm type 6) were found in the ON-FARM and BOTH groups;

● the highest proportion of intensive farms (i.e. horticulture, pigs and poultry; farm type 8) was in the ON-FARM group;

● LFA farms (farm types 1-3) were found mainly in the non-pluriactive and OFF-FARM groups (Table 3.1).

Table 3.1. The percentage distribution of Scottish Office ('SOAFD') Farm Types among the farm groups in Grampian, 1991 (socio-economic survey data). *n* = number of farms.

FARM GROUP	Non-pluriactive $n = 84$	OFF-FARM pluriactivity $n = 147$	ON-FARM pluriactivity $n = 32$	BOTH pluriactivities $n = 32$	Overall $n = 295$
1. LFA sheep	1.2	0	0	0	0.3
2. LFA sh+c	1.2	3.4	0	0	2.0
3. LFA cattle	20.2	16.3	6.3	9.4	15.6
4. LFA arable	11.9	18.4	9.4	12.5	14.9
5. sh+c	16.7	10.2	6.3	9.4	11.5
6. cropping	25.0	23.8	37.5	46.9	28.1
7. dairy	6.0	2.7	9.4	3.1	4.4
8. intensive	6.0	5.4	15.6	0	6.1
9. small units	11.9	19.7	15.6	18.8	17.0
Total	100	100	100	100	100

sh+c = sheep+cattle

3.3 *The Extent of Pluriactivity within the Region*

Dalton and Wilson (1989) reported that 40% of all farms in Scotland were pluriactive; Grampian was reported to be the fourth most pluriactive region with 42% of farms then involved in pluriactivity. Fig. 1.2 has already indicated that the uptake of pluriactivity between 1981 and 1991 had trebled. In 1991, nearly 72% of Grampian farms were involved in pluriactivity compared to 47% in Dumfries & Galloway and 51% in Fife. Half of all farms in the Dent *et al* (1993) survey were involved in OFF-FARM pluriactivity (Table 3.2).

Table 3.2. The frequency of farms within each farm group in 1991 (socio-economic survey data) and projected for Grampian assuming 2226 farms in the region (Scottish Office Department of Statistics; A. Reid, *pers. comm.*).

FARM GROUP	Number in the socio-economic survey	%	Projected number for the region [a]
Non-pluriactive	84	28.5	634
OFF-FARM pluriactivity	147	49.8	1109
ON-FARM pluriactivity	32	10.9	243
BOTH pluriactivities	32	10.9	243
Total	295	100	2229

[a] the projected number of farms in each group were rounded up.

The proportion of the region covered by each farm group is also determined by the average farm area as well as the frequency of farms within each group. The ON-FARM group tends to have the larger farms whilst the OFF-FARM and BOTH groups have smaller farms (Table 3.3). Therefore, in 1991, even with some of the smaller farm areas, the OFF-FARM group was estimated to manage over 40% of Grampian's agricultural land whilst the ON-FARM group, although less frequent, was estimated to manage about one sixth. About one third was estimated to be managed by non-pluriactive farms. That non-pluriactive farm households tended to occupy farms in the middle of the size range agrees with earlier studies in England (Harrison, 1966; Buttel, 1982; Gasson, 1983).

Table 3.3. Average farm area and estimated range (hectares and %) for each farm group within Grampian, 1991 (socio-economic survey data). Estimated areas were calculated by multiplying the projected number of farms (Table 3.2) with the inter-quartile ('IQ') range of the farm area. The % is of the IQ range for each farm group divided by the IQ range of the total land area.

FARM GROUP	Farm area (ha)		Estimated range within Grampian	
	Median (IQ range)	df	IQ range (ha)	%
Non-pluriactive	100.3 (59.0, 218.0)		37,430 - 138,299	33.0 - 33.8
OFF-FARM pluriactivity	92.6 (41.4, 170.1)^{NS}	1,229	45,896 - 188,572	41.5 - 45.0
ON-FARM pluriactivity	144.7 (66.0, 250.1)^{NS}	1,114	16,011 - 60,674	14.5
BOTH pluriactivities	89.9 (46.5, 131.2)^{NS}	1,114	11,281 - 31,829	7.6 - 10.2
Overall	98.0 (47.0, 186.4)		110,618 - 419,375[a]	

NS = no significant difference between the non-pluriactive farms and the pluriactive group using a two-way ANOVA and $\log_{(e)}$ transformed data[3]. IQ = inter-quartile range (i.e. 25-75%).
[a]The total land area in Grampian is 870,100 ha (Scottish Abstract of Statistics, 1992) but 38-40% is estimated to be mountainous and of little agricultural use (ITE Land Classification database, Merlewood, and the MLURI Land capability classification).

3.4 *Farm Tenure*

Decisions on the use and management of land can be affected by its tenure either from incentive and motivation and/or governing restrictions. Owner-occupancy and tenancy are the two farm tenures traditionally recognised (excluding farm estates). Owner occupancy presumably provides a greater incentive to develop the land (for example, in planting trees) than tenancy. Even where tenant farmers have interest in developing land, the landowner's permission may or may not be granted. More recently, however,

"there is growing evidence of new, more complex, land-holding arrangements between 'landlords' and 'tenants' involving, for example, landlord-tenant partnerships and sharecropping arrangements" (Munton & Marsden, 1991).

In England, the number of mixed-tenure farms are growing faster than any other category of farm tenure (Hill & Gasson, 1985), although this does not always allow a greater flexibility in developing the land than straight-forward

[3] statistical differences cannot be determined between two populations with skewed distributions. To produce two populations with normal distributions the data are transformed: $x = \log_{(e)}(x+1)$. Mention is made whenever this is employed within this study.

tenancies (Coulter, *pers. comm.*).

In 1991, two-thirds of Grampian farms were owner-occupied, 22% were tenanted (compared with 29% of all British holdings tenanted in 1986; Munton & Marsden, 1991) and 12% were mixed owner-tenancies (Table 3.4).

Table 3.4. The proportion (expressed as a %) of owner-occupied and tenant farms in each farm group (socio-economic survey data).

FARM GROUP	Owner occupied	Tenancy	Mixed ownership/ tenancy	Total
Non-pluriactive	72.6	17.9	9.5	100
OFF-FARM pluriactivity	63.9	25.2	10.9	100
ON-FARM pluriactivity	65.6	15.6	18.8	100
BOTH pluriactivities	62.5	21.9	15.6	100
Overall	66.4	21.7	11.9	100

The greatest proportion of owner-occupied farms were non-pluriactive whilst the OFF-FARM group had the greatest proportion of tenanted farms (contravening the notion that such farmers might be more interested in owning than farming the land; Gasson, 1966). The greatest proportion of mixed owner-tenant farms occurred within the ON-FARM group. The greatest restrictions and, perhaps motivation, in developing the land might therefore be seen within the OFF-FARM group.

3.5 *Economic Characteristics*

The British Size Unit (BSU) is a measure of farm size based on farming income. Farms can be grouped according to their BSU size:

- small farms = 4-16 BSU ('one man' farms),
- medium farms = 16-40 BSU ('2-3 man' farms),

and
- large farms = >40 BSU (farms with more than 3 men)

(Farm Account Scheme notes, various years).

Most farms in Grampian were small-medium although the type of pluriactivity was associated with the extremes; the ON-FARM group contained medium and large farms whilst the OFF-FARM and BOTH groups contained small to small-medium farms. Mirroring the farm area pattern, the non-pluriactive farms were mainly medium sized; only the OFF-FARM group significantly differed to non-pluriactive farms (Table 3.5).

Table 3.5. The average British Size Unit (BSU) for each farm group (socio-economic survey data). BSU is a measure of farm size based on farm income.

FARM GROUP	BSU		
	Median	IQ range	df
Non-pluriactive	21.0	(10.0, 37.0)	
OFF-FARM pluriactivity	16.0*	(9.0, 27.8)	1,229
ON-FARM pluriactivity	36.5^{NS}	(17.0, 63.5)	1,114
BOTH pluriactivities	17.0^{NS}	(9.0, 27.0)	1,114
Overall	19.0	(10.0, 34.0)	

NS = no significant difference, *$P<0.05$ level of significance between the non-pluriactive farms and the pluriactive group using a one-way ANOVA and $\log_{(e)}$ transformed data.

Using other survey datasets, Dalton and Wilson (1989) and Davies and Dalton (1993a) noted that significantly higher proportions of farms engaged in off-farm pluriactivity were on small farms (generally about 24 BSU). Dalton and Wilson (1989), however, noted that on-farm pluriactivity (i.e. inclusive of the BOTH group) was significantly more common at the extreme ends of the BSU scale than in the middle region (particularly between 16-24 BSU). This may have been due to on-farm activities associated with differing farm groups; at the higher end of the BSU scale the non-agricultural activities were associated with the ON-FARM group whereas the small BSU farms may have been mainly within the BOTH group.

The average farming incomes for the four farm groups in Grampian for 1991 are presented in Table 3.6. Although there was no significant difference in the farm income of each pluriactive group from the non-pluriactive farms, the proportion of income from farming was least for the BOTH group and most for the non-pluriactive farms, as might be expected.

Table 3.6. The average income (£) for each farm group with the proportions (%) from farming and from pluriactivity (socio-economic survey data). The inter-quartile (IQ) range is shown in brackets. Property income (e.g. rents, dividends) and transfer payments (e.g. pensions, state benefits) are omitted.

FARM GROUP	Median farm income (IQ range)	df	% from farming (IQ range)	% from pluriactivity (IQ range)	df
Non-pluriactive	7500 (3750, 15,000)		66.8 (50,100)	0	
OFF-FARM pluriactivity	7500^{NS} (5058, 14,813)	1,226^{MV}	45.0** (24.1, 50.0)	50.0** (26.6, 51.9)	1,229
ON-FARM pluriactivity	8438^{NS} (5000, 16,688)	1,113^{MV}	50.0** (34.8, 68.3)	12.3** (0, 26.9)	1,114
BOTH pluriactivities	9188^{NS} (7500, 17,188)	1,113^{MV}	27.9** (10.0, 49.7)	50.6** (34.2, 68.3)	1,114

NS = no significant difference, **P<0.01 level of significance between the non-pluriactive farms and the pluriactive group using a one-way ANOVA (the percentage data were used with an angular transformation). MV = missing values, i.e. the farm household were unwilling to give details of their income although they were willing to provide details of the proportions of their income from different sources.

The ON-FARM group appeared most likely to employ another person to work on the farm although this was not significantly more than the non-pluriactive farms (Table 3.7).

Table 3.7. The average number of farm employees within each farm group (socio-economic survey data). The inter-quartile (IQ) range is shown in brackets.

FARM GROUP	Number of farm employees		
	Median	IQ range	df
Non-pluriactive	0.0	(0.0, 1.0)	
OFF-FARM pluriactivity	0.0^{NS}	(0.0, 0.3)	1,229
ON-FARM pluriactivity	1.0^{NS}	(0.0, 1.0)	1,114
BOTH pluriactivities	0.0^{NS}	(0.0, 0.5)	1,114

NS = no significant difference between the non-pluriactive farms and the pluriactive group using a one-way ANOVA and $\log_{(e)}$ transformed data.

3.6 *Farm Household Characteristics*

At least 50% of surveyed Grampian farmers were between 42 and 57 years although farmers on non-pluriactive farms were significantly older ($P<0.01$) at 48-65 years than farmers in any pluriactive group. The youngest farmers were within the ON-FARM and BOTH groups (37-54 years old). This pattern was repeated with the age of the household (Table 3.8). Pluriactive farm households also had significantly more ($P<0.01$) family members than non-pluriactive farms although only the ON-FARM and BOTH groups had significantly more ($P<0.01$) children (Table 3.9).

Table 3.8. The average age of the farmer and farm household for each farm group (socio-economic survey data). The age of the farm household includes the age of the farmer. The inter-quartile (IQ) range is shown in brackets.

FARM GROUP	Age of farmer (years)	Age of farm household (years)	
	median (IQ range)	median (IQ range)	df
Non-pluriactive	55.5 (48.5, 65.0)	47.6 (35.5, 60.7)	
OFF-FARM pluriactivity	50.0 (43.0, 56.0)**	37.8 (30.6, 44.6)**	1,229
ON-FARM pluriactivity	44.0 (37.5, 53.5)**	33.3 (24.9, 41.7)**	1,114
BOTH pluriactivities	47.5 (38.5, 54.5)**	32.1 (27.4, 38.2)**	1,114
Overall	50.5 (42.0, 57.0)	38.3 (30.0, 48.7)	

**$P<0.01$ level of significance between the non-pluriactive farms and the pluriactive group using a one-way ANOVA.

Table 3.9. The average number of household members, number of children and number of earners within a farm household for each farm group (socio-economic survey data).

FARM GROUP	Number in farm household	Number of children	Number of earners	
	median (IQ range)	median (IQ range)	median (IQ range)	df
Non-pluriactive	3 (2, 4)	0 (0, 1)	2 (2, 3)	
OFF-FARM pluriactivity	4 (3, 5)**	0 (0, 1)^{NS}	3 (2, 4)^{NS}	1,229
ON-FARM pluriactivity	5 (3, 6.5)**	1.5 (0, 3)**	2.5 (2, 3)*	1,114
BOTH pluriactivities	4 (3, 5.5)**	1.0 (0, 2)**	3 (2, 4)*	1,114

NS = no significant difference, *$P<0.05$, **$P<0.01$ level of significance between the non-pluriactive farms and the pluriactive group using a one-way ANOVA and $\log_{(e)}$ transformed data.

Farmer involvement in pluriactivity was high; 61% of farmers within the OFF-FARM group were involved in off-farm work, 75% within the ON-FARM group were involved in non-agricultural activities whilst within the BOTH group 93% of farmers were involved in some form of pluriactivity (Table 3.10).

Table 3.10. The proportion (%) of household members involved in pluriactivity for each farm group (socio-economic survey data).

	Farmer only	Farmer+ non-farmer	Non-farmer members only
OFF-FARM pluriactivity	19.1	41.5	39.4
ON-FARM pluriactivity	43.8	31.3	25.0
BOTH pluriactivities	13.3	80.0	6.6
Overall	22.0	45.5	32.5

It is possible that the lower proportion of farms with farmer involvement in the OFF-FARM group is related to the older household age structure and greater availability of young adults in the household. Involvement by the farmer may have greater implications for the type and quality of land management than involvement by non-farmer members alone.

The degree of impact on the land may be also determined by the perceived future of the farm with a greater incentive to develop the land where the farm is expected to continue being farmed by a member of the family. In this survey, over one half of all farms expected the management of the farm to be continued by at least one family member with a slightly higher expectation within pluriactive farms (Table 3.11). This contrasts to the trend reported by Shucksmith *et al* (1989) where only 25-30% of Grampian farmers were certain of family succession with even less certainty within pluriactive households.

Table 3.11. The proportion (%) of farms where at least one family member is expected to succeed in farming the land (socio-economic survey data).

FARM GROUP	% of farms where a family member is expected to succeed
Non-pluriactive	55.6
OFF-FARM pluriactivity	57.2
ON-FARM pluriactivity	62.1
BOTH pluriactivities	67.7
Overall	58.4

About two-thirds of all households had received some formal higher education, whether at college or university, agricultural or non-agricultural. Forbes *et al* (1980) noted that in a farm survey the farmers who had received formal training or further education tended to farm more intensively. However, there was great variation between the farm groups with non-pluriactive farms being the least educated and the most educated farms having some form of on-farm pluriactivity. The ON-FARM group had the greatest proportion of farmers with higher qualifications (Table 3.12). These data indicate a greater level of education with younger households.

Table 3.12. The proportion (%) of farms where household members had obtained a tertiary level of education within each farm group (socio-economic survey data).

FARM GROUP	The farmer exclusively	At least one non-farmer member	No household member
Non-pluriactive	27.9	24.4	47.7
OFF-FARM pluriactivity	36.1	32.0	32.0
ON-FARM pluriactivity	62.5	21.9	15.6
BOTH pluriactivities	36.7	36.7	26.7
Overall	36.6	29.2	34.2

3.7 *Discussion of the Land and Farm Characteristics in Grampian*

Grampian is a varied and moderately fertile region in all but the upland areas and therefore distinguished from most other regions of Scotland. Although nearly half the farms in the socio-economic survey were economically small, farms tended to be managed for crops and/or non-suckler beef cattle which are intensive forms of agriculture. Nearly three-quarters of Grampian farms were recorded as being involved in pluriactivity in 1991 with over half of all farms involved in off-farm work. The extent of land managed by pluriactive farm households was estimated to cover three-quarters of the region with 44-45% of the region managed by the OFF-FARM group.

It was surprising that having defined the four farm groups by their non-involvement or type of involvement in pluriactivity, there were significant differences in socio-economic characteristics between the pluriactive farm groups and the non-pluriactive farms. However, differences in economic size, the level of education of the farmer, and the age and size of households have already been recorded in a number of previous studies by other researchers (as cited throughout the chapter). The BOTH group, which has not been identified as a separate group to either the OFF-FARM or ON-FARM groups before, appears to be distinct. Therefore, before the land management and farmland ecology data are examined for each farm group, there are indications that farming (and therefore ecological differences) may already exist between the farm groups.

Although the OFF-FARM and BOTH groups contained similar sized farms, both in terms of area and economic size, farmers within the BOTH group were better educated than those in the OFF-FARM group. Correspondingly, 47% of farms in the BOTH group were involved in cropping in contrast to 30% of farms in the OFF-FARM group involved in livestock. The BOTH group might therefore be expected to manage their farms more intensively.

The ON-FARM group had the largest farm businesses and farm areas as well as having the most educated households. Sinclair (1983) also noted a significant association between younger farmers and larger holdings and that younger farmers and larger farms are associated with intensive farming and active landscape changes which are usually detrimental to the landscape (such as hedgerow removal) (also see EDC, 1973). That the ON-FARM group might be farming more intensively than other farm groups is indicated by 38% of farms involved in cropping and 16% categorised as 'intensive' by the Scottish Office, i.e. involved in horticulture, pig units and/or poultry. Although the ON-FARM group would be expected to farm intensively and therefore with least ecological interest, Piddington (1981) and Westmacott and Worthington (1984) noted that farms developing non-agricultural enterprises on the farm are associated with active conservation measures such as tree planting and game. It is therefore difficult to predict the farmland characteristics of the ON-FARM group.

Despite non-pluriactive farms having farms mid-range in both area and BSU sizes, they contained older, less educated households. That non-pluriactive farms occupy the middle range of farm sizes has been attributed to their farmers being old age pensioners, single, widowed or divorced, or female (Buttel, 1982; Gasson, 1983), as well as having low education, rendering such farms "uncompetitive in the urban labour markets" (Buttel, 1982). About one quarter of these farms were cropping farms and one fifth were categorised as 'LFA cattle' farms. From such descriptions it might be expected that the non-pluriactive farms would manage their land less intensively than the pluriactive groups, particularly the ON-FARM and BOTH groups.

In conclusion, any ecological differences which might be seen between the farm groups might be more likely to be *associated* with their farm household characteristics rather than *resultant* from the involvement in pluriactivity. Although this statement reinforces those made in Chapter One, the association between the intensity of farming and the household characteristics are now inverted. Instead of pluriactivity associated with lowered levels of management intensity, it now seems as if some forms of pluriactivity may be associated with intensive forms of farming.

With over 60% of farms in owner occupation it is believed that, on the whole, household decisions would have an unrestricted knock-on effect onto the management of the farm and hence the farmland ecological characteristics.

CHAPTER 4

The Ecology Sample

Introduction

A smaller sample of farms (the 'ecology sample') were to be selected from those used in the socio-economic survey to allow detailed ecological data to be collected. In order to stratify the ecology sample by type of involvement in pluriactivity and ITE Land Class, the socio-economic data collection needed to be complete before the vegetation season (i.e. June 1991). However, the socio-economic survey started in Grampian the first week of July 1991 and ended December 1991; the data did not become available until May 1992. This resulted in the ecology sample being selected over two years.

This chapter describes the procedure which evolved during the selection of the ecology sample and compares the land, farming and socio-economic characteristics of the ecology sample to those described in Chapter 3. The socio-economic data summarised in this chapter are used again in Chapter 9 to account for the variation in the number of species in grass fields (Chapter 8).

4.1 *The Selection of the Ecology Sample farms*

The selection of the ecology sample farms started at the end of the second week of July 1991. Farms were selected by hand from completed socio-economic questionnaires returned to the School of Agriculture in Aberdeen. This was repeated at the end of each week until October 1991, providing 2-3 farms per week. The selection, at this stage, was relying on secondary information or hypotheses to determine which type of farm grouping or ITE Land Class to select from:

- in 1989, Dalton and Wilson reported that off-farm pluriactivity occurred on 33% of Grampian farms, on-farm pluriactivity on 14% (the lowest proportion in Scotland) and both pluriactivities on 5% of farms (along with Strathclyde and Central regions, the lowest proportion in Scotland). Farms from the BOTH group were therefore not selected during 1991.

- in Chapter 2, it was hypothesised that involvement in pluriactivity by the farmer was more likely to affect the type and intensity of land management than if another household member was involved. During July and August 1991 only pluriactive farms with farmer involvement alone were selected although due to dwindling numbers of suitable farms by September, involvement by any household member was included.

- in Chapter 1, it was hypothesised that upland areas may be least affected by pluriactivity. Farms were therefore not selected from upland land classes, leaving Land Classes 25, 26, 27 and 28 from which to select. These four land classes accounted for 61% of the total land area in Grampian, or 98% of the lowland and marginal-upland areas (Table 4.1). Eighty-six per cent of Grampian socio-economic survey farms fell within these land classes.

Table 4.1. The frequency and proportion (%) of each ITE Land Class in Grampian (ITE Land Classification database; D.Howard, *pers. comm.*). The regional area is 8930km^2. Farms in Land Classes 25-28 were selected for the ecological field survey.

ITE Land Class (from Bunce, Barr & Whittaker, 1981)	N° km^2's	% of region
9. Fairly flat, open intensive agriculture, often built-up.	1	0
18. Rounded hills, sometimes steep slopes, varied moorlands.	1	0
19. Smooth hills, mainly heather moors, often afforested.	83	0.9
20. Mid valley slopes, wide range of vegetation types.	28	0.3
21. Upper valley slopes, mainly covered with bogs.	90	1.0
22. Margins of high mountains, moorlands, often afforested.	2234	25.0
23. High mountain summits, with well drained moorlands.	1067	12.0
24. Upper, steep, mountain slopes, usually bog covered.	66	0.7
25. Lowlands with variable use, mainly arable.	*2708*	*30.3*
26. Fertile lowlands with intensive agriculture.	*688*	*7.7*
27. Fertile lowland margins with mixed agriculture.	*900*	*10.1*
28. Varied lowland margins with heterogeneous land use.	*1025*	*11.5*
29. Sheltered coasts with varied land use, often crofting.	36	0.4
30. Open coasts with low hills dominated by bogs.	3	0

In May 1992, farms within the BOTH group were found to constitute 11% of the Grampian survey farms, i.e. the same proportion as the ON-FARM group, and were therefore included in the 1992 sampling procedure (see Table 3.2). After the second vegetation survey Land Class 22 (an upland land class) was found to be the most pluriactive land class in the three regions covered by the socio-economic survey; 68% of farms were recorded as having off-farm pluriactivity and 23% as having on-farm pluriactivity (H.Edmond, *pers. comm.*). Nearly 14% of the Grampian socio-economic survey farms occurred in Land Class 22 which suggests that Land Class 22 should have been included in the sample stratification.

Thirty-three farms were selected during 1991 by hand and 38 were selected during May 1992 using the computerised socio-economic database. The final selection of 71 farms, representing 95 holdings, are shown in Table 4.2. The ideal had been to obtain the same number of farms in each cell but certain types of pluriactivity were not recorded as frequently in some land classes as others; for example, only two farms within the ON-FARM group were recorded in Land Class 28. However, the uneven distribution of farms was more the result of the sampling procedure.

Table 4.2. The sample of farms used in the ecology survey, Grampian Region 1991 and 1992, stratified by type of pluriactivity and ITE Land Class.

ITE Land Class	FARM GROUP				
	Non-pluriactive	OFF-FARM pluriactivity	ON-FARM pluriactivity	BOTH pluriactivities	Total
25	6	6	4	4	20
26	6	4	4	2	16
27	7	4	3	3	17
28	6	5	2	5	18
Total	25	19	13	14	71

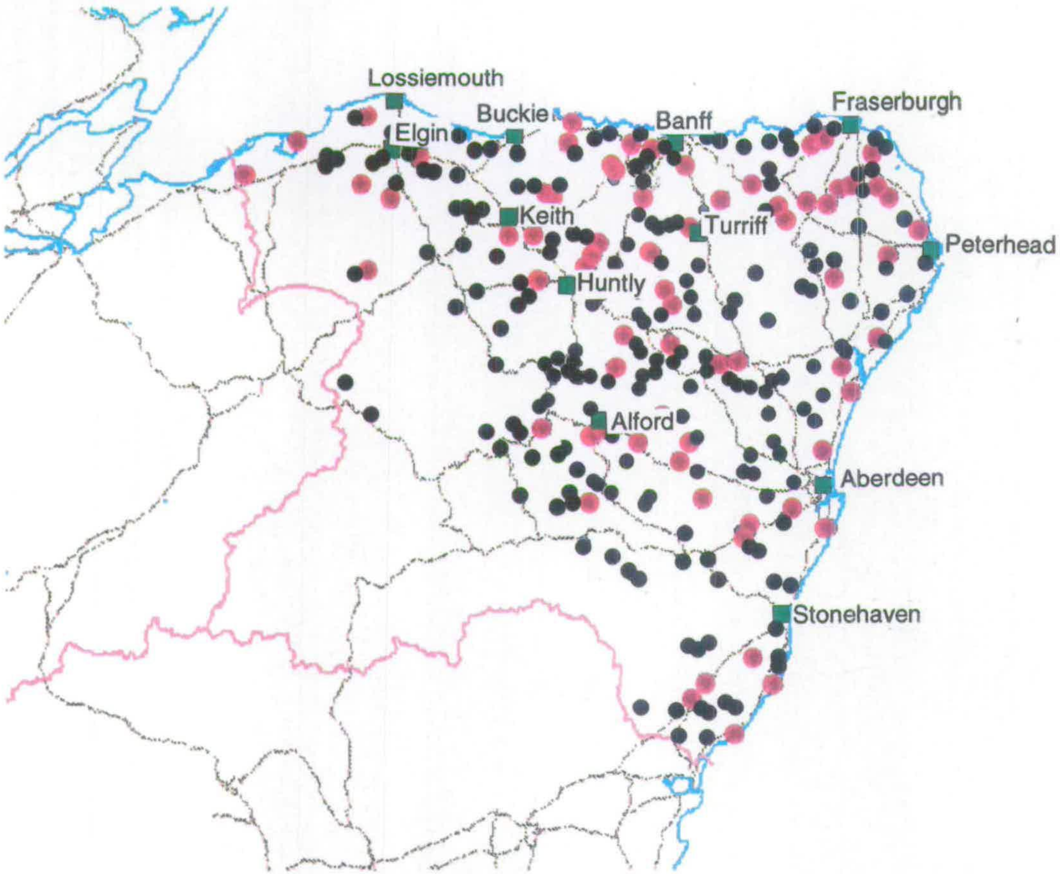
About five originally selected farms were discarded when the farmer was unable to clarify boundaries of holdings not collected on the farm map during the socio-economic survey interview. Each was replaced with another farm randomly selected in the same sampling cell. No geographical clustering of farms was apparent for any farm group (Dent *et al*, 1993) (Fig. 4.1), although the ecology sample farms appeared to be more frequent towards the north-east and less frequent towards the west where Land Class 22 is more prevalent (ITE Land Classification database).

4.2 *The Representativeness of the Farming Characteristics*

Soil data were extracted from 1:63 360 scale maps (Macaulay Institute Soil Research) and transferred to copies of the 1:10 000 scale farm maps for the seventy-one farms by J.S. Bibby and passed to myself. The extent of each soil series was estimated per farm using an acetate grid over the farm map and counting the number of 0.1 hectare squares ($1000m^2$) covering each one. The data were entered into an Oracle database and the proportions of each soil series over the total area of each farm were calculated. J.S. Bibby also provided pH, drainage, texture and base status details for each soil series so that the extents of each acid-alkaline, free-poor draining, coarse-organic and base-poor to base-rich soil categories could be calculated for each farm and means calculated per farm group.

About 90% of the soils were moderately acid, about 50% were freely drained and 70-90% were of coarse/medium textures; only 12-20% of soils were base-rich (Fig. 4.2). No statistical differences were seen between the non-pluriactive farms and any pluriactive group.

Fig.4.1. The Distribution of farms selected for the ecological investigation over Grampian. (The map had originally been produced on a Geographical Information System by K.Corcoran, School of Agriculture, Edinburgh).



KEY

- farms used in the socio-economic survey (see Dent *et al*, 1993)
- farms used in the ecological field survey
- A-roads

Note: each point covers approximately 10km² on the ground and therefore cannot specifically indicate the location of any farm.

20 km

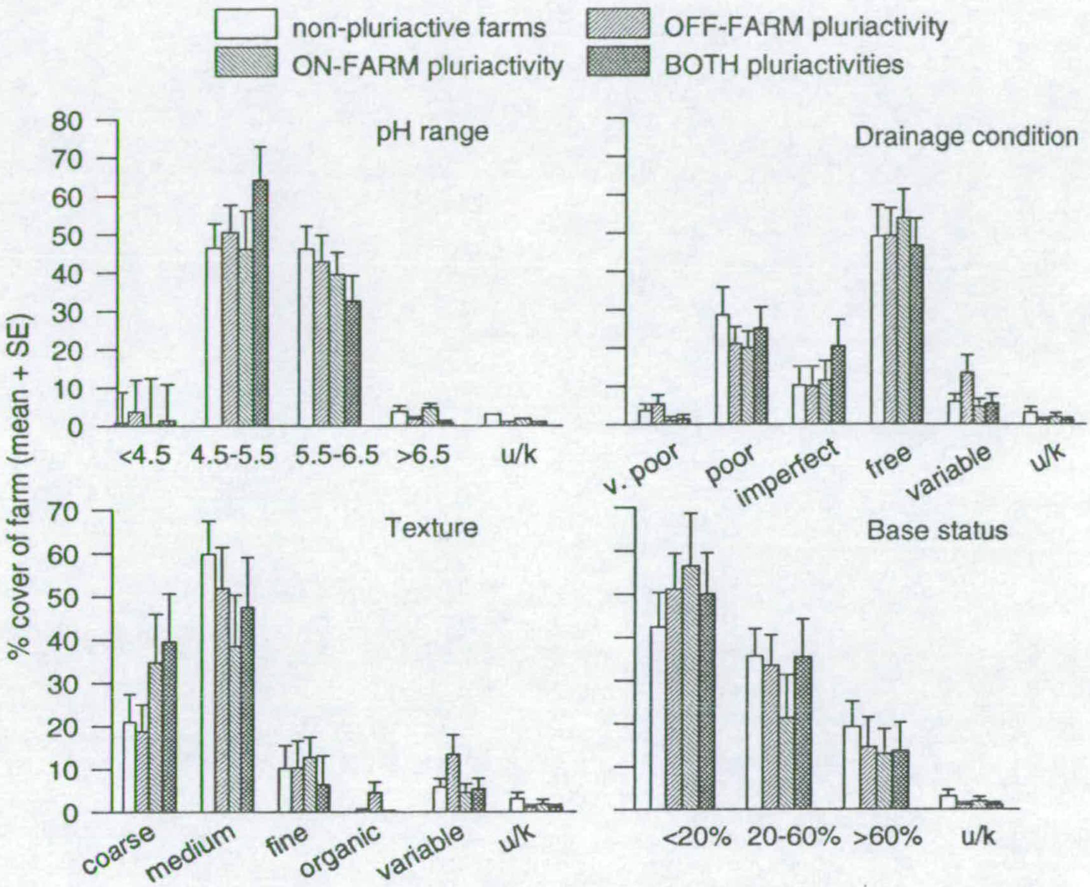


Fig. 4.2. The mean extent (%) of each soil category within each farm group. Bars indicate standard error about the mean. U/k = unknown. No significant differences (P>0.05) were seen between the non-pluriactive farms and any pluriactive group using one-way ANOVA's and angular transformed data.

The distribution of SOAFD farm types within this ecology sample did not significantly differ to that within the socio-economic sample although LFA sheep and LFA sheep+cattle, which together had only constituted less than 3% of the socio-economic sample, were not recorded (Fig. 4.3).

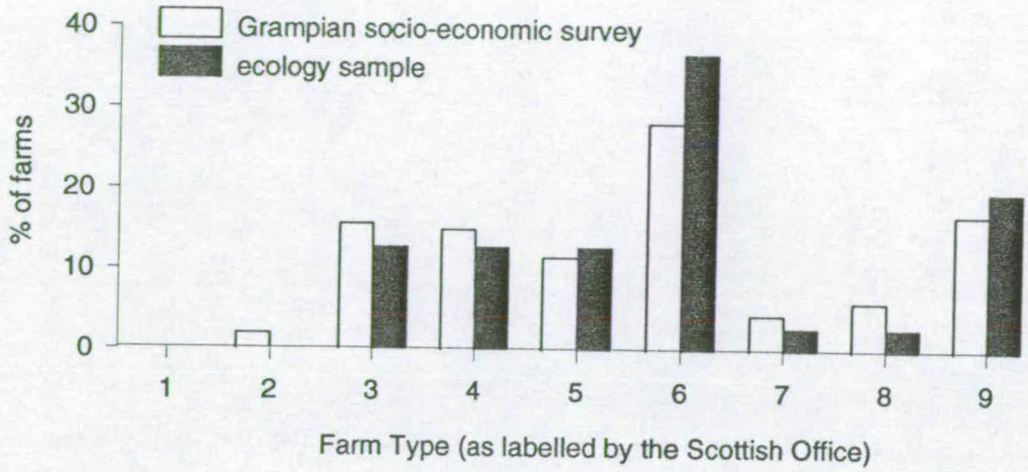


Fig. 4.3. The proportion of Scottish Office ('SOAFD') Farm Types in the ecology sample and in the Grampian socio-economic sample. 1 = LFA sheep; 2 = LFA sheep+cattle; 3 = LFA cattle; 4 = LFA with arable; 5 = lowground sheep+cattle; 6 = cropping; 7 = dairy; 8 = intensive; 9 = small units (4-16 BSU).

There were, however, differences in the distribution of the farm types within each farm group in comparison to the distribution within the socio-economic sample (see Table 3.1). LFA cattle farms were 10% more prominent in the OFF-FARM group, cropping farms in the ON-FARM and BOTH groups now constituted 50% from 38% and 47% respectively whilst LFA cattle farms were not recorded in these two groups (decreasing from 6% and 9% respectively). Dairy farms were now absent from the non-pluriactive and ON-FARM groups (despite being 6% and 9% of farms within the socio-economic sample respectively) but were represented by the OFF-FARM and BOTH groups by double the proportion of farms as within the socio-economic sample. Small unit farms had increased by 8% in the non-pluriactive farms (Table 4.3).

Table 4.3. The percentage distribution of Scottish Office (SOAFD) farm types among the farm groups in the ecology sample (socio-economic data). *n* = number of farms.

Farm Type	Non-pluriactive *n* = 25	OFF-FARM pluriactivity *n* = 19	ON-FARM pluriactivity *n* = 13	BOTH pluriactivities *n* = 14	Overall *n* = 71
3. LFA cattle	16.7	26.3	0	0	13.0
4. LFA arable	16.7	10.5	8.3	14.3	13.0
5. sh+c	20.8	5.3	8.3	14.3	13.0
6. cropping	25.0	31.6	50.0	50.0	36.2
7. dairy	0	5.3	0	7.1	2.9
8. intensive	0	0	8.3	0	1.4
9. small units	20.8	21.1	25.0	14.3	20.3
Total	100	100	100	100	100

sh+c = sheep+cattle

4.3 *Representiveness of the Farm Areas*

The farm areas of the ecology sample were, overall, 15% smaller than farms in the socio-economic survey with the greatest reduction being 34% within the OFF-FARM group and 22% within the ON-FARM group (Table 4.4). Although the ON-FARM group still contained farms with the greatest farm areas there was no significant difference from the non-pluriactive farms. Farm areas within the BOTH group were similar to those in the socio-economic sample although the median was nearly 4 ha greater.

Table 4.4. The farm area of each farm group in the ecology sample (socio-economic survey data). The inter-quartile (IQ) range is shown in brackets.

FARM GROUP	Farm area (ha)		
	Median	IQ range	df
Non-pluriactive	82.8	(39.8, 139.5)	
OFF-FARM pluriactivity	60.7^{NS}	(40.7, 147.4)	1,42
ON-FARM pluriactivity	113.3^{NS}	(33.9, 213.7)	1,36
BOTH pluriactivities	93.9^{NS}	(46.5, 144.0)	1,37
Overall	82.8	(40.4, 151.2)	

NS = no significant difference between the non-pluriactive farms and the pluriactive group using a one-way ANOVA.

4.4 *Representiveness of Farm Tenure*

About two-thirds of farms in the Grampian socio-economic sample were owner-occupied but this increased to three-quarters of farms in the selection of the ecology sample, the loss being in the tenancy category; the mixed ownership/tenancy category remained the same (Table 4.5).

Table 4.5. The proportion (%) of owner-occupied and tenant farms in each farm group in the ecology sample (socio-economic survey data).

FARM GROUP	Owner-occupied	Tenancy	Mixed ownership/tenancy	Total
Non-pluriactive	76.0	16.0	8.0	100
OFF-FARM pluriactivity	73.7	15.8	10.5	100
ON-FARM pluriactivity	69.2	15.4	15.4	100
BOTH pluriactivities	78.9	7.1	14.3	100
Overall	74.7	14.1	11.3	100

4.5 *Representiveness of the Economic Characteristics*

The BSU sizes, however, remained much the same as those within the socio-economic sample although there was no significant difference between the OFF-FARM group and non-pluriactive farms (Table 4.6).

Table 4.6. The average BSU of each farm group in the ecology sample (socio-economic survey data). The inter-quartile (IQ) range is shown in brackets.

FARM GROUP	BSU		
	Median	IQ range	df
Non-pluriactive	20.0	(11.8, 41.3)	
OFF-FARM pluriactivity	15.0	(8.5, 30.0)^{NS}	1,42
ON-FARM pluriactivity	43.0	(9.5, 55.8)^{NS}	1,36
BOTH pluriactivities	13.5	(9.0, 22.0)^{NS}	1,37
Overall	19.0	(9.3, 37.0)	

NS = no significant difference between the non-pluriactive farms and the pluriactive group using a one-way ANOVA and $\log_{(e)}$ transformed data.

However, the average farm incomes were greater in the OFF-FARM and BOTH groups than those in the main socio-economic survey. For the OFF-FARM group this may have arisen from the selection of older farm households where a greater number of young adults who, though now working off the farm, were still living at home. However, there appears to be no reason for the BOTH group to have a higher average farm income than the socio-economic sample (Table 4.7).

Table 4.7. The average income (£) for each farm group in the ecology sample with the proportion (%) gained from pluriactivity (socio-economic survey data). The inter-quartile (IQ) range is shown in brackets. Property income (e.g. rents, dividends *etc.*) and transfer payments (e.g. pensions, state benefits *etc.*) are omitted.

FARM GROUP	Median farm income (IQ range)	% from pluriactivity (IQ range)	df
Non-pluriactive	7500 (4406, 17,229)	0	
OFF-FARM pluriactivity	12,500^{NS} (7500, 18,060)	50.0** (30.8, 66.7)	1,39
ON-FARM pluriactivity	6800^{NS} (4031, 9844)	10.0** (7.5, 40.0)	1,33
BOTH pluriactivities	12,188^{NS} (8375, 19,375)	68.4** (50.0, 80.0)	1,35

NS = no significant difference, ***P*<0.01 level of significance between the non-pluriactive farms and the pluriactive group using a one-way ANOVA (the percentage data were used with an angular transformation).

The average number of employees per farm in each group are similar to those for the main socio-economic survey, despite the smaller farm sizes, although the average number of employees on a farm within the ON-FARM group is now less than one (Table 4.8).

Table 4.8. The average number of farm employees within each farm group (socio-economic survey data). The inter-quartile (IQ) range is shown in brackets.

FARM GROUP	Number of farm employees		
	Median	IQ range	df
Non-pluriactive	0.3	(0.0, 1.0)	
OFF-FARM pluriactivity	0.0^{NS}	(0.0, 0.0)	1,39
ON-FARM pluriactivity	0.3^{NS}	(0.0, 1.0)	1,33
BOTH pluriactivities	0.0^{NS}	(0.0, 1.0)	1,35

NS = no significant difference between the non-pluriactive farms and the pluriactive group using a one-way ANOVA and $\log_{(e)}$ transformed data.

4.6 *The Representiveness of Farm Household Characteristics*

Although the average *age of the farmer* in the ecology sample was, overall, only two years older than the socio-economic sample, farmers within the ON-FARM group were, on average, nine years older. The overall farm *household age* was also two years older than the socio-economic sample, with the average household age in the OFF-FARM group about four years older and that within the ON-FARM group being seven years older (Table 4.9). Probably the result of the bias towards older members, households within the ecology sample had 1-2 fewer members than those within the socio-economic sample, the result of fewer children living at home (Table 4.10). In comparing the household characteristics of each pluriactive group to those on non-pluriactive farms, only the BOTH group differed at the same level of significance as seen for the socio-economic sample, having younger, larger households ($P<0.01$).

Table 4.9. Farmer and farm household age, and the number of household members for each farm group in the ecology sample (socio-economic survey data).

	Age of farmer (years)	Age of farm household (years)	
FARM GROUP	median (IQ range)	median (IQ range)	df
Non-pluriactive	54.0 (43.8, 66.8)	45.5 (35.2, 63.6)	
OFF-FARM pluriactivity	52.0 (43.5, 59.8)^{NS}	41.7 (32.6, 55.4)^{NS}	1,42
ON-FARM pluriactivity	53.0 (37.8, 55.5)^{NS}	40.7 (24.2, 53.0)^{NS}	1,36
BOTH pluriactivities	46.0 (39.0, 58.0)^{NS}	32.2 (28.2, 35.5)**	1,37
Overall	52.0 (42.0, 60.0)	38.3 (30.0, 48.7)	

NS = no significant difference, $^{**}P<0.01$ level of significance between the non-pluriactive farms and each pluriactive group using one-way ANOVA's (^{t} and $\log_{(e)}$ transformed data).

Table 4.10. The average number of household members, number of children and number of earners within a farm household for each farm group in the ecology sample (socio-economic survey data).

	Number in farm household	Number of children	Number of earners	
FARM GROUP	median (IQ range)	median (IQ range)	median (IQ range)	df
Non-pluriactive	2 (2, 4)	0 (0, 0)	1 (1, 2)	
OFF-FARM pluriactivity	3 (2, 5)*	0 (0, 1.8)^{NS}	2 (2, 3)^{NS}	1,42
ON-FARM pluriactivity	3 (2, 6)^{NS}	0 (0, 2.3)^{NS}	2 (1.7, 3.2)*	1,36
BOTH pluriactivities	4 (4, 5)**	1.0 (0, 2)*	2 (2, 3)*	1,37

NS = no significant difference, *P<0.05, **P<0.01 level of significance between the non-pluriactive farms and the pluriactive group using one-way ANOVA's and $\log_{(e)}$ transformed data.

The selection of farms where the farmer alone was involved in pluriactivity also meant that such farms accounted for 18% more farms in the OFF-FARM group and 10% in the ON-FARM group, although the BOTH group also had an inexplicable 8% increase in such farms (Table 4.11). However the combination of the two categories of farm (farmer only and farmer+non-farmer) produced nearly identical figures to the socio-economic sample, i.e. 58%, 77% and 93% for the OFF-FARM, ON-FARM and BOTH groups (cf: 61%, 75% and 93%).

Table 4.11. The proportion (%) of household members involved in pluriactivity for each farm group in the ecology sample (socio-economic survey data).

	Farmer only	Farmer+ non-farmer	Non-farmer members only
OFF-FARM pluriactivity	36.8	21.1	42.1
ON-FARM pluriactivity	53.9	23.1	23.1
BOTH pluriactivities	21.4	71.4	7.1
Overall	37.0	37.0	26.1

Over half of all farms expected the management of the farm to be continued by at least one family member in the socio-economic sample. There was a reduction in this optimism in the ecology sample (although only about 4% less so for the BOTH group) probably the result of this sample having selected older households which have already witnessed or were in the process of witnessing children leaving the farm (Table 4.12).

Table 4.12. The proportion (%) of farms where at least one family member is expected to succeed in farming the land in the ecology sample (socio-economic survey data).

FARM GROUP	% of farms where a family member is expected to succeed in its management
Non-pluriactive	33.3
OFF-FARM pluriactivity	50.0
ON-FARM pluriactivity	38.5
BOTH pluriactivities	64.3
Overall	46.3

About 10% of the farm households were less well educated than the socio-economic sample which is also possibly linked to the older household occupants (Table 4.13). The OFF-FARM group had the greatest reduction in farmers with tertiary qualifications with about 10% fewer farmers than the socio-economic sample with any qualification.

Table 4.13. The proportion (%) of farms where household members had obtained a tertiary level of education within each farm group for the ecology sample (socio-economic survey data).

FARM GROUP	The farmer exclusively	At least one non-farmer member	No household member
Non-pluriactive	28.0	16.0	56.0
OFF-FARM pluriactivity	26.3	26.3	47.4
ON-FARM pluriactivity	61.5	7.7	30.8
BOTH pluriactivities	35.7	35.7	28.6
Overall	35.4	21.1	43.7

4.7 *Discussing the Characteristics of the Ecology Sample in relation to the Characteristics of Farms in the Socio-economic Survey Presented in Chapter 3*

It was unavoidable that, with the selection of farms for the ecology sample occurring during the socio-economic survey, some deviation from the characteristics of these farms would result. The main differences were in farm areas, with those in the non-pluriactive farms, OFF-FARM and ON-FARM groups reduced in extent by one-fifth to one-third. There was also some bias towards owner-occupancy, smaller farms, older, smaller households and fewer household members with tertiary qualifications. All (except owner-occupancy) have been associated with lower intensities of land management (EDC, 1973; Sinclair, 1983).

The bias towards smaller farms had resulted from two actions:

(1) the initial visiting of smaller BSU farms during July and August 1991 by the socio-economic survey group; there is generally a correlation between the BSU and the area of a farm. The first farms visited during the socio-economic survey were selected from the top of the farm list provided by the Scottish Office, the list having been ordered by BSU size. Therefore, during 1991 the socio-economic sample was composed of small-acreage farms so that farms selected for the ecology sample during that year were biased towards small farms.

(2) during July and August 1991, farms were only selected if the farmer was involved in pluriactivity which was based on the hypothesis that the greatest impact on the land management of the farm would result from farmer involvement in pluriactivity (see section 1.5). This was the result of not having analysed the complete socio-economic dataset to obtain the nature and extent of the various pluriactivities and the proportion of involvement of each household member.

With a generally lower prospect of handing on the farm to the family in the ecology sample than the socio-economic sample, the motivation to develop the land may also be less than farms in Grampian generally. Therefore the ecological characteristics which are defined within this study for the non-pluriactive, OFF-FARM and ON-FARM groups may be indicative of less intensive forms of management than would otherwise be the case. However, comparisons are to be made between each pluriactive group and the non-pluriactive farms so that differences between them may be of a similar magnitude to that for an unbiased dataset. The BOTH group, having only been selected during 1992 from a complete socio-economic sample dataset, showed little or no bias.

The greater incidence of owner-occupancy in the ecology sample would be more likely to reveal any consequences of household decision-making on the land than within the socio-economic sample. Since no significant differences were seen in the extents of different soil types managed by each group, the potential of the land to be developed ought to be the same between the farm groups. However, the ON-FARM group appears to develop land-based activities whilst the BOTH group appears not to (Table 4.14) which therefore suggests a greater influence of socio-economic factors over the physical characteristics of the land in determining land use.

Table 4.14. The division (%) of on-farm non-agricultural enterprises between the land and not on the land for the ON-FARM and BOTH groups of the ecology sample (socio-economic survey data).

	Land-based	Not land-based
The ON-FARM group	46.2	53.9
The BOTH group	35.7	64.3

Land-based activities included: quarrying, horticultural/organic crops (including flowers), chemical storage areas, shooting and horses-jumping. Farm shops were also included in 'land-based' activities since they were associated with crops specifically for the farm shop. Activities not directly using the land included: bed & breakfasts, holiday cottages (utilising old buildings), static caravans (usually in steading area), hairdressing, childminding, agricultural plant hire contracting and haulage contracting.

CHAPTER FIVE

The Field Survey

Introduction

At the end of Chapter 2, the ecological investigation was defined as a three-tiered field survey. For each farm group, defined by type of involvement or non-involvement in pluriactivity, data would be obtained on:

(1) vegetation cover, to identify habitat types encouraged or discouraged by the farm group;

(2) grass field use and management, to establish whether there were different emphases between and within land uses according to the farm group;

(3) species composition within and along grass fields, to determine the species diversity and quality associated with each farm group, as well as to assess the importance of field boundaries as species reserves.

This chapter describes the details of the field survey at each of these levels and how data was checked and entered into the databases. The statistical procedures used are also broadly outlined.

With the field survey extending over two summers, the consistency of field data collection is also examined.

5.1 *The Field Survey Structure*

The Institute of Terrestrial Ecology (ITE) developed their land classification to enable various land cover extents and species composition data, obtained through field survey within one-kilometre grid squares, to be extrapolated to regional and national levels (Bunce and Heal, 1984). In this study a classification of farms by type of involvement or non-involvement in pluriactivity was used in a similar fashion (Table 5.1).

Table 5.1. The comparison of the strategy employed by the Institute of Terrestrial Ecology (ITE) to determine regional and national estimates of vegetation and the methodology employed in this study (from Bunce, Barr & Whittaker, 1983).

ITE method	Pluriactivity study method
Classification using 32 land classes defined by climatic, geological, topographical & Human settlement data.	Classification using 4 farm groups defined by type of involvement or non-involvement in pluriactivity.
Characterisation using field surveys over one-kilometre grid squares.	Characterisation using field surveys over whole farm areas.
Prediction using estimates of the area covered by each land class.	Prediction using estimates of the area managed by each farm group.

The method for surveying and recording land cover and vegetation composition characteristics (to be described in sections 5.2 - 5.5) was adopted from the ITE survey methodology (Barr *et al*, 1993) so that data from this regional study could be compared to national figures generated by ITE.

5.2 *Field Survey Preparations*

The farm boundary from the 1:25 000 scale map, obtained during the socio-economic survey interview, was transferred onto a 1:10 000 scale map[1]. A photocopy of the map was prepared for vegetation mapping by tipexing all unnecessary features within the farm boundary so that lines delimiting vegetation units could be drawn clearly in the field. Features such as field boundaries, buildings and roads were left for orienteering purposes. This was photocopied onto waterproof paper for use in the field.

A second copy of the map was made as a 'reference' map for both fields and quadrat locations; alphabetic codes were used to identify fields whilst quadrat positions were labelled 1 to 10 in a north-south direction (Fig. 5.1). The quadrat locations were determined by overlaying the map with an acetate grid and reading four-figure random numbers until ten provisional locations lay within the farm boundary. Where the farm consisted of several holdings on various

[1] a single farm may have had upto six holdings scattered over the region which necessitated a number of different map preparations.

maps, the maps were laid side-by-side so that the acetate grid accommodated as much of the farm area as possible.

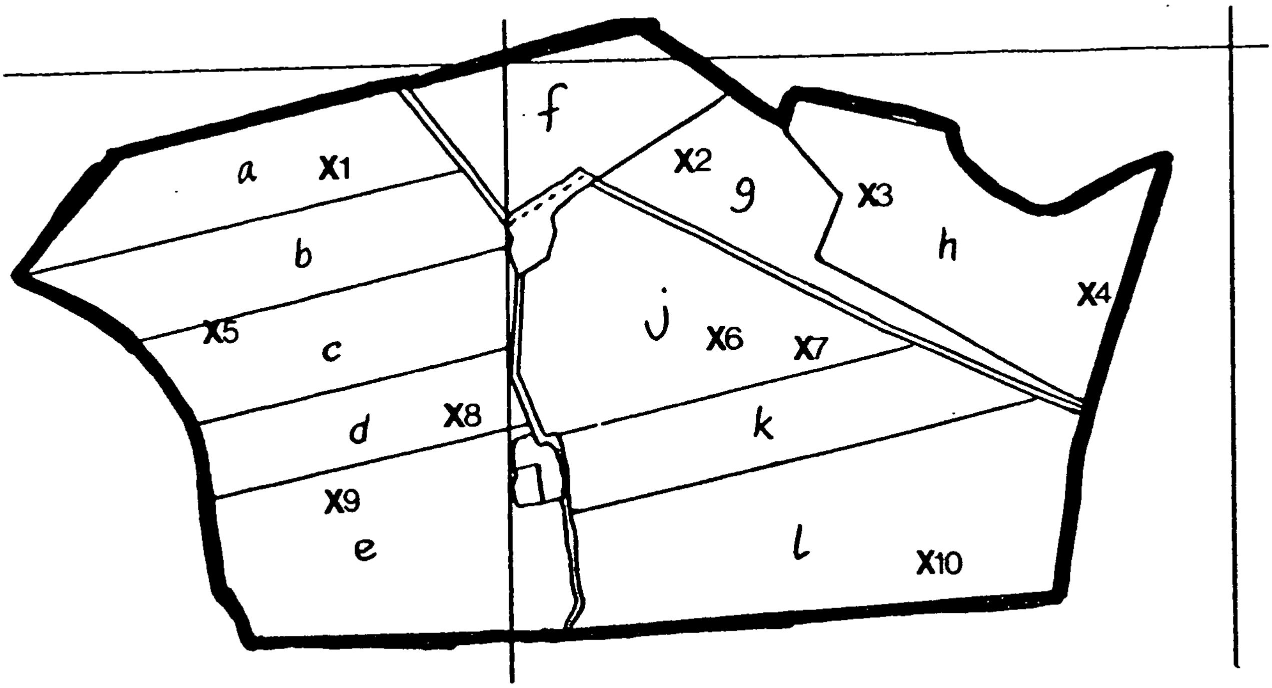


Fig. 5.1. An example of a farm boundary placed on a 1:10 000 Ordnance Survey map. Fields are identified and coded 'a' to 'l' for the grass field use questionnaire interview. The quadrat positions are indicated by the 'X's.

The field questionnaire was the second of two interviews for the farm so was designed to be short, allowing about one minute per field, i.e. to last 5-10 minutes in the majority of cases. This was partly achieved by using corresponding field codes on the answer sheet to the reference map and partly by using categories of variables (such as classes of nitrogen application rate) rather than attempting to obtain specific details (such as the exact amount of nitrogen applied to a field in the previous year). A copy of the field management questionnaire and answer sheet is placed in Appendix 1. This would not allow the overall average of each type of management to be calculated but the means per category could be compared between the different farm groups. Data obtained through the field questionnaire were:

(a) the main use(s) of the field over the past 12 months;

(b) whether the field had been permanently grass or part of an arable rotation over the last 10 years;

(c) when the field was last reseeded;

(d) the rate of inorganic nitrogen application over the previous 12 months;

(e) whether any organic nitrogen (farmyard manure, slurry, silage effluent *etc.*) had been applied;

(f) whether the field had been stocked to its potential, given the current status of the vegetation and soil;

(g) whether herbicides had been applied in the last 12 months.

Telephone calls and 'reminder' postcards agreed the time and date to meet with the farmer[2] of the farm selected for the field survey. Lunchtime or Sunday afternoons were found the best time to contact the main farmer. A day every other week in the timetable was left free to accommodate farmers' requests for changes in dates during the survey, allowing upto one hundred hectares to be covered a day with two persons. Usually one farm each day was feasible but two small (<30 ha) farms would be timetabled for one day. Particularly large farms (>150 ha) might take several days, but even allowing for this, it was expected that some might 'spill over' onto the 'free' dates. The re-visiting of some 1991-surveyed farms during the 1992 survey were also to take place within the 'free' dates (section 5.8).

5.3 *Arriving at the Farm*

Farm and field boundaries on the prepared maps were checked with the farmer on arrival at the farm. If possible the field questionnaire interview was completed <u>before</u> the vegetation survey so that details could be cross-checked the same day whilst surveying the fields and, if necessary, re-checked with the farmer before leaving the farm. If quadrat positions were found to be outside

---

[2] 'farmer' includes the farm manager or similar (called 'grieves' in the north-east of Scotland) or any person available to conduct the interview with an adequate knowledge of the running of the farm.

grassland they were re-positioned following three rules:

(a) the nearest grass field to the initial quadrat position was identified,

(b) a line was drawn either due north, east, south or west from the initial quadrat position into that field,

(c) the new quadrat position was fixed approximately 3 metres from the field boundary across which the line was drawn.

More informally, farmers on pluriactive farms were asked whether there had been any obvious alterations in land use or management as a consequence of involvement in non-farming activities and to indicate the area affected on the map. However no-one admitted to making drastic alterations[3].

The field work was carried out by two persons. The vegetation mapping was carried out by one person whilst the quadrat work was the responsibility of the other. However, the two persons worked as a team, making decisions together where necessary and taking 'turns' in mapping and quadrat work between farms. A field handbook defined the survey methods which was a shortened adaptation of ITE's 'Countryside Survey 1990 Field Handbook' (Barr, 1990). The handbook defined the vegetation types and the rules for the quadrat work which are now described in the next two sections.

5.4 *Vegetation Mapping*

The extent and distribution of each vegetation cover type (crop, grass type, woodland *etc.*) were outlined on the 1:10,000 map, the boundary of each vegetation unit defined by the presence and cover of indicator species; for example, the presence of *Anthoxanthum odoratum* and *Agrostis tenuis* covering at least 25% alone or together would define the unit as 'upland grassland'. The vegetation cover types, taken from the ITE 'Countryside Survey 1990 Field Handbook' (Barr, 1990), are listed and defined in Appendix 2, as are rules for

[3] Quarrying was the main non-farming activity to affect the landscape but it was rarely recognised as a 'non-agricultural' activity *per se* by the farmers. Quarries, however, were mapped with the vegetation (described in section 5.4) and their extents are reported in Chapter 6.

defining grassland and related cover types devised by R.G.H.Bunce (ITE, Merlewood) for the ITE surveys.

Unique alphabetic ('parcel') codes were written in each delimited vegetation unit ('parcel') and below the map with a vegetation cover type code. Species constituting at least 25% of the vegetation unit ('dominant' species) were also recorded with the extent of their cover as attribute codes of the parcel code (Fig. 5.2). The codes used during the survey are listed in Appendix 2. The minimum mappable area for vegetation units was initially 0.04 ha ($400m^2$), in accordance with the ITE survey method. However, during the 1991 field survey the minimum mappable area became 0.02 ha ($200m^2$) which was more quickly recognisable/defined than the bigger unit within agricultural habitats and since a number of vegetation types associated with on-farm non-agricultural activities would not have been recorded other-wise, e.g. cover for game around the periphery of fields and smaller areas used for farm shop produce like raspberries and organic crops. The minimal mappable unit was drawn by the side of the recording map to standardise its use in the field.

The approximate age of woodlands and trees were also recorded on farms where it was feasible time-wise, maintaining the timetable of farm visits as topmost priority and therefore accuracy of the basic vegetation mapping.

Linear vegetation types, such as lines of trees or of scrub, were recorded as lines on the vegetation map and treated in the same way as areal vegetation cover types. The minimum mappable length for linear features was 20 m (in accordance with the ITE survey).

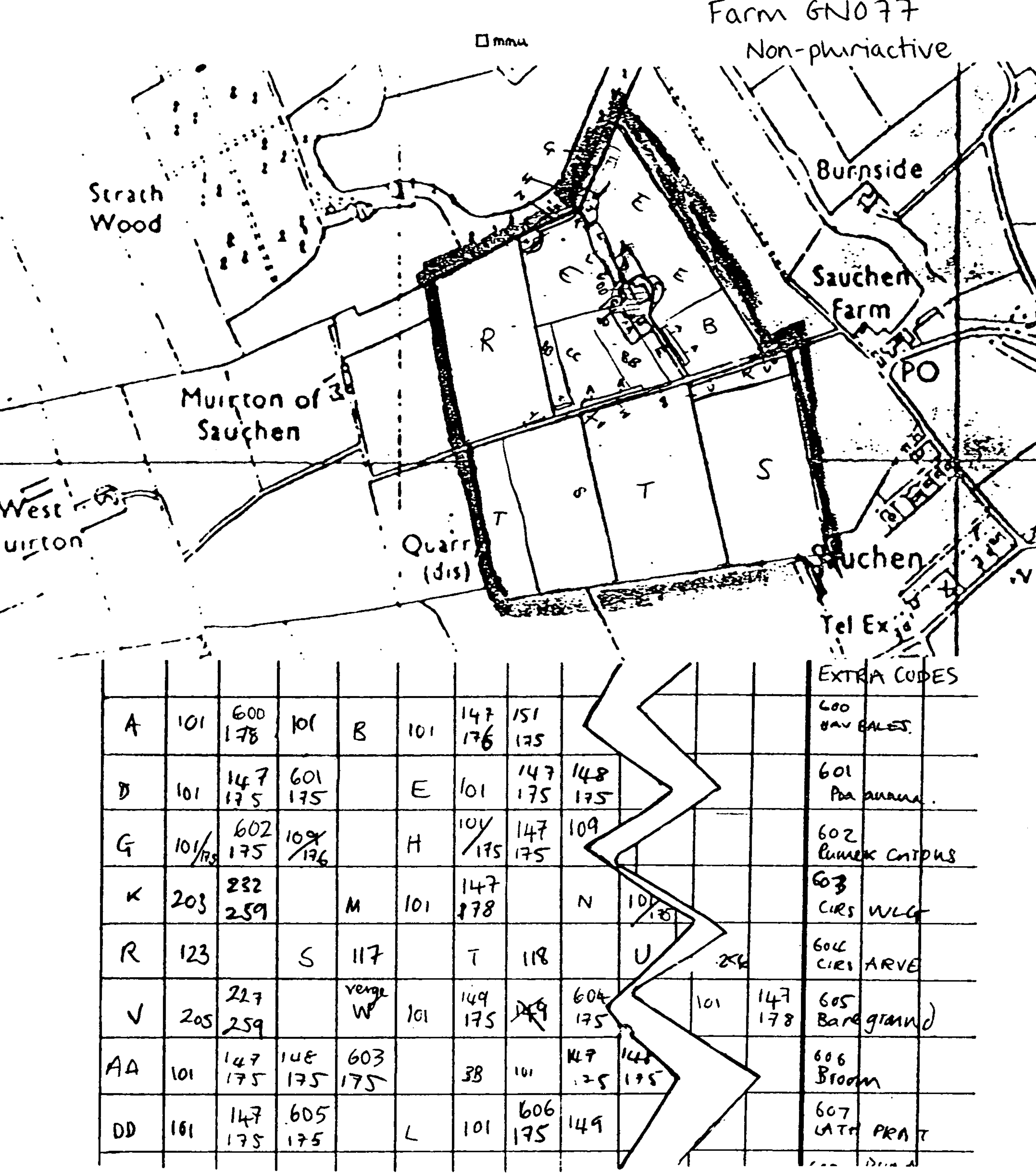


Fig. 5.2. An example of a vegetation map drawn during the field survey. Codes A - Z were used to identify each vegetation parcel. Below the map the vegetation parcel 'A' is given attribute codes; for example, code 101 is agricultural grass and the codes 147 and 176 indicate that ryegrass covers 50-57% of the area defined (see Appendix 2 for codes). The methodology follows that used in the ITE surveys (Barr, 1990; Barr *et al*, 1993).

5.5 *The Positioning and Recording of Species within Quadrats and Boundary Plots*

Quadrat positions were located as close as possible to the position indicated on the map although there was no need to identify the exact location. 2 x 2m quadrats were used in preference to 1 x 1m so that direct comparisons could be made to data collected in the ITE surveys. Rodwell (1992) noted that "almost always" 2 x 2m quadrats were adequate to provide a representative sample of mesotrophic grasslands.

Quadrats were placed at least three metres from the field boundary to ensure the recording of open field vegetation alone. Even-numbered quadrats (2, 4, 6 *etc.*) were set out in an approximate N-E-S-W orientation so that, after completion, the nearest permanent field boundary (fence, stone wall *etc.*) could be identified (i.e. excluding *temporary* electric fences) and a line either due north, south, east or west would then be followed from the centre of the quadrat to the boundary. The plot was laid ten metres to the left of the point of contact, one metre outward from the boundary centre (not edge), measuring 1m x 10m, as defined in the ITE surveys (Fig. 5.3).

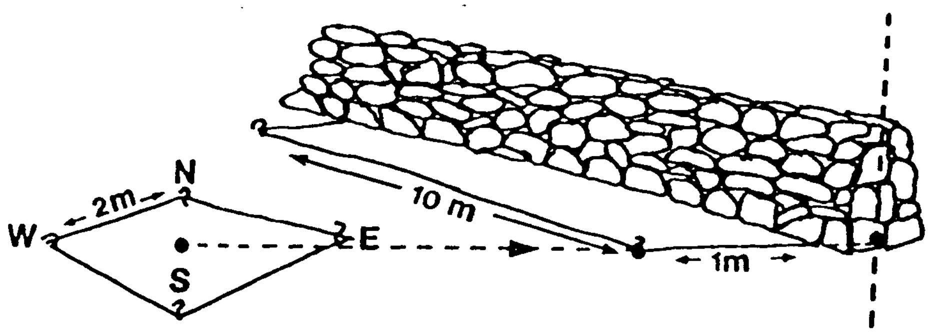


Fig. 5.3. The position of a field quadrat and its boundary plot.

Sample areas (i.e. quadrats or plots) were scanned for 3-4 minutes to ensure that the majority of species were noted before manually moving vegetation to detect infrequent species. This could take upto ten minutes for boundary plots. Species were noted on copies of recording sheets used during the 1990 ITE

Countryside Survey which listed the 200 most common species in Britain, thereby minimising the recording-time. Species which were found but not listed on the sheet were also recorded.

The cover of every species in each sample area was estimated and then recorded to the nearest 5% value it exceeded (i.e. 5%, 10%, 15%...100% *etc.*) although species with a cover less than 5% were attributed an arbitrary value of 1%, important later for the multivariate analyses. Where vegetation was tall (such as in fields to be cut or within boundary plots) species cover was recorded before a detailed investigation for less conspicuous species. However, in estimating species cover for boundary plots where the boundary was a stone wall, the area covered by the wall was also estimated. This was ill-repaired stone walls could cover upto 50% of the plot. Although it may have been preferable to obtain a species list within an area of 1m x 10m (from the edge of the boundary) for this survey it had been intended to compare these results to the ITE survey data (see Fig. 5.3).

Species cover was estimated by the two persons as often as possible which is known to increase the accuracy of the assessment (ECOLUC report, 1988). In practical terms this usually occurred for two field quadrats and five or six boundary plots (which are larger) per farm. If only one person was estimating species cover, the time taken to estimate the cover of each species was double that given by two persons (varying between 10-15 minutes as opposed to 5-10 for the fields quadrats). Species cover recorded on the recording sheet was totalled at the quadrat site to ensure that estimates were reasonably close to 100%, allowing for greater than 100% where there were several layers of plant cover.

"Cover is defined as the proportion of ground occupied by perpendicular projection on to it of the aerial parts of individuals of the species under consideration....Cover is usually expressed as a percentage.....the total cover for all species in a community may exceed 100% and normally does so in all except open communities" (Greig-Smith, 1983).

The proportion of bare ground was also estimated, although not used within the analyses, which would confirm the 'accuracy' or reveal insufficiency in the estimation. Estimation of species cover was preferred to determining species densities since this usually helped to determine the dominants for the vegetation mapping and is less time consuming, particularly where individuals of rhizomatous/stoloniferous species are concerned. The actual quadrat positions were confirmed on the reference map before leaving the farm.

5.6 *Handling the Field Survey Data - Computer Input and Verification*

Records were checked for completeness and accuracy the evening of the farm visit. This included checking:

● that lines delimiting each vegetation unit on the map were complete and that all codes recorded on the map were recorded below with appropriate attribute codes;

● that the reference map recorded all quadrat positions and that each field was labelled with a corresponding code to the field questionnaire answer sheet;

● that records on the field questionnaire answer sheet were complete and legible;

and ● that quadrat/boundary plot data were complete, i.e. all species were identified. Plant species collected for identification or verification were checked with the appropriate botanical authority and with any specimens previously collected and verified. Dubious specimens were verified with the botanical county recorder (D. Welch, ITE Banchory).

Data were entered into the computer databases at the end of each survey, i.e. October - November. Vegetation maps were digitised into a Geographic Information System (Arc/Info). For each farm, two Arc/Info files were created:

1) one recording the cover of vegetation parcels (polygon attribute tables, 'PAT' files),

and 2) one recording the lengths of linear vegetation features such as lines of trees (arc attribute tables, 'AAT' files).

This was unavoidable since PAT files only accept complete polygons. The 'attribute table' data were transferred into an Oracle database (a relational database) from Arc/Info (both Oracle and Arc/Info were version 6). Codes from the vegetation map recording sheet were punched into Oracle and cross-checked with codes from the Arc/Info data. Rectification of errors usually involved reference to the original field map and recording sheet, and the use of Arcplot and Arcedit (programs within Arc/Info which aid the identification and editing of incompletely digitised areas) and then updating the Oracle database. Calibration of Arc/Info generated readings to hectares and metres are presented in Appendix 3.

Field management and species data were punched directly into Oracle and were verified by comparing printouts with the original forms.

The overall structure of the database is shown in Fig. 5.4.

5.7 *Analysing the Field Survey Data*

Data were extracted from Oracle into ASCII (American Standard Computer Information Interchange) files to use within the statistical package GENSTAT, version 5.2.2 (Payne *et al,* 1987). Each pluriactive group was compared individually to the non-pluriactive farms, i.e. characteristics were not compared between any two pluriactive groups. GENSTAT was used to manipulate the data into tables and to restrict variates to the farm groups and the variables in question. Averages for each farm group were calculated as means and standard errors (SE's) where the data distribution was normal, or using median and inter-quartile ranges where data were skewed. One-tailed analyses of variances (ANOVA's) were used to test for differences between the non-pluriactive farms and each pluriactive group. Where data were skewed the ANOVA's were carried out with a log transformation, i.e. $x = \log_e (x + 1)$. Where the data were percentages, the ANOVA's were carried out with an angular transformation, i.e. $x = (180/\pi) \times \arcsin(\sqrt{\%p/100})$ where %p is a percentage.

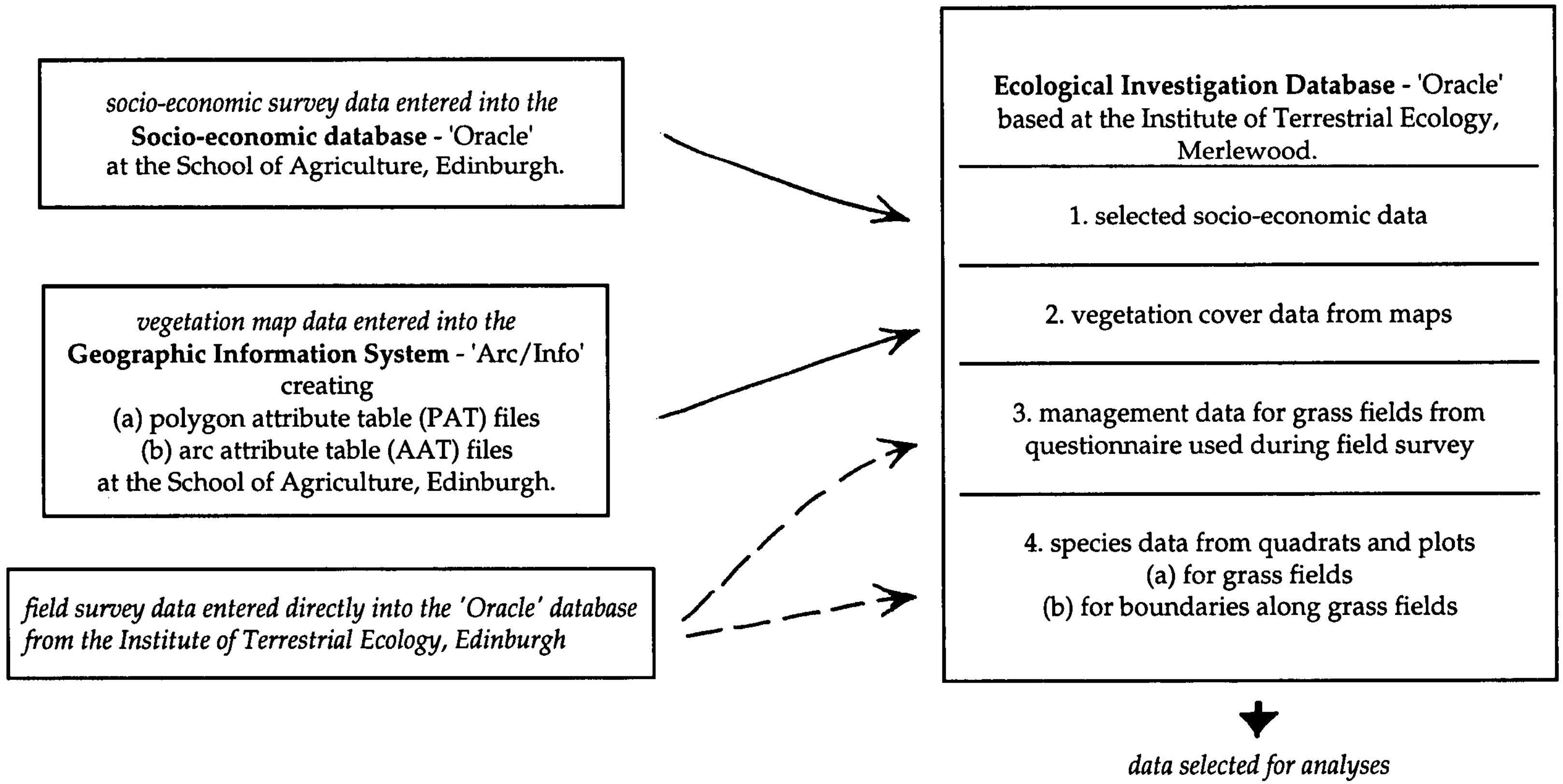


Fig. 5.4. The overall structure of the database used in the ecological study. The ecological investigation database was based at the ITE, Merlewood, where there is a Land Classification database and lists of British species with species codes used during the surveys.

Two multivariate programs written in Fortran by Hill (1979a,b) were also used with the species data. These were: Two Way Indicator Species Analysis program ('TWINSPAN') and Detrended Correspondence Analysis ('DECORANA'). R. Addinall (NERC Computing Services) wrote a program (in SAS) to convert the ASCII species data into a form which could be accepted for these two programs (described in Hill 1979a,b).

5.8 *Controlling the Consistency of Data Collection over Two Seasons*

Initially it was envisaged that the ecological data would only be collected over one season. However (as described in Chapter 4) the ecological survey had to be extended into the summer of 1992. During each summer a field survey assistant was employed. Both assistants, although botanically trained, needed training in field survey techniques. Training took place at the first two farms each year through making all decisions together and making full use of the field handbook, i.e. taking two days for every 100 ha of farmland. It was therefore imperative to check that the interpretation of the handbook and particularly the vegetation mapping rules (i.e. the determination of *indicator* and *dominant* species) was consistent between the two years and between the three surveyors (myself included). Therefore some of the farms surveyed in 1991 were re-visited in 1992 to ensure that the second assistant and myself were continuing to interpret the handbook definitions in the same way.

Three farms within each farm group were selected for re-survey work except for farms within the BOTH group which had not been surveyed in 1991. Three fields per farm were chosen. A greater number of fields on different farms was preferred to extra fields on fewer farms since the latter would be more likely to reveal the affects of the physical and mental ability of the surveyor on the day(s) in question rather than any real differences in recording.

The nine farms chosen had been surveyed at different times in 1991. However, they were chosen within two geographically close clusters of farms to minimise travelling time between each since the re-visits were to occur within 'slack' time during the second survey, i.e. to be spaced evenly over the second summer. Due to the lack of time and the re-organisation of visit dates at the request of farmers in 1992, only five farms were re-visited:

- one non-pluriactive farm
- three farms within the OFF-FARM group

and • one farm within the ON-FARM group.

These farms were visited during the 19th and 20th August 1992.

During each re-visit, second vegetation maps were made without reference to those made in 1991 using the two surveyors for every decision. Adjoining land to each re-selected field was also re-mapped. Thirty-six parcels were re-mapped.

In assessing the deviance of the mapping rules between the two years, the two sets of maps for a farm were compared by eye. Comparison by eye is quicker than digitising a second map and entering the new codes into Oracle (see Fig. 5.4), and could also be done whilst 'on survey'. For each parcel, comparisons were made between:

1) the delimitation of the parcel,
2) the vegetation cover type code,
3) the dominant species,

and whether differences were due to:

a) observation/recording error,
b) management changes,

and/or c) successional changes.

The results were recorded in table form (Appendix 4).

The delimitation of parcels was remarkably constant. The main differences were in the recording of dominant species mainly in grassland. Since dominant species were not used quantitatively in analysing grass sward composition, this has not affected the results presented in this study.

Although some quadrat locations were re-visited, species change between the two years was quite substantial and alterations in estimating the cover of species would be difficult to prove. The consistency of quadrat data recording was therefore excluded from this assessment.

5.9 *Extra Quadrats*

Although ten quadrats were placed within each farm, there had been no rule to determine this number. With varying grassland areas, sampling density between the farms therefore varied.

During the second survey year, extra quadrats were therefore placed within grass fields not covered by any of the ten quadrats randomly distributed over the grassland. The aim was to reveal whether extra quadrats would reveal further species. Since the aim was only to obtain further species lists over the farm no cover estimates were made of species in the extra quadrats.

The number of farms with extra quadrats, and the number of extra quadrats per farm, varied according to time availability and not with the area of grassland. Extra quadrats were placed on six farms but the number of extra quadrats per farm varied from three to ten. Where there were a large number of un-quadrated fields, the extra quadrats were placed randomly in fields with uses (e.g. silage, 'empty' *etc.*) not covered by the ten quadrats, but always at least 3m from a field boundary. These data were not used in the main analyses.

The number of species did not level off at or before ten quadrats (Appendix 5). However, the levelling of the curves bore no relation to the grassland area due to differing management intensities between farms. Although ten quadrats cannot therefore be considered sufficient in obtaining near-complete lists of species from the grassland of a farm, the number cannot be predicted before a survey - species-quadrat curves would need to be plotted whilst on the survey, continuing to obtain species lists until the curve levelled off. However, using a set number of quadrats per farm (i.e. surveying the same area) allowed correlation of botanical richness values to socio-economic data (see Chapter 9).

CHAPTER 6

Field Survey Results I
Vegetation Cover

Introduction

The vegetation map data obtained through the PAT (polygon attribute table) and AAT (arc attribute table) files in the Geographic Information System, Arc/Info, are presented. The proportionate cover of each vegetation type, the size of vegetation parcels and the variety of vegetation types per kilometre square area of farmland are reported for each farm group as are the lengths of each linear vegetation type and the variety of linear vegetation types. The species composition of tree and scrub features are also described.

6.1 *The Extents of Areal Vegetation Covers*

Most farmland consisted of arable crops and grass, although the proportion of unfarmed land (woodland, neglected land and moorland) was greatest on pluriactive farms (Fig. 6.1).

Both the ON-FARM and BOTH groups had 14-17% less grassland than non-pluriactive farms although these were not significant; the OFF-FARM group had a slightly greater extent of grass. Unfarmed land covered 15 and 13% more land within the ON-FARM and BOTH groups respectively than within non-pluriactive farms. Within the ON-FARM group, this was mostly woodland which covered, on average, 9% more land ($P<0.01$) but within the BOTH group this was mainly neglected land. Both these groups also had 5-6% more arable than non-pluriactive farms whilst the OFF-FARM group had 7% less. The proportion of un-farmed land within the OFF-FARM group was 6.8%.

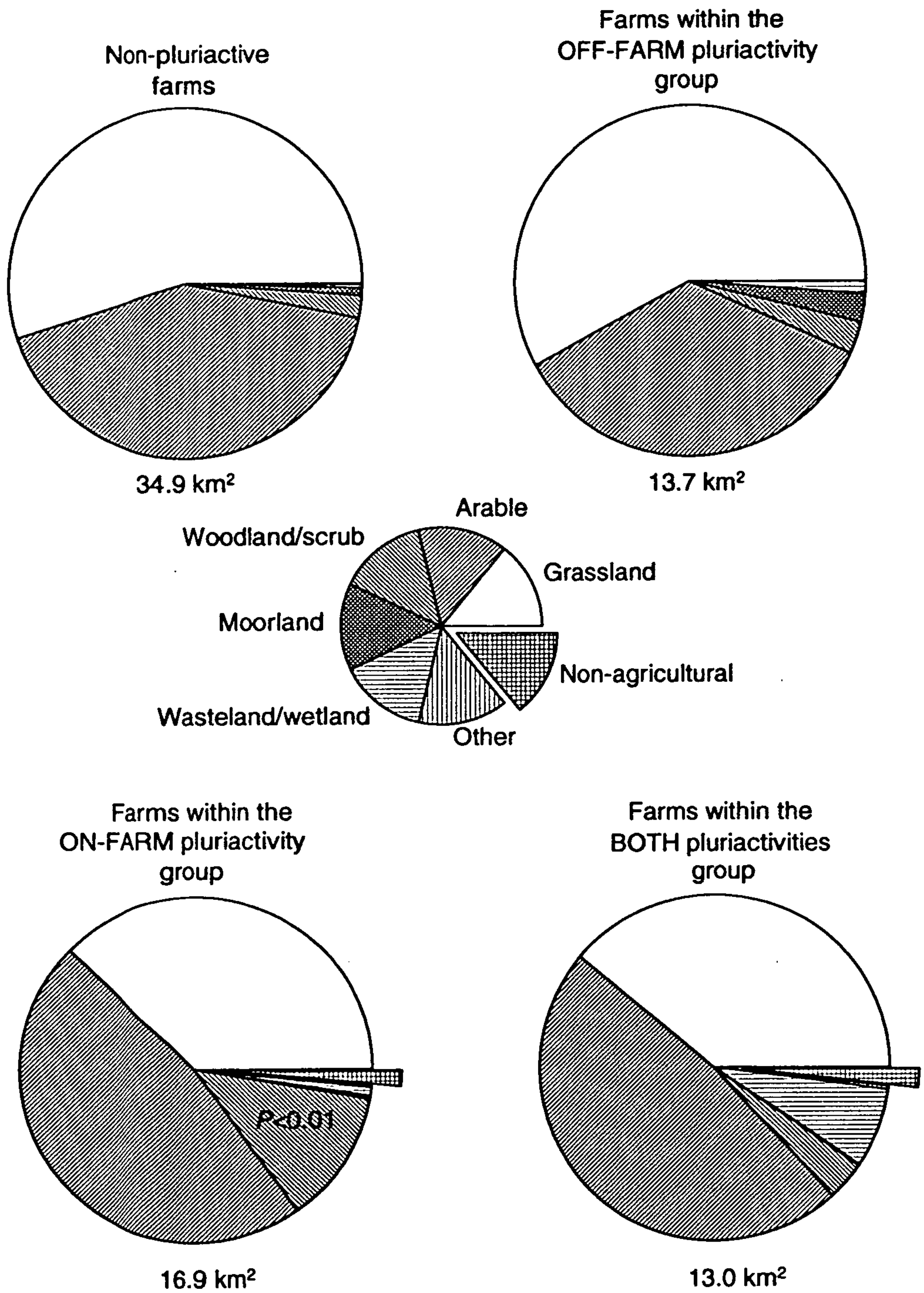


Fig. 6.1. The mean proportion of each vegetation cover type for each farm group. km^2 = the total area surveyed within the farm group. $P<0.01$ = level of significance between the non-pluriactive farms and the pluriactive group using a one-way ANOVA and angular transformed data.

Table 6.1. The proportion (%) of each vegetation cover type for a farm in each farm group; for definitions see Appendix 2. Dominant or distinguishing figures in a farm group are italicised.

n = number of farms surveyed	Non-pluriactive *n* = 25	Type of pluriactivity: OFF-FARM *n* = 19	ON-FARM *n* = 13	BOTH *n* = 14
GRASSLAND Lowland agricultural	*51.9*	*54.8*	*36.7*	*37.9*
Upland grass	0.5	1.2	0.3	0.3
Moorland grass	0.4	0.4	0.5	0.1
Marsh	2.1	1.5	0.3	0.6
Total	**54.9 ± 2.5**	**57.9 ± 3.1**	**37.8 ± 2.5**	**38.9 ± 2.7**
ARABLE Wheat	3.8	4.2	5.0	6.9
Barley	*28.6*	*23.6*	*24.9*	*27.2*
Oats	1.6	1.9	7.2	5.6
Turnips/swedes/root	3.4	2.1	2.0	2.7
Kale	0.0	0.0	0.3	0.0
Potatoes	2.1	0.8	3.6	2.3
Field beans	0.2	0.0	0.0	0.0
Oilseed rape	2.2	2.6	1.9	1.2
Other crops	0.0	0.0	0.9	1.7
Ploughed	0.0	0.2	1.3	0.0
Total	**41.91 ± 0.7**	**35.4 ± 0.8**	**47.1 ± 1.0**	**47.6 ± 1.0**
WOODLAND Scattered trees	0.1	0.2	0.4	0.2
Belt of trees	0.2	0.1	*2.7*	0.8
Clump of trees	0.1	0.0	0.5	0.5
Woodland/forest	1.1	2.0	*6.7*	0.6
Total	**1.5 ± 0.1**	**2.3 ± 0.3**	**10.3 ± 1.3****	**2.1 ± 0.2**
SCRUB Scattered scrub	0.4	0.1	*1.8*	0.9
Patch of scrub	0.2	0.6	0.3	0.7
Total	**0.6 ± 0.1**	**0.7 ± 0.2**	**2.1 ± 0.6**	**1.6 ± 0.3**
MOORLAND Moorland-shrub heath	0.7	*2.6*[a]	0.3	0.1
Total	**0.7 ± 0.7**	**2.6 ± 2.7**	**0.3 ± 0.2**	**0.1 ± 0.1**
WASTE/WETLAND Tall herb vegetation	0.0	0.1	0.2	0.1
Neglected	0.1	0.3	0.6	*6.9*[b]
Abandoned	0.1	0.2	0.0	0.0
Aquatic macrophytes	0.0	0.0	0.0	0.1
Aquatic marginal	0.1	0.6	0.1	0.3
Fen/flush	0.0	0.0	0.0	0.1
Total	**0.3 ± 0.0**	**1.2 ± 0.1**	**0.9 ± 0.1**	**7.5 ± 1.0**
NON-AGRICULTURAL Flowers	-	-	0.0	0.2
Touring caravan park	-	-	0.2	0.0
Quarry	-	-	1.3	1.6
Total	**-**	**-**	**1.5 ± 0.1**	**1.8 ± 1.8**
OTHER	0.1	0.0	0.2	0.3

**$P<0.01$ level of significance between non-pluriactive farms and the pluriactive group using a one-way ANOVA and angular transformed data. [a] exclusion of two anomalous farms gives 0.3%. [b] exclusion of one anomalous farm gives 0.1%.

When each cover type was broken down into the categories used during the field survey (see Appendix 2), 95-97% of grassland within each farm group was classified as lowland agricultural grass (Table 6.1). The non-pluriactive and OFF-FARM groups showed the most rush invasion of their grasslands (categorised as marsh), presumably a reflection of cattle grazed fields, although this only accounted for 1% of their grassland areas.

Arable crops were principally cereal, notably barley. Oats covered 4-5% and wheat 1-3% more land within the ON-FARM and BOTH groups than non-pluriactive farms. To a much lesser extent, potatoes were more abundant within the ON-FARM group and other crops, such as flowers and horticultural crops, were more predominant within the BOTH group. Kale and sunflower (classified within 'other crops') were specifically planted for game cover about the edges of the fields and therefore were more predominant within farms with on-farm pluriactivity. Other crops also included raspberries, cabbages, peas *etc.* which tended to occur in small proportions on farms with farm shops.

Trees were mainly classified as 'woodland' for each farm group although the BOTH group had roughly the same proportion of trees planted as belts. The ON-FARM group noticeably had the greatest extent classed as woodland (nearly 7%) although belts of trees were also substantial (nearly 3%) in comparison to other farm groups.

Scrub was often gorse (*Ulex europeaus*), sometimes with broom (*Cytisus scoparius*), occasionally hawthorn (*Crataegus* spp.), rowan (*Sorbus aucuparia*) or elder (*Sambucus* spp.). Tree species, such as sycamore (*Acer pseudoplatanus*) and beech (*Fagus sylvatica*), were included as scrub when there was no visible trunk/crown structure. Scrub was slightly more predominant on pluriactive farms, with scattered scrub, particularly, more predominant within the ON-FARM group.

Moorland was heather (*Calluna vulgaris*) dominated. Although some of the marginal areas of Grampian are covered by extensive tracts of heather, moorland made up relatively little of the farmland in each group. The OFF-FARM group appeared to have most moorland at 2.6% but when two farms were excluded this fell to 0.3% which was less than the extent within non-pluriactive farms and comparable to the extent within other pluriactive groups.

Waste/wet land made up the least proportion of all farmland. Tall herb vegetation, consisting of umbellifers and tall herbs such as rosebay willow herb (*Chamaenerion angustifolium*), was found along ditch banks, track verges, corners of fields and headlands. Aquatic vegetation was found along and within ditches and streams. Neglected land with no obvious current management, and typified by tall grasses and annual flowering species, was more predominant than abandoned land, typified by shrub invasion. The BOTH group appeared to have 7% more waste/wet land than non-pluriactive farms, but with the exclusion of a farm where set-aside land had not been mown (whose vegetation was therefore nearly all categorised as 'neglected'), this fell to 0.1% which was less than that for non-pluriactive farms.

Land used for pluriactivity (as opposed to other non-agricultural land) took up surprisingly little land, less than 2% within either the ON-FARM group or BOTH group with quarrying accounting for nearly 90% of this figure. 'Other' cover types included bare ground or stony areas covering, at most, 0.3% of farmland.

6.2 *Description of the Trees*

Clumps of trees sometimes entirely consisted of beech or sometimes entirely of Scots pine (*Pinus sylvestris*). Scattered trees and woodland were often ash (*Fraxinus excelsior*), elm (*Ulmus* spp.) and sycamore whilst belts of trees were mainly coniferous species (e.g. Sitka spruce, *Picea sitchensis*, Corsican pine, *Pinus nigra*, and Scots pine) planted alongside tracks.

The recording of tree age was of low priority in the field when time was short. Unfortunately, tree age was not recorded for a small proportion of non-pluriactive farms and the OFF-FARM group, but increased to one-fifth of farms within each of the ON-FARM and BOTH groups (Fig. 6.2). The high proportion of unrecorded trees within the last two groups was more a reflection of the greater frequency of woodlands on these farms. No statistical tests were therefore performed but trends seen in Fig. 6.2 do provide some indication of the type of differences in the age structure of trees between the farm groups.

Although the ON-FARM and BOTH groups had planted one-fifth of their trees over the previous four years, another fifth within the ON-FARM group were older than 100 years and the BOTH group had most of its trees recorded as being 21-100 years old. The OFF-FARM group had nearly half of its trees in the 5-20 year category which was more than three times as many trees in this category than any other farm group. Nearly two-thirds of trees on non-pluriactive farms were between 21 and 100 years.

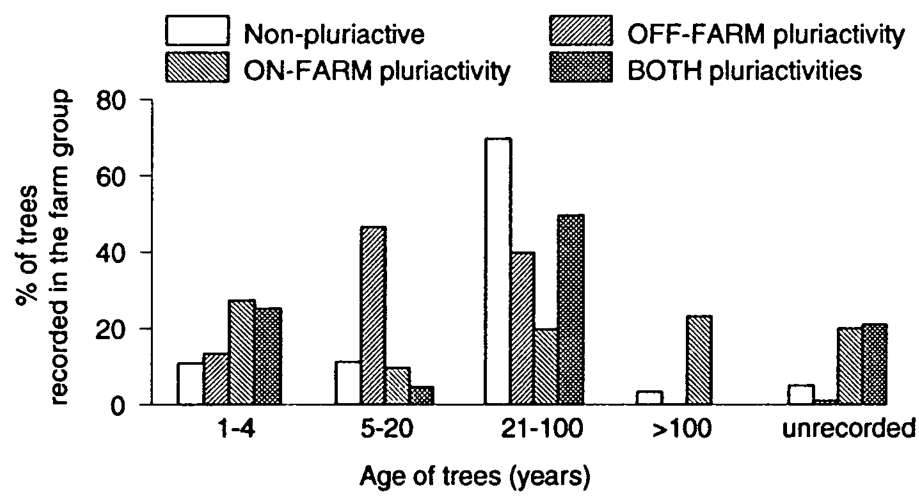


Fig. 6.2. The overall proportion (%) of each age category of tree for each farm group (excluding trees in linear vegetation types).

There were no significant differences in the proportions of coniferous, broadleaf and mixed conifer/broadleaf woodlands. However when the mean proportion of tree cover over a farm was taken into account, the ON-FARM group showed the greatest extent of broadleaves and the BOTH group the greatest extent of coniferous trees (Fig. 6.3).

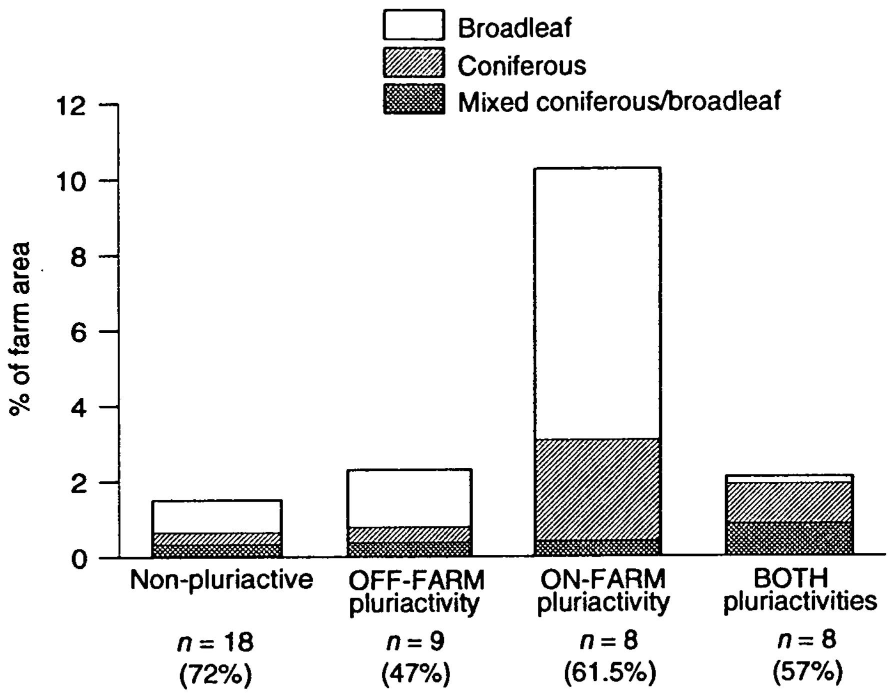


Fig. 6.3. The mean proportion (%) of broadleaf, coniferous and mixed woodlands per farm for each farm group. There were no significant differences between the proportion of either broadleaf, coniferous or mixed woodland types within non-pluriactive farms and any pluriactive group using one-way ANOVA's and angular transformed data. *n* = the number of farms with recorded tree cover in each group, the brackets indicating the proportion that these farms constitute within the farm group.

6.3. *The Distribution of Vegetation Cover over Farmland*

The size of each vegetation parcel (or 'grain size'; Baudry, 1984) affects the number of species; fine grain landscapes consist of small fields and are associated with extensive management, and coarse grain landscapes consist of large fields and are associated with intensive management.

"Increase in grain size allows open-field birds to colonise the landscape (Constant *et al*, 1976), this increase leads to a decrease in species number as well as in bird population density from 99 pairs of nesting birds for 10 ha in a fine grain landscape to 62.5 pairs in a coarse grain landscape and 35.3 pairs in an open-field landscape (Constant *et al*, 1976)" (Baudry, 1984).

In this study the distribution of vegetation cover over the farmland of each farm group has been investigated:

(a) by comparing *the number of different vegetation cover types occurring within a given km²* (which takes into account differing farm areas);

and (b) by comparing *the average size (m²) of vegetation parcels* recorded on the vegetation map.

(a) Using the number of different vegetation cover types on a farm and its vegetated area to account for the differences between the farm groups, the variety of different vegetation cover types per km^2 ranged from eight to thirty-one. A greater variety tended to occur within the ON-FARM group (Table 6.2).

Table 6.2. The average number of different vegetation cover types per vegetated km^2 per farm for each farm group. Linear vegetation types (e.g. lines of trees) were not included. IQ = the lower or upper limit of the inter-quartile (IQ) range.

FARM GROUP	Lower IQ	Median	Upper IQ	df
Non-pluriactive	9.0	12.3	17.8	
OFF-FARM pluriactivity	8.0	11.1^{NS}	20.4	1,42
ON-FARM pluriactivity	8.5	12.1^{NS}	30.6	1,36
BOTH pluriactivities	9.2	10.4^{NS}	15.0	1,37

NS = no significant difference between the non-pluriactive farms and the pluriactive group using a one-way ANOVA of log transformed data.

(b) Using the subcategories of vegetation cover types (listed in Table 6.1), digitised parcel areas were found to range between 72 m^2 to nearly 2000 m^2 (0.2ha) (Table 6.3). The larger vegetation parcels tended to occur within the ON-FARM and BOTH groups and were associated with the larger expanses of arable land.

Table 6.3. The overall average vegetation parcel size (m^2) for each farm group. IQ = the lower or upper limit of the inter-quartile (IQ) range.

FARM GROUP	Lower IQ	Median	Upper IQ	df
Non-pluriactive	72	200	1,630	
OFF-FARM pluriactivity	72	180^{NS}	1,220	1,42
ON-FARM pluriactivity	82	280^{NS}	1,710	1,36
BOTH pluriactivities	82	270^{NS}	1,960	1,37

NS = no significant difference between the non-pluriactive farms and the pluriactive group using a one-way ANOVA of log transformed data.

6.4 *Linear Vegetation Types*

Grampian has remarkably few linear vegetation features so that detecting real differences between each farm group was not possible.

Lines of trees and lines of scrub were often found alongside fences or stone walls and, in the case of scrub, along dry ditches. Hedgerows were found to be rarely used as field boundaries.

Lines of trees were entirely ash or beech or mixtures of pine (*Pinus* spp.), poplar (*Populus* spp.), hawthorn (*Crataegus* spp.) and willow (*Salix* spp.). Oak (*Quercus* spp.), elm (*Ulmus* spp.), lime (*Tilia* spp.) and birch (*Betula* spp.) were less dominant constituents. Lines of scrub were mainly gorse (*Ulex europaeus*) and broom (*Cytisus scoparius*) although alder (*Alnus* spp.), hawthorn, rowan (*Sorbus aucuparia*) and ash (*Fraxinus excelsior*) also formed lines of scrub. Hedgerow trees were less frequent but those that occurred were hawthorn, sycamore and beech. Of the four hedgerows recorded, two were beech (*Fagus sylvatica*), one was hawthorn and one was a mixture of beech and hawthorn.

Eighteen farms (25%) of the field survey farms had no linear vegetation types. They were excluded from analyses determining the average length of the vegetation type per km^2. Seventy-two per cent of non-pluriactive farms had linear vegetation cover types in comparison to 42% of the OFF-FARM group, 46% of the ON-FARM group and 57% of the BOTH group.

The average number of different linear vegetation types per vegetated km^2 ranged from less than one on pluriactive farms to nearly two on non-pluriactive farms (Table 6.4).

Table 6.4. The average number of different linear vegetation cover types per vegetated km^2 per farm for each farm group. IQ = lower or upper limit of inter-quartile (IQ) range. Linear vegetation types were lines of trees or scrub, hedgerow trees and hedgerows. Farms with no linear vegetation types were NOT excluded from the calculations.

FARM GROUP	Lower IQ	Median	Upper IQ	df
Non-pluriactive	0.63	1.96	2.99	
OFF-FARM pluriactivity	0.00	0.68^{NS}	2.80	1,42
ON-FARM pluriactivity	0.40	1.43^{NS}	2.68	1,36
BOTH pluriactivities	0.66	1.35^{NS}	2.51	1,37

NS = no significant difference between the non-pluriactive farms and the pluriactive group using a one-way ANOVA of $log_{(e)}$ transformed data.

Where linear vegetation types occurred within the farmland, the average length of a line of trees was 150-237m per km^2 and lines of scrub 275-576m per km^2. Hedgerows were more variable, varying between 72 and 394m per km^2. However, the frequency of farms having different types of linear vegetation varied; notably the non-pluriactive farms were more likely to have lines of trees than other farm groups and the OFF-FARM group least likely to have any linear vegetation type (Table 6.5).

6.5 *Discussion of the Vegetation Cover Characteristics*

With most LFA cattle farms occurring within the non-pluriactive and OFF-FARM groups, it was not surprising that these farms were associated with the greatest extents of grassland. Cropping farms constituted 50% of the ON-FARM and BOTH groups and were associated with the greatest extent of arable land, although not significantly more than that within the non-pluriactive group. That the ON-FARM and BOTH groups were more associated with significantly less grassland areas than non-pluriactive farms therefore appears to be associated with the increase in non-agricultural vegetation types such as scrub, woodland and neglected areas. That the ON-FARM group contained the most extensive farms with the greatest extent of arable and the least extent of grass, agrees with Gasson (1983):

"The larger the holding, the greater the share of arable and the smaller the proportion of land devoted to grass..." (Gasson, 1983).

Table 6.5. The average length (metres) of linear vegetation types per km^2 of vegetation per farm for each farm group. IQ = lower or upper limit of inter-quartile (IQ) range. Farms with no linear vegetation types were excluded from the calculations. *n*= the number of farm used in the calculations. % = the proportion of farms with the linear vegetation type in the farm group.

FARM GROUP	Lower IQ	Median	Upper IQ	*n*	%
Lines of trees					
Non-pluriactive	97.0	150.4	432.8	18	72.0
OFF-FARM pluriactivity	122.7	178.0^{NS}	579.4	8	42.1
ON-FARM pluriactivity	87.0	237.3^{NS}	569.4	6	46.2
BOTH pluriactivities	73.3	200.5^{NS}	462.9	8	57.1
Lines of scrub					
Non-pluriactive	129.1	392.9	798.2	17	68.0
OFF-FARM pluriactivity	176.0	274.5^{NS}	594.7	7	36.8
ON-FARM pluriactivity	165.9	342.0^{NS}	668.3	10	76.9
BOTH pluriactivities	182.3	576.2^{NS}	859.3	8	57.1
Hedgerow trees					
Non-pluriactive	139.0	139.0	139.0	1	4.0
OFF-FARM pluriactivity	65.0	65.0^{NS}	65.0	1	5.3
ON-FARM pluriactivity	2601.6	2601.6^{NS}	2601.6	1	7.7
BOTH pluriactivities	226.9	226.9^{NS}	226.9	1	7.1
Hedgerows					
Non-pluriactive	13.6	241.0	576.5	6	24.0
OFF-FARM pluriactivity	77.6	393.6^{NS}	709.6	2	10.5
ON-FARM pluriactivity	37.0	71.6^{NS}	374.0	3	23.1
BOTH pluriactivities	432.4	954.5^{NS}	1241.1	4	28.6
Overall	108.9	224.9	670.9		

NS = no significant difference between the non-pluriactive farms and the pluriactive group using a one-way ANOVA of $\log_{(e)}$ transformed data.

In terms of arable and grass cover, the BOTH group was similar to the ON-FARM group, although the surveyed farms in this group were approximately 19 ha smaller on average and only 10-11 ha greater than non-pluriactive farms. In fact, the BOTH group had the greatest extent of arable at 40%. Gasson (1966) noted that part-time farming (equivalent to the OFF-FARM and BOTH groups in this study) in southern England was associated with a greater proportion of cereal arable as a strategy to simplify the farm enterprise mix.

The NCMS (1988) noted that the extent of grass had increased by 10.4% in Grampian between the 1940's and the 1970's and that the extent of arable had increased by 13.6% (which included reseeded grass). More recently and generally, the ITE 'Countryside Survey' in 1990 (Barr *et al*, 1993), indicated that over Britain, from 1984, 4% of arable land had been lost along with 3% of managed grass; rough grassland had increased by 1% and marsh by 45%. It is difficult from a static comparison of farms at this one time to indicate whether the Grampian farms are following the national trend recognised by Barr *et al* (1993) but it is notable that the pluriactive farmers are the youngest farmers and that they are associated with the greatest extents of non-agricultural vegetation types.

Woodland was most extensive within the ON-FARM group, broadleaf woodland covering at least 6% of the farmland. Broadleaf trees have a greater wildlife value than coniferous trees in that they harbour a greater number of species. However coniferous woodland was also most extensive within the ON-FARM group, but proportionally the BOTH group had more indicating that the BOTH group may be more interested in the commercial interest of trees rather than the visual and wildlife value of the landscape. For both groups, it is likely that upto a quarter of the trees had been planted in the four years prior to the survey although the data obtained in this survey was not conclusive.

From the incomplete figures for the age of trees within this chapter it seems that Grampian has had an increase of 6-25% of woodland between 1987/8 and 1991/2. This is on a parr to the 12.5% increase in broadleaf <u>plantations</u> and the 6.6% increase in coniferous <u>plantations</u> identified for Grampian region between the 1940's and the 1970's by the NCMS (1988) but not as great as the loss of 28.3% of natural broadleaf woodland between the 1940's and the 1970's (NCMS, 1988). The Broadleaved Woodland Grant Scheme (introduced in 1985), the Farm Woodland Scheme (introduced in 1989) and the Forestry Commission's Woodland Grant Scheme (introduced in 1988) appear to be rectifying these losses although this appears to be only happening on the largest arable farms, the ON-FARM group. Over Britain generally there has been a 1% increase of broadleaf/mixed woodland and scrub and a 5% increase in coniferous woodland between 1984 and 1990 (Barr *et al*, 1993).

Between the 1940's and 1970's, there had been a loss of 26.3% in the extent of heather moor in Grampian (inclusive of the upland areas) although the greatest vulnerability occurred within the lowland areas (Moray and Banff & Buchan districts) (NCMS, 1988). No farm group had a significant cover of moorland, so any replacement of moorland does not appear to be occurring.

Although the area of unfarmed land was greater on pluriactive farms, none of it (or, at most, only a small proportion) was unmanaged. Neglected land constituted less than 1% of land in each farm group; only one farm within the BOTH group had a substantial area of land classified as 'neglected' (which, incidentally, was supposed to be *managed* set-aside). Abandoned land did not appear to exist. It is possible that abandoned land was recorded as areas of scrub (i.e. gorse) as well as the possibility that, what might otherwise have become 'abandoned' land, was planted with trees through the use of forestry grants which became available from the mid 1980's.

No golf courses occurred within the socio-economic survey farm sample (Dent *et al*, 1993) but were seen about the region. Golf courses were reported to be more predominant in England and are usually built at the expense of arable land (Barr *et al*, 1986). The small proportion of land classed as purely 'non-agricultural' (<2% of farm area) on farms with on-farm pluriactivity mainly consisted of quarrying. Farms with on-farm pluriactivity also contain areas planted with game cover around the edges of fields and an increase in the variety of crops within a field where farm shops exist; for example, a number of horticultural crops (e.g. raspberries).

Coarser grain landscapes (*sensu* Baudry, 1984) were associated with arable land and therefore more associated with farms with on-farm pluriactivity. However, the variety of different vegetation types per km^2 tend to also be greater within the ON-FARM group, possibly due to the greater frequency of scrub and woodland areas as well as game cover and the variety of horticultural crops.

The NCMS reported the loss of 5.6% of the length of tree lines between the 1940's and the 1970's in Grampian as well as a loss of 41.5% of the hedgerow length. Very few linear vegetation types were recorded although they were more frequent within non-pluriactive farms; 72% had linear vegetation types in comparison to 42-57% of pluriactive farms. However, the length of linear vegetation types per km^2 on pluriactive farms (where they occurred) did not vary significantly from the non-pluriactive farms and no clear tendencies were seen.

6.6 *Extrapolation of the Field Survey Vegetation Cover Analyses Using Air Photography Interpretation Data*

Air photography interpretation (API) data were obtained from the MLURI 1:25 000 scale maps by photocopying the original maps at MLURI (see section 2.4). However, map data were obtained for only sixty-six of the seventy-one field-surveyed farms[1].

The extent of each MLURI land cover category (see MLURI, 1990) was estimated for each farm using an acetate grid divided into 0.1 hectares and counting the number of squares covering each category on the map. The proportion of each land cover category was calculated for each farm and means calculated for each farm group.

Arable land was found to be over-recorded in the API data by about 100%, grassland under-recorded by about 90% and other land cover categories were negligible (Fig. 6.4). Therefore the use of API land cover data to obtain the land cover characteristics of farms in the other regions used in the socio-economic survey (Fife and Dumfries & Galloway; see Dent *et al*, 1993) was not feasible.

[1] some farm boundaries were incomplete during June 1992 when the data were collected.

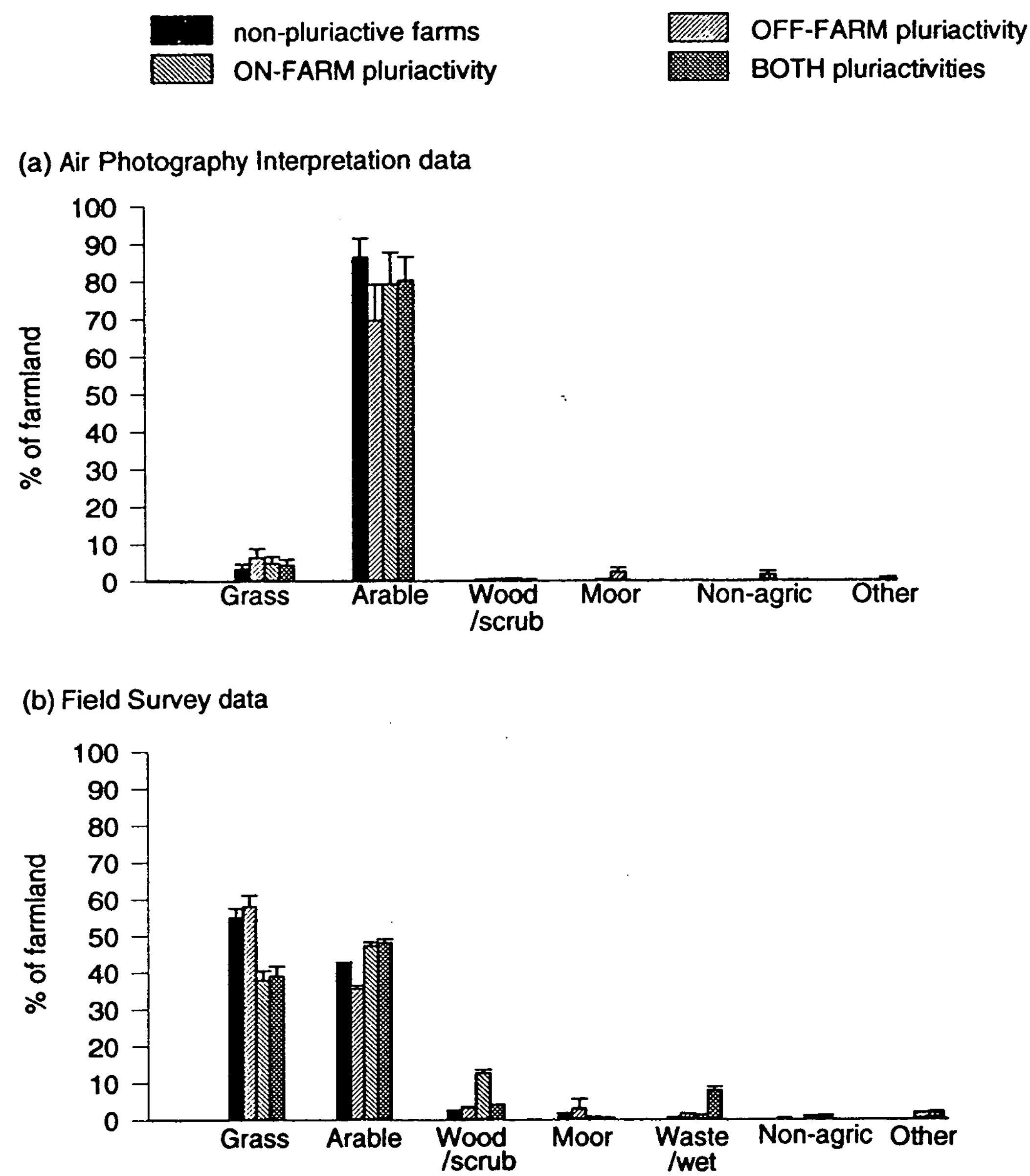


Fig. 6.4. (a) The mean proportion of each MLURI land cover category interpreted onto 1:25 000 scale maps from air photographs (MLURI, 1990) for sixty-six of the field-surveyed farms in this study. This is compared to (b) the mean proportion of each vegetation cover category used in the field survey for each of the seventy-one field-surveyed farms (see Table 6.1). Bars indicate SE about the mean. MLURI categories equivalent to the 'waste/wet' land category in this study were not recorded within the farm boundaries outlined on the 1: 25 000 scale API maps.

CHAPTER 7

Field Survey Results II
Grass Field Use and Management

Introduction

This chapter outlines the use of grass fields and the intensity of their management within each farm group as obtained through the field use questionnaire interview with the farmer. A copy of the field questionnaire is placed in Appendix 1.

7.1. *The Number and Estimated Size of Grass Fields*

Of the seventy-one field survey farms, three had no grass. Of the sixty-eight farms with grass, two rented out (i.e. 'let') all grass and one had placed all its grass under the 'cereal set-aside' scheme. Data on the use of grass fields were therefore only collected from sixty-eight farms and on the management of fields from the sixty-five farms which managed their grass (Table 7.1). Data from non-pluriactive farms made up 40% of the dataset with 25% from the OFF-FARM group, 14% from the ON-FARM group and 22% from the BOTH group.

Table 7.1. The collection of data on the use of grass fields from sixty-eight farms and on the management of grass fields from sixty-five farms. The number of grass fields are also shown.

FARM GROUP	Surveyed farms	**Farms with grass**	Grass fields with use data	**Farms managing own grass**	Fields with management data
Non-pluriactive	25	**24**	277	**24**	270
OFF-FARM pluriactivity	19	**18**	172	**17**	165
ON-FARM pluriactivity	13	**12**	96	**11**	96
BOTH pluriactivities	14	**14**	149	**13**	134
Total	71	**68**	694	**65**	665

The vegetation cover analyses (Table 6.1) showed that the non-pluriactive and OFF-FARM groups had, on average, more than half of their farmland covered by grass. In contrast, grass within the ON-FARM and BOTH groups covered approximately 38% of farmland. Ninety-five per cent to 97% of all grass was classified as lowland *agricultural* grass. In lowland areas field size can give an indication of the intensity of land management with larger fields associated with intensive farming and smaller fields with less intensive farming (Morrison & Idle, 1972). By dividing the total area of grass (obtained from Arc/Info) by the number of grass fields from the field questionnaire (shown in Table 7.1) fields within non-pluriactive farms were found to be larger than fields within pluriactive farms (Table 7.2). From this alone, non-pluriactive farms were expected to show the greatest intensity of management within their grass fields.

Table 7.2. Approximation of field size (hectares) for each farm group using the total area of surveyed grassland within each farm group divided by the number of fields.

FARM GROUP	Total grass area	Approx. area of each grass field (ha)
Non-pluriactive	1726.6	6.23
OFF-FARM pluriactivity	893.5	5.20
ON-FARM pluriactivity	503.3	5.23
BOTH pluriactivities	618.1	4.15

7.2 *The Use of Grass Fields*

Thirteen categories of field use were identified using the main use(s) of the field from the time of the field survey with the use(s) for the three to four months prior to the survey, i.e. from March, April or May depending on whether the survey was in July, August or September (Appendix 1).

Cattle was the predominant grassland use, accounting for 37% of the surveyed fields (Fig. 7.1). Ninety per cent of cattle fields were stocked with non-suckler beef. The OFF-FARM and BOTH groups had 27-33% fewer ($P<0.01$) cattle fields proportionally than the non-pluriactive farms. The ON-FARM group, although not significantly, used 20% fewer fields for cattle.

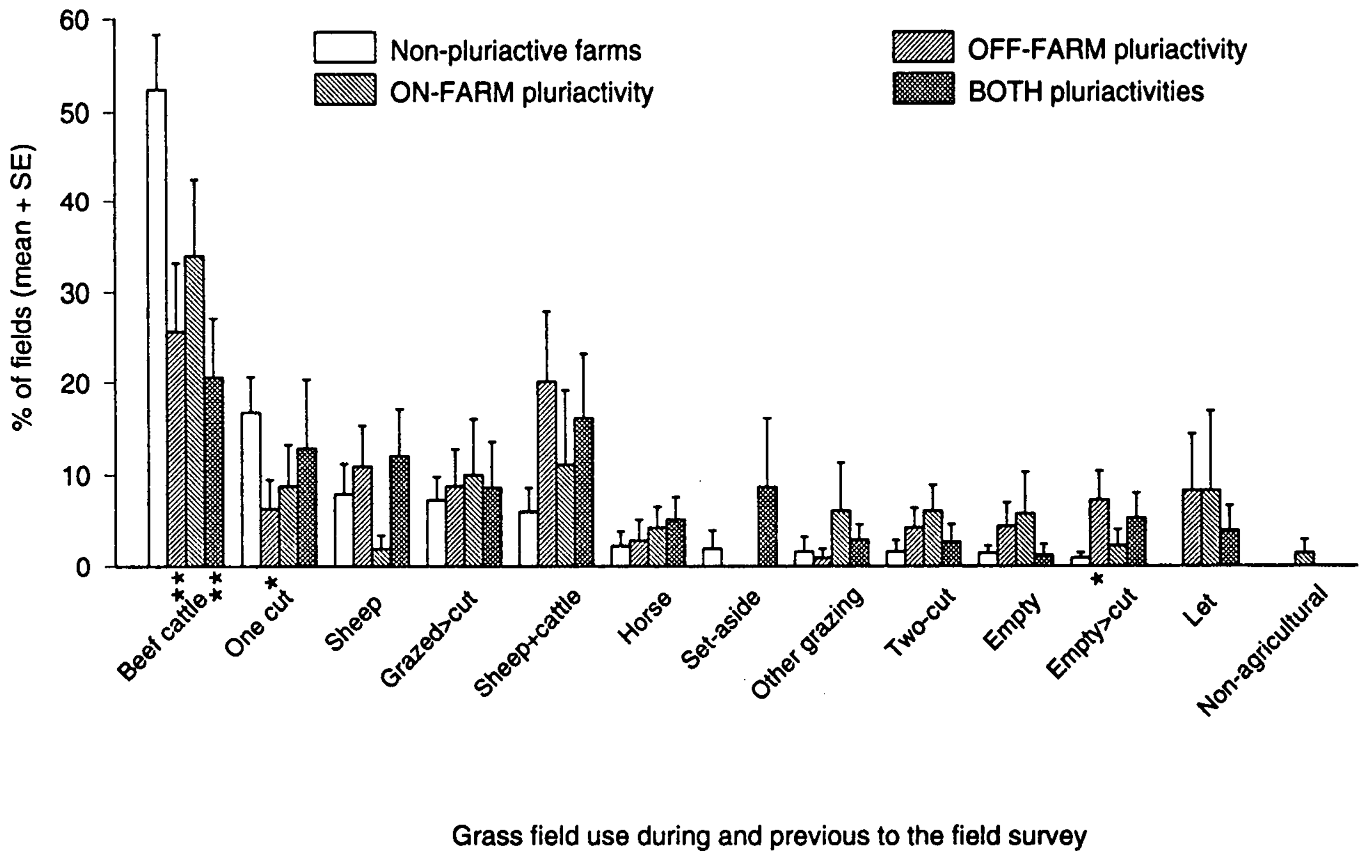


Fig. 7.1. The mean proportion (%) of each field use for each group of farms based on the use of the field during the field survey and for the 3-4 months prior to the survey. Other grazing includes pigs, poultry and goats. The non-agricultural activity was horse jumping. Bars indicate SE about mean. **P*<0.05, ***P*<0.01 level of significance between the non-pluriactive farms and the pluriactive group using a one-way ANOVA and angular transformed data.

Seventy-six per cent of one-cut fields were taken as silage-cuts; 24% were hay-cuts. Silage is used as fodder for in-house feeding of cattle over winter so that the proportion of silage fields followed a similar pattern as cattle fields, for example the OFF-FARM group had 10% fewer one-cut fields ($P<0.05$) than the non-pluriactive group. However, the proportion of one-cut fields withinthe BOTH group was unexpectedly high. All two-cut fields were silage but only accounted for 4% of all fields and were more frequent within pluriactive farms. However, pluriactive groups had a greater proportion of fields with sheep+cattle than non-pluriactive farms which may account for the extra silage production.

The proportion of fields used for sheep did not follow an inverse pattern to the number of fields used for cattle so there was no definite switch from cattle grazing to sheep grazing; the ON-FARM group which had the least number of fields used for cattle used only 2% of their fields for sheep.

There was a similar policy to aftermath grazing across all farm groups with 8-10% of fields grazed-after-cut in each farm group.

Generally, pluriactive farms had more empty fields, i.e. either the grass was being left for mowing or the field was temporarily not being used for anything. The OFF-FARM group had significantly more empty-after-cut fields ($P<0.05$). Similarly, the pluriactive farms were letting 3-8% of their fields; no non-pluriactive farm 'let' fields.

As with the vegetation cover analyses, non-agricultural activities accounted for very few fields; in this case, the fields accounting for little over 1% within the ON-FARM group belonged to one farm with horse jumps. No non-agricultural activity within the BOTH group used grassland. However, other types of grazing (pigs, poultry and goats) as well as horse grazing tended to be more common on pluriactive rather than non-pluriactive farms. 'Cereal set-aside' land was most common within the BOTH group accounting for 8% of fields as opposed to 2% within non-pluriactive farms and none within the other farm groups.

7.3 *Grass Field Management Characteristics*

At the time of the interview each field was placed into a number of categories (outlined in section 5.2) according to:

- the type of grassland, whether *permanent* or *arable* grass;
- the age of the grass;
- the rate of inorganic nitrogen application;

and • whether the field had been stocked to its potential or not.

The definition of *permanent* and *arable* grassland was taken from Hopkins *et al* (1985):

"A field which during the previous 10 years had been used for 1 or more year's tillage cropping, i.e. cereals, potatoes or other cash crops, or 2 or more years of forage cropping, i.e. kale, stubble turnips *etc.*, was classified as *arable* grassland. Fields classified as *permanent* grassland had spent either the whole of the previous 10 years in grass (although grass-to-grass reseeding may have taken place during this period) or 9 years in grass with a tenth year in a forage crop." (Hopkins *et al*, 1985).

The age categories were taken from analyses by the Grassland Research Institute and the Agricultural Development and Advisory Service 'Permanent Pasture Group' (Forbes *et al*, 1980; Green, 1982; Hopkins *et al*, 1985). The age categories were:

- 0-4 years old,
- 5-8 years old,
- 9-20 years old,

and • more than 20 years old.

The inorganic nitrogen application categories were amalgamations of those defined by Hopkins *et al* (1985). For the twelve months prior to the field survey, these were:

- no nitrogen fertiliser applied,
- 1-124 kg N/ha,
- 125-249 kg N/ha,

and • more than 250 kg N/ha.

The classification as to whether the field could carry more livestock was taken from Forbes *et al* (1980);

Given the current soil and vegetation status:

- could the grassland carry more stock?

or
- was the grassland stocked to its potential?

It is stressed that the classification of the stocking rate of a field was based upon the farmer's judgement and not on the type and number of livestock per hectare.

About two-thirds of grass fields in each group were in arable rotation (Fig. 7.2a). In general, fields were therefore relatively young with 80-85% of fields having been reseeded during the previous eight years. The ON-FARM group tended to reseed more often than non-pluriactive farms whilst the OFF-FARM and BOTH groups tended to reseed less often (Fig. 7.2b).

About 20% of fields had received no inorganic nitrogen during the previous twelve months and over 50% had received 1-125 kg N/ha. Pluriactive farms used significantly less ($P<0.05$) inorganic nitrogen when considered as one group (Fig. 7.2c). The higher proportion of fields receiving >250 Kg N/ha in the ON-FARM group ($P<0.05$) was associated with two-cut fields.

Ninety-two per cent of fields had been stocked during the 12 months prior to the survey. Over half of these fields were reported to be stocked to potential with the OFF-FARM group reporting a tendency to have most fields in this category (Fig. 7.2d).

The ON-FARM group applied organic manures (farmyard manure, slurry *etc.*) to 37% of fields whilst other farm groups did so to 17-26% of fields; no pluriactive group varied significantly to the non-pluriactive farms. Very few fields were sprayed with herbicide and those that were generally spot-sprayed (rather than sprayed all-over) so that effects were localised. The ON-FARM group tended to spray the least proportion of fields (1.7%) whilst the OFF-FARM group tended to spray the most (>5%) (Table 7.3).

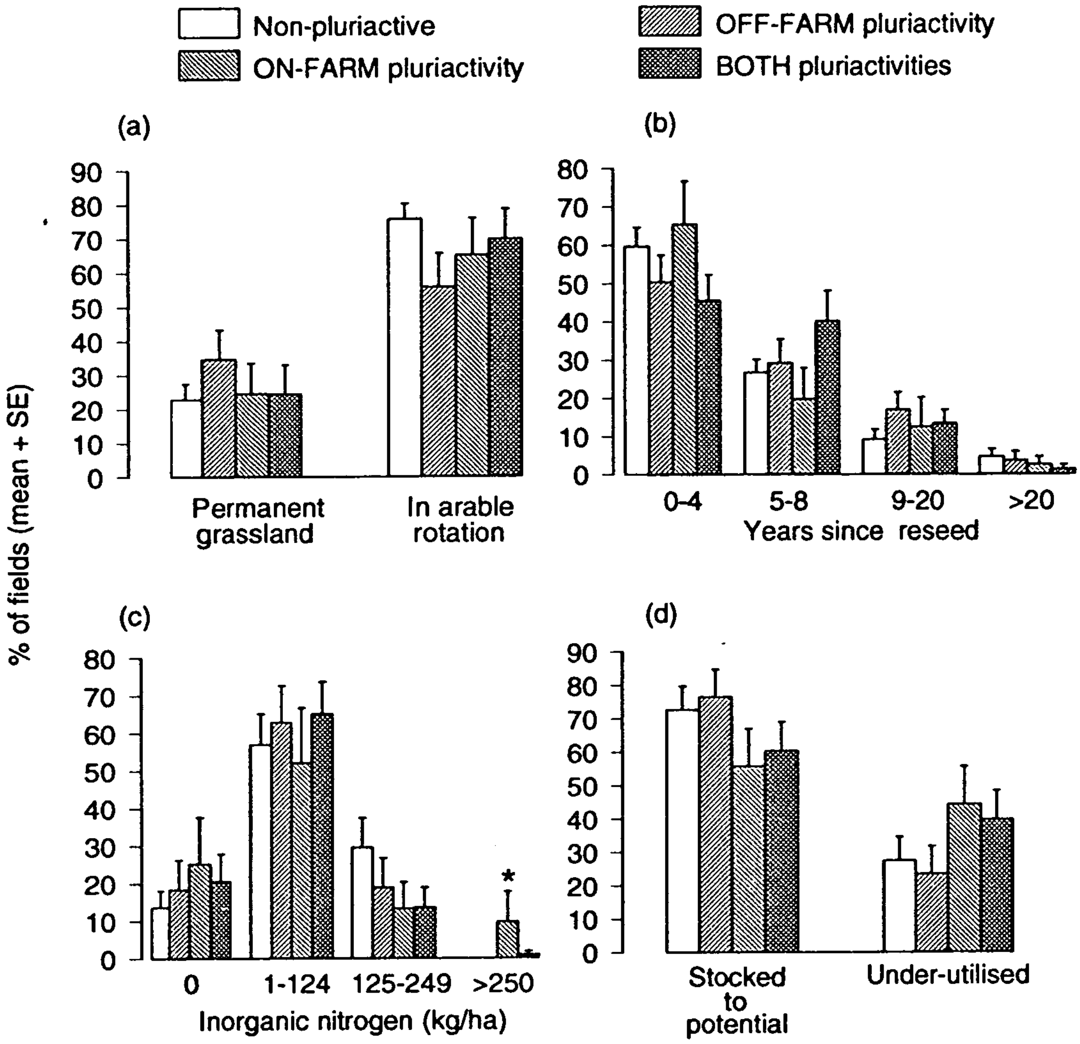


Fig. 7.2. The proportion (%) of grass fields within various management categories for each farm group. (a) the type of grassland during the previous ten years, (b) the age of the grass swards (years since last reseed), (c) rate of inorganic nitrogen application (kg N/ha), and (d) the level of stocking within field (whether to potential or under-utilised, excluding fields that were not stocked). Bars indicate SE about mean. *$P<0.05$ level of significance between the non-pluriactive farms and the pluriactive group using a one-way ANOVA and angular transformed data.

Table 7.3. The proportion (%) of fields which had organic manure and herbicide applied to them during the twelve months previous to the field survey.

FARM GROUP	Organic manures	Herbicides	Number of farms
Non-pluriactive	25.6 ± 5.8	3.7 ± 1.8	24
OFF-FARM pluriactivity	24.5 ± 7.1^{NS}	5.8 ± 3.6^{NS}	17
ON-FARM pluriactivity	37.0 ± 11.9^{NS}	1.4 ± 1.5^{NS}	11
BOTH pluriactivities	15.9 ± 6.4^{NS}	4.2 ± 2.5^{NS}	13

NS = no significant difference between the non-pluriactive farms and the pluriactive group using a one-way ANOVA and angular transformed data.

7.4 Discussion of the Use and Management of Grass Fields

Gasson (1966, 1983) noted that part-time farmers (i.e. the OFF-FARM and BOTH group) in the south of England favoured beef cattle, sheep, egg production and cereals (i.e. "enterprises which were least likely to require constant managerial attention", Gasson, 1983) rather than milk production, pigs or intensive crops. In the Grampian context where there has traditionally been fewer dairy farms anyway but where grassland management has tended to be more intensive than most regions within Britain, the field use and management characteristics of the OFF-FARM and BOTH groups are close to those of part-time farms in southern England although the OFF-FARM and BOTH groups vary in their emphases. Davies and Dalton (1993b) noted in a study covering most of Scotland that households with off-farm employment were more likely to have sheep on their farms than non-pluriactive farms and were more likely to be involved in gimmering (fattening lambs over winter for sale next summer) than breeding which is more intensive.

The ON-FARM group, however, although still having more sheep, empty and 'let' fields than non-pluriactive farms tended to have fewer traditional livestock (sheep and cattle) but had the most other types of grazing (pigs, poultry and goats). These farms, possibly because of the location of the pluriactivity, are more able to manage more intensive enterprises like pigs.

The BOTH group tended to have the most land under the 'cereal set-aside' scheme. From conversations with farmers it seemed that this group was least concerned about the appearance of the landscape; farmers within the other three groups were extremely adverse to the scheme perceiving it to be an 'eyesore'. The BOTH group, however, still had the greatest cover of cereal even with some land under the 'set-aside' scheme.

An extremely high proportion of grass was in arable rotation; Hopkins *et al* (1985) recorded only 26% of their surveyed grassland in south-west England as arable. The OFF-FARM group tended to keep 35% as permanent in agreement with Gasson's (1966, 1983) assertions that such farms tend to increase the area of grass. However, less than 4% of all fields were older than twenty years despite a trend in south-west England towards older grassland with 43% of fields over 20 years old (Peel *et al,* 1985; Hopkins *et al,* 1985). The high reseed rate in the ON-FARM group may be due to the high proportion of fields in arable rotation although this does not appear to be the case for the BOTH group.

Each pluriactive farm group applied inorganic nitrogen to fewer fields (74-82%) than non-pluriactive farms (87%). Only the ON-FARM group significantly differed from the non-pluriactive farms in the quantity of nitrogen applied in the last year but only in the highest category which was associated with two-cut fields.

The average input of fertiliser in Britain generally was about 4 kg/ha in 1943/5 which rose to 22-54 kg/ha on permanent and temporary grassland (Yates & Boyd, 1965) and then to over 140 kg/ha in 1976 on temporary grass (Church & Lewis, 1977). Hopkins *et al* (1985) reported an average of 100 kg/ha for livestock farms in south-west England and higher rates for other farms, the average being 168 kg/ha. Grampian farms with over half their fields having 1-124 kg/ha therefore contrast to the English south-west where the average use of inorganic nitrogen has increased (Hopkins *et al,* 1985).

Over half the surveyed fields were reported to be 'stocked to potential' in contrast to 16% of non-suckler beef fields thus stocked in England and Wales

(Forbes *et al*, 1980). This may reflect the fact that Forbes *et al* (1980) selected farms with high proportions of permanent grass. The ON-FARM and BOTH groups both had the greatest proportion of fields under-stocked, perhaps a reflection that these are mainly arable farms.

Hopkins *et al* (1980) reported that 40% of their surveyed fields received organic manures. Within this study, only the ON-FARM group came close to this figure, the other farm groups applying organic manures to approximately half this proportion. However, the frequency of herbicide application in this study compares with the 4-5% of lowland grass fields sprayed in England and Wales by Fuller (1987) but not with Sly (1986) who reported that 42.5% of grass in England and Wales received herbicide.

Generally the analysis of the field questionnaire data indicated less intensive forms of field *use* and *management* on pluriactive farms in comparison to non-pluriactive farms. However, the categorisation of fields within different levels of management at the time of the interview (rather than within the analyses) may have obscured more significant differences.

CHAPTER 8

Field Survey Results III
Species Characteristics of Grass Fields and their Boundaries

Introduction

Chapter 7 revealed that, generally, pluriactive farm groups were managing grassland less intensively in comparison to non-pluriactive farms. Using Grime's (1979) 'hump-backed' model (see Fig. 1.5) a greater number of species might therefore be expected in their swards, either across the whole farm or associated with particular field uses. The type of species might also vary according to the type of management most characteristic of the farm group. Therefore the number and type of species found within grass fields and along grass field boundaries are presented in this chapter.

Out of the seventy-one farms used in the field survey, only sixty-five farms provided both land use and management details for their grass fields (Table 7.1). Since ten quadrats were placed within the grass fields of each farm (see Fig. 5.1), species data for 650 grass field quadrats and for 325 field boundary plots (see section 5.5) were collected (Table 8.1). Sixty per cent of all fields had at least one quadrat placed within them.

Table 8.1. The number of farms, field quadrats and boundary plots used to collect species data within each farm group.

FARM GROUP	Number of farms	Field quadrats	Boundary plots
Non-pluriactive	24	240	120
OFF-FARM pluriactivity	17	170	85
ON-FARM pluriactivity	11	110	55
BOTH pluriactivities	13	130	65
Total	65	650	325

The distribution of quadrats and boundary plots between field uses tended to reflect the proportion of fields under each use although grazed+cut fields were under-sampled and one-cut fields were over-sampled (Table 8.2).

Table 8.2. The number and proportion (%) of grass fields sampled, and the number and proportion of field quadrats and boundary plots, within each field use. Data were not collected from 'set-aside' or 'let' land (since management would not be under farm household decisions) nor land used for non-agricultural purposes. The proportion of fields in each use were obtained from the grass fields questionnaire (see Fig. 7.1) adjusted for the exclusion of 'set-aside', 'let' land and land used for non-agricultural purposes (i.e. 694 - 30 = 664 fields).

Grass field use	N° fields	% of fields	Field quadrats N°	Field quadrats %	Boundary plots N°	Boundary plots %
Beef cattle	258	37.2	255	39.2	122	37.5
Empty	24	3.5	18	2.2	7	2.2
Empty after cut	29	4.2	33	5.1	18	5.5
Grazed+cut	50	7.2	13	2.0	3	0.9
Horse	18	2.6	11	1.7	8	2.5
One-cut	74	10.7	147	22.6	74	22.8
Other grazing	12	1.7	12	1.9	6	1.9
Sheep	66	9.5	47	7.2	26	8.0
Sheep+cattle	103	14.8	91	14.0	47	14.5
Two-cut	30	4.3	23	3.5	13	4.0
Total	664	100	650	100	325	100

Nearly two-thirds of boundary plots fell against wire fences and one-quarter fell against the more traditional field boundary type, stone walls (Table 8.3).

Table 8.3. Boundary types found in the Grampian survey and the frequency with which the boundary plots fell against each type.

Boundary type	N° of boundary plots	%
Wire fencing	207	64.0
Stone wall	80	24.6
Permanent electric fence	14	4.3
Edge of ditch	4	1.2
Unrecorded	20	6.2
Total	325	100

Nomenclature follows Clapham, Tutin and Moore (1987) for vascular plants and Watson (1981) for bryophytes. Species frequency terms used (i.e. how often the plant is found on moving from one sample to the next) correspond to the National Vegetation Classification, i.e. *scarce* = 1-20% of samples, *occasional* = 21-40%, *frequent* = 41-60%, *constant* = 61-100% (Rodwell, 1992). However, only two measures of abundance are used: *sparse* = <1% cover of a species in a sample and *dominant* = >20% cover of a species in a sample.

Section A (p.103) describes the characteristics of species within the open field and section B (p.125) the characteristics of species along the field boundaries. An overall discussion of the species characteristics in the agricultural grasslands of Grampian is given at the end of the chapter (p.131).

Section A. Describing the Species Characteristics Within Grass Fields

A8.1 *Vegetation Groups in Grass Fields*

The main objective was to identify and summarise the vegetation characteristics of grassland in each farm group, i.e. to identify the main constituent species and the heterogeneity of species in the swards. From this, some indication of the external factors most influential in determining the number and type of species would be identified and, therefore, the type of analyses needed to accentuate the differences in grassland composition between non-pluriactive farms and each pluriactive farm group.

Underlying patterns within data may be revealed and summarised (in the case of large datasets such as this) by multivariate analyses (Williams and Gillard, 1971). However, there were a number of multivariate techniques to choose from.

- 'Polythetic' multivariate analyses use information on all the data rather than on the presence or absence of a single species (as in 'monothetic' classification).
- 'Divisive' multivariate techniques are those where quadrats (and/or species) are sorted into classes by successively dividing a batch of quadrats into increasingly similar classes rather than accumulating similar quadrats together (as in 'agglomerative' techniques).
- 'Hierarchical' multivariate techniques are those where classes are arranged in an order to indicate relationships rather than simply clustering

similar quadrats.

Techniques which are polythetic, divisive and hierarchical therefore examine major gradients in the data in contrast to small differences between quadrats (as in monothetic and agglomerative techniques).

"The larger, significant differences in community composition, but not the tiny differences, are related to differences in environment and history, which an ecologist wants to express in a classification. Hence two-way indicator species analysis (TWINSPAN), being polythetic and divisive, is recommended for hierarchical classification because of its effectiveness and robustness" (Gauch, 1982).

Two-way indicator species analysis ('TWINSPAN'; Hill, 1979a) was therefore used to classify and order the 650 quadrats and constituent species. The successive division of each class of quadrats (and, secondly, species) occur mid-range along ordinations[1] for each data sub-set TWINSPAN produces so that an alternative and a more correct description might therefore be "dichotomized ordination analysis" (Hill, 1979a). The two-way classification arranged in a sample-by-species matrix is similar to the classification tables devised by Braun-Blanquet (1921).

TWINSPAN also uses species abundance data by generating pseudospecies (Hill, Bunce & Shaw, 1975), i.e. defining a 'new species' by associating each abundance class with the species. The default levels for pseudospecies were 1%, 2-5%, 5-10%, 10-20% and >20% so that, for example, *Lolium perenne* (Lp) had five pseudospecies - Lp1 (1%), Lp2 (2-5%), Lp3 (5-10%), Lp4 (10-20%) and Lp5 (>20%). However, in this study the percentage covers were assessed in 5% bands so that the second pseudospecies did not appear in this classification. Although the pseudospecies cut levels can be altered easily, time did not allow the comparison of the effect of other cut levels on the resultant classification to be assessed. The default levels were therefore taken.

Only the ordering of the quadrats is now considered.

---

[1] there are actually three main ordinations for each dichotomy in TWINSPAN (Hill, 1979a). The ordinations are based on reciprocal averaging.

TWINSPAN formed twenty-four vegetation classes from the 650 quadrats. The number of quadrats in the cells of a table formed by 24 TWINSPAN groups and four farm groups were sometimes less than five which for the chi-square analyses to be performed is considered statistically undesirable, particularly for the expected values (Bailey, 1983). The twenty-four classes were therefore combined into ten broader groups by eye using the computer print-out of the sample-by-species matrix, combining the quadrat groups at earlier division levels according to the dominant species. The groups were then labelled A to J (Table A8.1).

Table A8.1. The ten grassland groups defined by TWINSPAN using the 650 grass field quadrat data. The number of quadrats that fell within each group are shown in brackets. The {} brackets indicate the presence of constant but sparse species across Groups F to J. Extra species indicated for Group J were not constants and therefore not specified; examples include *Carex* spp., *Deschampsia cespitosa* and *Juncus effusus*.

TWINSPAN		**Species cover**	
group	Dominant >20%	10-20%	1-10%
A (11)	*Lolium multiflorum, Phleum pratense*		
B (26)	*Dactylis glomerata, Lolium perenne, Phleum pratense*		
C (48)	*Dactylis glomerata, Lolium perenne, Phleum pratense, Trifolium repens*		
D (59)	*Lolium perenne, Phleum pratense*		
E (163)	*Lolium perenne, Trifolium repens*	*Phleum pratense*	
F (46)	*Lolium perenne, Trifolium repens*		{*Agrostis tenuis*} {*Bellis perennis*}
G (185)	*Lolium perenne, Trifolium repens*	*Poa annua*	{*Cerastium fontanum*} {*Dactylis glomerata*}
H (32)	*Lolium perenne, Phleum pratense, Poa annua*		{*Eurynchium* spp.} {*Holcus lanatus*} {*Phleum pratense*}
I (53)	*Agrostis tenuis, Holcus lanatus, Lolium perenne, Trifolium repens*		{*Poa annua*} {*Ranunculus repens*} .
J (27)	*Holcus lanatus, Lolium perenne, Trifolium repens*		{species indicative} {of wet conditions}

By knowing the ecological characteristics of species in the quadrats of each

TWINSPAN group, both a nutrient and soil moisture gradient appeared to be influential in determining the quadrat ordering. The ten TWINSPAN groups might be therefore be considered 'management' classes with Group A indicative of intensive management and Group J indicative of less intensive management, which are shown broadly grouped into four classes in Table A8.2.

Table A8.2. The classification of the 650 grass field quadrat data into four management classes using the quadrat groups defined by TWINSPAN (Hill, 1979a). The TWINSPAN groups are defined in Table A8.1.

(1) Intensive management - quadrats contain, mostly or exclusively, sown or 'agriculturally preferred' species: *Dactylis glomerata* (cocksfoot), *Lolium* spp. (ryegrasses), *Phleum pratense* (timothy grass), *Trifolium repens* (white clover) (TWINSPAN groups A, B, C);
(2) Moderately-intensive management - quadrats contain mainly *Lolium perenne* (perennial ryegrass) and *Trifolium repens*, general purpose agricultural species (TWINSPAN groups D, E);
(3) Moderate management - quadrats contain non-sown species in some proportion with *Poa annua* (annual meadow grass) indicating sward damage or poor establishment after reseeding (Hopkins, 1979) (TWINSPAN groups F, G, H);
(4) Low-intensity management - quadrats contain a greater frequency and abundance of non-sown species, particularly characteristic of disturbance (*Bellis perennis, Cerastium fontanum, Eurynchium* spp.) and poorer drained soils (*Carex* spp., *Deschampsia cespitosa, Juncus effusus*) (TWINSPAN groups I, J).

The frequency of quadrats within each management class and farm group significantly differed from that expected using chi-square tests ($P<0.001$, df=9; Table A8.3). Non-pluriactive farms were associated with intensive management (there were 45.5% more quadrats in class 1 than expected), the BOTH group with moderately-intensive management (+45.4%, class 2) and the ON-FARM group with low-intensity management (+85.2%, class 4) (Appendix 6A-1).

In contrast, the frequency of the quadrat distribution between different field uses did not differ from that expected ($P>0.05$, df=12; Appendix 6A-2).

In summary at this stage, it was realised that:

- the non-pluriactive farms were managing their grass swards in a manner so as to encourage a greater frequency of agriculturally-preferred species,
- the ON-FARM group were managing grass swards in some way

which was allowing grass species indicative of less intensive management to enter,

- the BOTH group may be sowing a different set of agriculturally-preferred species,

and
- that the OFF-FARM group was not associated with any specific type of management practice.

Table A8.3. The frequency of quadrats in each farm group, each TWINSPAN group and management class. A chi-square test (using the management classes alone) showed that the distribution of quadrats was significantly different from that expected ($P<0.001$, df=9, Appendix 6A-1). Higher values than expected are underlined.

Management class	1. Intensive			2. Moderately intensive		3. Moderate			4. Low intensity		
TWINSPAN group	A	B	C	D	E	F	G	H	I	J	Total
Non-pluriactive	6	15	25	13	56	14	78	13	8	12	**240**
OFF-FARM*	3	5	9	16	39	10	57	10	9	12	**170**
ON-FARM*	0	5	13	8	25	11	18	5	23	2	**110**
BOTH*	2	1	1	22	43	11	33	4	13	1	**130**
	11	26	48	59	163	46	185	32	53	27	
Total			85		222			263		80	**650**

*pluriactivity types

What was now needed was a multivariate analysis which would order the species data in n-dimensions to reveal any gradients in the dataset, but this time using only one ordination per axis instead of separate ordinations for each data subset.

Detrended[2] Correspondence Analysis 'DECORANA' of Hill (1979b) was therefore used on the complete 650 quadrat dataset; splitting the data into farm groups would merely define the smaller differences *within* the farm group rather than *between* the farm groups.

Through knowing the ecological characteristics of each species, the first DECORANA axis was interpreted as ordering the species along a nutrient

[2] The tendency for correspondence analysis (also known as 'reciprocal averaging') to develop an arched distribution of data on the second axis (and higher axes), and for data to be compressed at each end of the axes, is eliminated by detrending (see Hill, 1979b) and therefore more likely to reveal clearer gradients.

gradient and the second axis as ordering the species along a soil moisture gradient (Fig. A8.1).

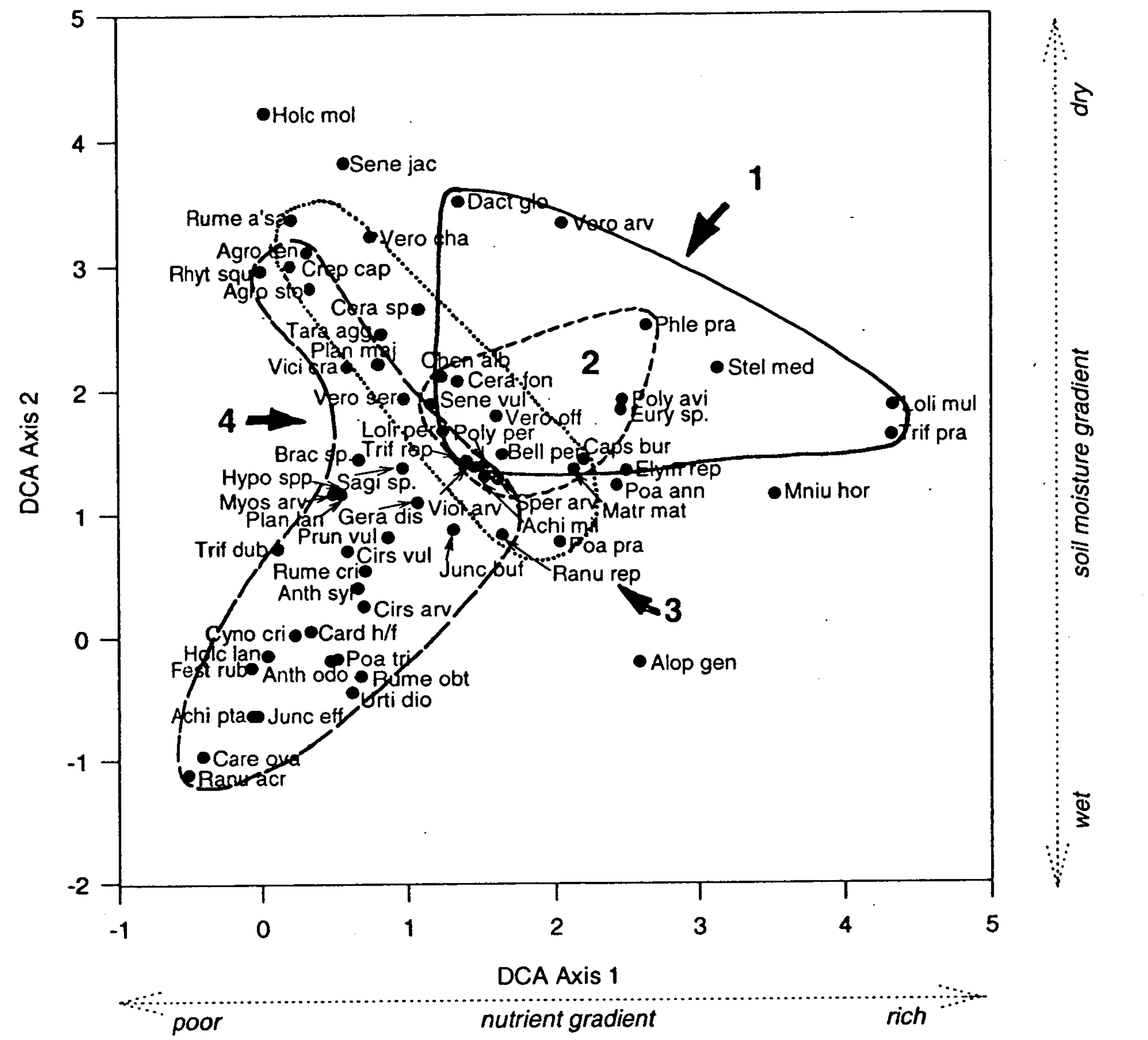


Fig. A8.1. The Detrended correspondence analysis ordination (DECORANA, 'DCA'; Hill 1979b) of species in the 650 field quadrats. For visual clarity, only 65 species (of 105 species) which occurred 3 or more times within the 650 quadrats are shown. Full species names are given in Appendix 7A. Axis 1 expresses a nutrient gradient, from species indicative of poor soil fertility to species indicative of high soil fertility. Axis 2 expresses a soil moisture gradient from species indicative of poor soil drainage to species indicative of good soil drainage. Axis scales are in units of average standard deviations of species turnover (see Hill, 1979b). The four 'management' classes of the TWINSPAN hierarchical ordering (see Table A8.2) are outlined: 1 = intensive management, 2 = moderately-intensive, 3 = moderate management, 4 = low-intensity management.

Since DECORANA quadrat scores are means of their constituent species scores, the quadrat distributions along axes 1 and 2 represented nutrient and soil moisture gradients respectively. Most quadrats tended to lie towards the relatively poorer end of the nutrient gradient and mid-range of the soil moisture gradient. Variations between the farm groups were therefore clearer shown separately (Fig. A8.2).

Both the mean quadrat score of the ON-FARM group along axis 1 and that of the OFF-FARM group along axis 2 were significantly lower ($P<0.01$, $P<0.05$ respectively) than the respective mean scores for the non-pluriactive farms (Table A8.4). This indicated that the low-intensity management associated with the ON-FARM group was related to a lower nutrient regime. Although the OFF-FARM group was not associated with any 'management' class, the association with species indicative of wetter soils suggested some form of low-intensity management. Ten quadrats within the BOTH group formed a separate cluster peculiar to this group, towards the relatively nutrient-poor end of axis 1 and towards the drier-end of axis 2. These quadrats belonged to one farm which only took hay-cuts and accounted for 18.9% of the quadrats in TWINSPAN group I.

Table A8.4. Mean quadrat scores (± SE) for axes 1 and 2 of the Detrended correspondence analyses for each farm group. Axis 1 expresses a nutrient gradient (high figures = high soil fertility, low figures = low soil fertility); axis 2 expresses a soil moisture gradient (high figures = good soil drainage, low figures = poor soil drainage). The number of quadrats in each group are given in Table 8.1.

FARM GROUP	Axis 1	Axis 2	df
Non-pluriactive	153.2 ± 3.2	172.8 ± 2.2	-
OFF-FARM pluriactivity	149.5 ± 2.9	165.8 ± 2.6*	(1, 408)
ON-FARM pluriactivity	139.6 ± 3.3**	177.5 ± 3.6	(1, 348)
BOTH pluriactivities	151.8 ± 2.9	175.4 ± 2.1	(1, 368)

*$P<0.05$, **$P<0.01$ level of significance between the non-pluriactive farms and the pluriactive group using a one-way ANOVA.

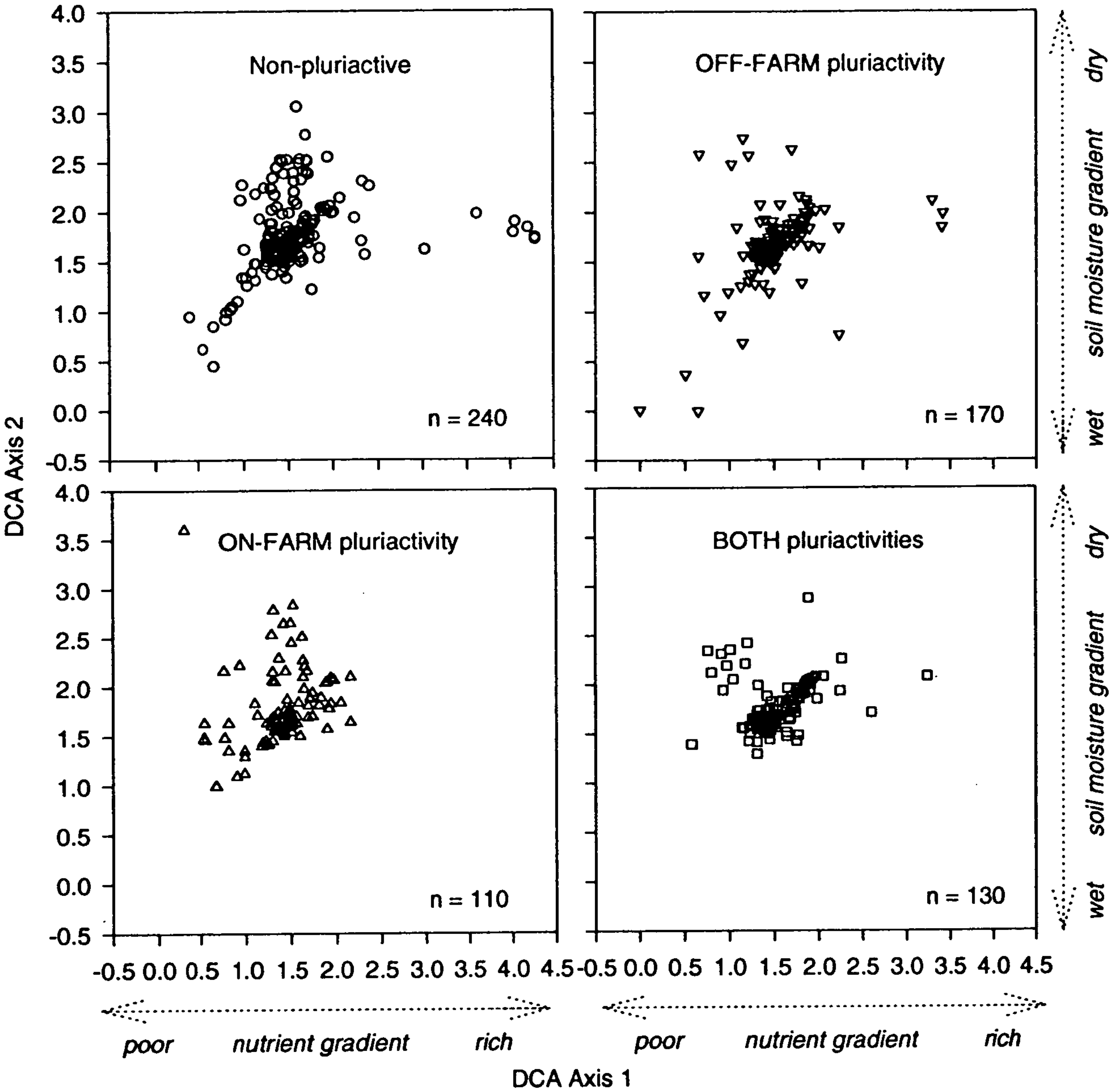


Fig. A8.2. Detrended correspondence analysis (DECORANA, 'DCA') ordination of the 650 field quadrats, the quadrats of each farm group shown separately. Axis 1 expresses a nutrient gradient, axis 2 expresses a soil moisture gradient (see Fig. A8.1). Both the mean quadrat score of the ON-FARM group along axis 1 and that of the OFF-FARM group along axis 2 were significantly lower ($P<0.01$ and $P<0.05$ respectively) than the respective mean scores for the non-pluriactive farms using one-way ANOVA's. n = the number of quadrats.

The mean DECORANA scores for quadrats in each field use across all farm groups, however, did not significantly differ from one another (Fig. A8.3).

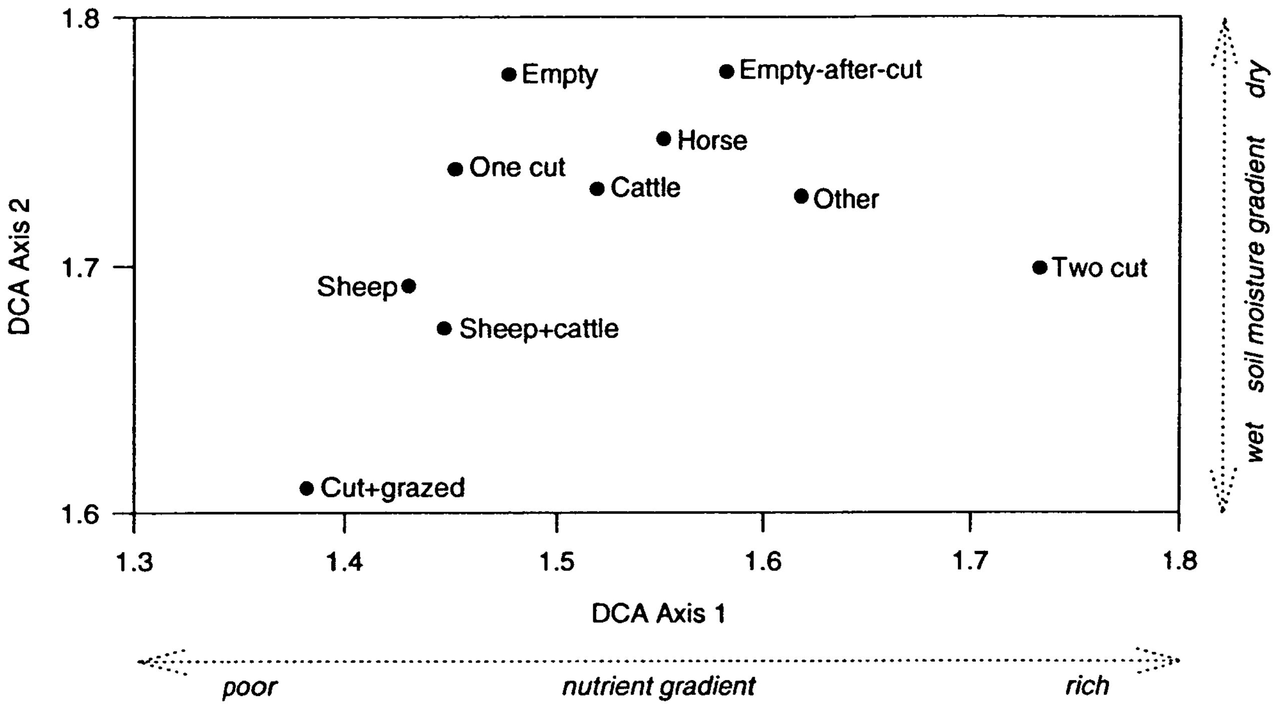


Fig. A8.3. The mean DECORANA quadrat score for each field use. Axis 1 expresses a nutrient gradient, axis 2 expresses a soil moisture gradient (see Fig. A8.1). SE bars are too large to be shown. The number of quadrats for each field use are given in Table 8.2.

The type of pluriactivity is therefore associated with factors which over-ride the effect of field use in determining the *type* of species in a sward.

A8.2 *Species Richness in the Open Field*

Species diversity has two main components (Lloyd and Ghelardi, 1964; Whittaker, 1972):

(a) the *number* of species in a community (or sample) also called '*richness*' (McIntosh, 1967)

and (b) the *evenness* of contribution (e.g. percentage cover, productivity *etc.*) of each species to the community (or sample).

If diversity can be regarded as a single entity, then maximum diversity results if individuals are distributed equally among species and decreases if most individuals belong to relatively few species. Instead of using the term *number*, the term *richness* has been adopted by most ecologists, although Whittaker (1977) also referred to this level of diversity as *internal alpha* or *point* diversity, and Hurlbert (1971) and Grime (1973 *et seq.*) as *species density*. In this thesis *richness* is used with *α-diversity* later used to contrast to species 'turnover', termed *β-diversity* (Whittaker, 1960) (see section A8.5).

Given that two, three or four species are sown and managed to dominate the sward there cannot be complete evenness of species contribution ('high diversity') within agriculturally-managed grass swards. *Evenness* (and the related concept of *equitability*) is therefore not applicable in this study.

"MacArthur (1965), Poole (1974), and Williamson (1973) considered [species counts] to be among the most effective richness measures, and Whittaker (1972) and Whittaker and Woodwell (1969) found the average number of species per sample to be the best index for the forests they were studying. Direct species counts, while lacking theoretical elegance, provide one of the simplest, most practical, and most objective measures of species richness" (Peet, 1974)

The mean number of species per quadrat were therefore compared between the farm groups and found to vary, even within the same field use (Fig. A8.4).

The most significant observations are:

(1) non-pluriactive farms had the lowest species richness values for most field uses, typically 4-8 species per $4m^2$. The exceptions were for fields used for sheep+cattle, cattle (significantly so) and one-cut where the ON-FARM group had the lowest species richness at about 6 species per $4m^2$;

(2) both the OFF-FARM and BOTH groups had the greatest species richness values across field uses with mean values of 7-11 species per $4m^2$;

(3) of the pluriactive farms, the ON-FARM group had the lowest richness values across all field uses, typically 5-10 species per $4m^2$;

(4) the ON-FARM group also had the greatest range with the lowest values for fields associated with cattle and the greatest value for horse

paddocks;

(5) with 80% of the 4m^2 quadrats containing between 6-10 species, no sward could be described as 'species-rich', a term which refers to at least 20 species within one square metre (Grime, 1973).

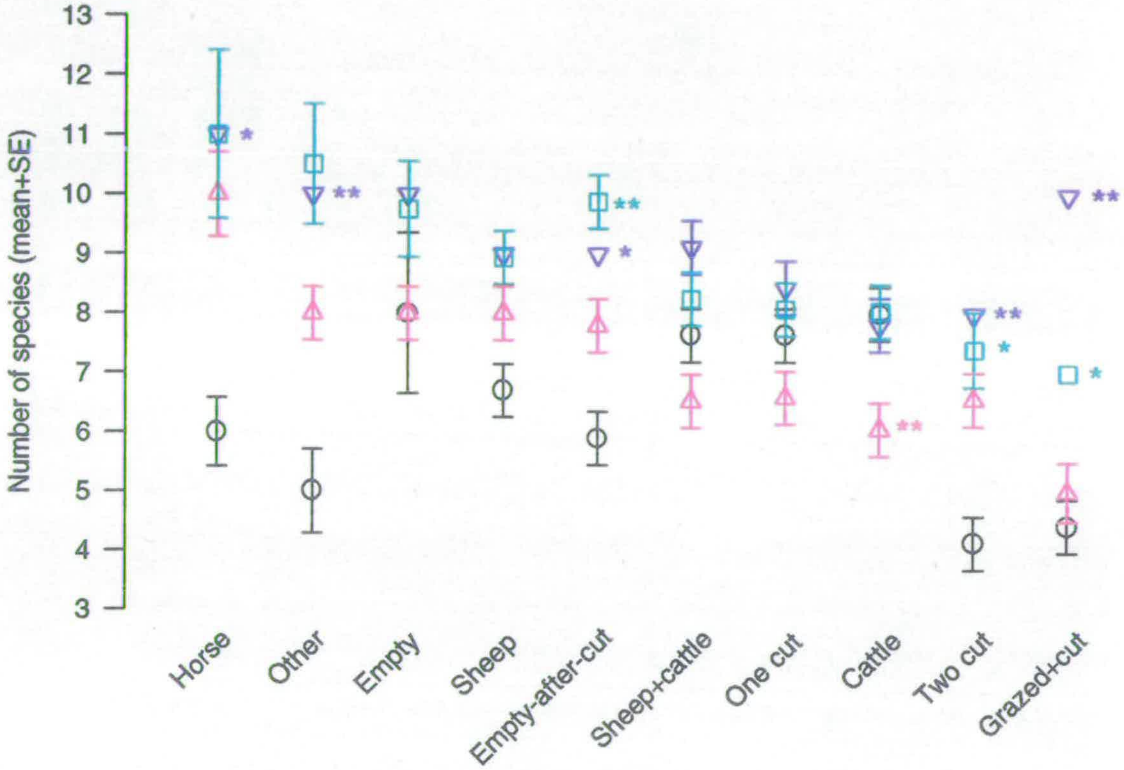


Fig. A8.4. Mean species richness per 4m^2 field quadrat for various field uses and each farm group. Non-pluriactive farms (○), OFF-FARM pluriactivity (▿), ON-FARM pluriactivity (▵), BOTH types of pluriactivity (□). Bars indicate SE about the mean. *$P<0.05$, **$P<0.01$ level of significance between the non-pluriactive farms and the pluriactive group using a one-way ANOVA. The number of quadrats within each field use are given in Table 8.2.

The consistent ordering of species richness values for each farm group, regardless of the field use, explains why field uses did not differ in their DECORANA quadrat scores (see Fig. A8.3); the most species-rich quadrats occurring within the non-pluriactive farms were of the same order of magnitude (about 8 species per 4m^2) as quadrats containing the least number of species in the OFF-FARM group. Quadrats from one farm within the BOTH group were identified as anomalous in Fig. A8.2 and this was attributed to hay-cutting, but it is noticeable that the high species richness of the BOTH group extends across all field uses.

The type of pluriactivity is therefore associated with factors which over-ride the effect of field use in determining the *number* of species in a sward.

However, the lower counts of species within the non-pluriactive farms and the ON-FARM group indicate higher levels of management intensity, although the ON-FARM group has already been associated with the greatest proportion of fields where no fertiliser nitrogen had been applied (Fig. 7.2c) and associated with grass species indicative of low nutrient conditions (Fig. A8.2). Presumably farms within the ON-FARM group are maintaining moderate levels of management through well-supervised grazing, cutting and reseeding regimes (Figs. 7.1 and 7.2b would confirm this). The lowest species richness values for the field uses associated with cattle with this group were probably more to do with the non-pluriactive farms sowing *Dactylis glomerata* and *Phleum pratense* within their swards along with *Lolium* spp. and *Trifolium repens*, whereas the ON-FARM group would sow only the latter two species (Table A8.5; also compare TWINSPAN groups A-C of Table A8.1, which are associated with the non-pluriactive farms, to Group I which is associated with the ON-FARM group).

Table A8.5. The proportion (%) of quadrats in which the sown species was recorded per farm group. The number of quadrats within each farm group are given in Table 8.1.

FARM GROUP	*Dactylis glomerata*	*Lolium multiflorum*	*Lolium perenne*	*Phleum pratense*	*Trifolium repens*
Non-pluriactive	32.2	5.8	97.5	84.6	90.8
OFF-FARM pluriactivity	24.1	1.2	99.4	79.4	98.8
ON-FARM pluriactivity	24.6	3.6	95.5	78.2	96.4
BOTH pluriactivities	17.1	6.2	95.4	79.2	98.1

Given that the ON-FARM group had been associated with the more species-rich swards in the TWINSPAN analyses and the BOTH group with some of the more species-poor swards (Table A8.1), it was surprising that when the mean number of species were considered per quadrat, swards within the ON-FARM group had less species than those within the BOTH group. It is possible that, with the TWINSPAN classification based mainly on the dominant species, the TWINSPAN groups were masking some degree of species heterogeneity between the quadrats, with an overall high number of species occurring less frequently within swards of the ON-FARM group and a smaller number of species occurring more frequently within swards of the BOTH group, i.e. a greater heterogeneity of less species-rich swards in the ON-FARM group and a greater homogeneity of more species-rich swards in the BOTH group.

However, the cumulative number of species with increasing numbers of quadrats[3] suggest that all pluriactive groups have a similar accumulation of species which is greater than that for non-pluriactive farms (Fig. A8.5).

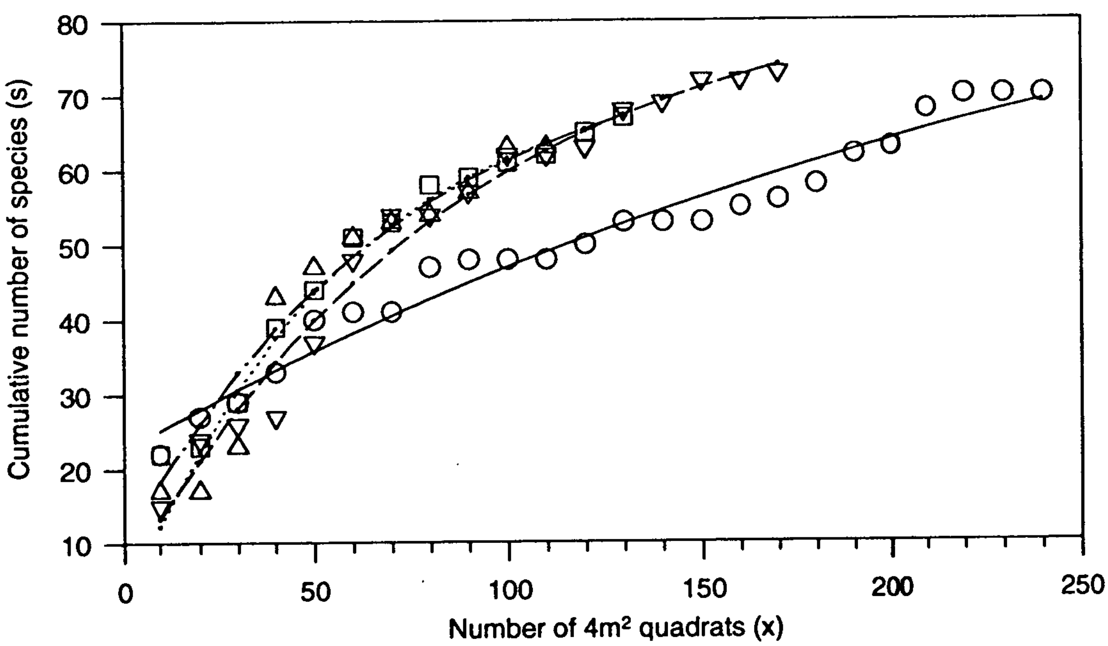


Fig. A8.5. The cumulative number of species (s) with increasing numbers of quadrats (x). Non-pluriactive farms (○, –) (250 quadrats), OFF-FARM pluriactivity (▽, —) (170 quadrats), ON-FARM pluriactivity (△, ···) (110 quadrats), BOTH pluriactivities (□, -·-) (130 quadrats). Non-linear regression curves were fitted using the equation, $s = a + br^x$.

---

[3] the area (in metres) can be obtained by multiplying the number of quadrats by 4. However, *quadrat number* is used in preference to *area* since the quadrat sampling density varied between the farms and quadrats were not contiguous.

The fitted non-linear regression curves also indicate that the overall number of species for a fixed number of quadrats is smallest for the ON-FARM group than the other two pluriactive groups (Table A8.6). However, this extrapolation was based on 110 quadrats for the ON-FARM group in contrast to 170 and 130 quadrats for the OFF-FARM and BOTH groups respectively; the smaller the number of quadrats the greater the likelihood of a greater weight (or 'leverage') being given to fewer points. There is therefore no firm evidence to disprove the assertion that there is a greater heterogeneity of less species-rich swards in the ON-FARM group in comparison to other farm groups.

Table A8.6. The cumulative number of species (s) with increasing numbers of quadrats (x) for each farm group. The fitted non-linear equation was $s = a + br^x$.

FARM GROUP	a ± SE	b ± SE	r	N°. species at x = 240
Non-pluriactive	101.2 ± 17.7	- 78.9 ± 16.4	0.996	70.0
OFF-FARM pluriactivity	85.5 ± 5.6	- 81.0 ± 4.3	0.989	79.8
ON-FARM pluriactivity	74.4 ± 11.1	- 74.0 ± 8.1	0.983	73.2
BOTH pluriactivities	78.4 ± 5.7	- 69.2 ± 4.3	0.986	76.1

The slope of such 'species-area' curves may be taken to indicate the degree of heterogeneity of habitats within a given area (Williams, 1964) or as a function of species immigration and extinction rates - the 'equilibrium theory of island biogeography' (MacArthur and Wilson, 1963, 1967). It seems that both these ideas can be applied here:

(1) that the curves have not levelled off may indicate the heterogeneity of grassland at the regional scale

and (2) immigration of species depends on the availability of species (from field boundaries, headlands *etc.*) with a greater intensity of management the greater the dominance of competitive species excluding other species, resulting in a less steep slope on the curve (e.g. as seen for the non-pluriactive farms).

A8.3 *The 'Quality Composition' of Grass Field Swards*

What were the 'extra' species giving rise to the higher species richness values on the pluriactive farms - weed, semi-natural or bryophyte? The 105 flowering and non-flowering plants identified in the fields were classified into *types* of species ('agriculturally preferred', 'agricultural weeds', 'semi-natural' and bryophytes) using the descriptions in botanical books (e.g. Clapham, Tutin & Warburg, 1981; Fitter, Fitter & Blamey, 1974) and scientific literature (Table A8.7).

Table A8.7. The classification of the 105 field quadrat species into four 'types' using the descriptions found in standard botanical books. Sometimes the category in which to place a species was not clear-cut; for example, a plant described as occurring in 'waysides' (Clapham, Tutin & Warburg, 1981) could either be placed in the 'agricultural weed' or 'semi-natural' category, or a species may be described as occurring in two 'contradictory' categories such as 'meadows, disturbed ground'. In such cases, a consensus was agreed with one or two botanical acquaintances at the Institute of Terrestrial Ecology. This only occurred for a very small number of species. The full list of species within each category is given in Appendix 7A.

- **Agriculturally preferred** species are those encouraged/sown by the farmer - ryegrass (*Lolium* spp.), clover (*Trifolium* spp.), cocksfoot (*Dactylis glomerata*), timothy grass (*Phleum* spp.) *etc.* (Peel & Forbes, 1978; Green, 1982).
- **Agricultural weeds** are not only those species termed 'weed' by Clapham *et al* (1981) but are also defined here as species associated with arable fields, wasteland and neglected or overgrazed pastures, e.g. creeping bent (*Agrostis stolonifera*), mouse-ear (*Cerastium fontanum*), ragworts (*Senecio* spp.), chickweed (*Stellaria media*) *etc.*
- **Semi-natural species** are species considered to belong to semi-natural habitats such as acid grassland, meadows, marshes, woods and hedges, e.g. bent grass (*Agrostis tenuis, A. canina*), yarrow (*Achillea* spp.), fescues (*Festuca rubra, F.ovina*), meadow grasses (*Poa* spp.), most speedwells (*Veronica* spp.) *etc.*
- **Bryophytes** - i.e. all mosses and liverworts. However, their presence could be interpreted in various ways:
(a) in agricultural grass fields bryophytes tend to indicate an open sward canopy caused by cattle hooves, over-grazing or over-cutting ('poaching') especially in autumn when grass growth is not as prolific and the soil is wetter, e.g. *Brachythecium* spp., *Eurynchium* spp., *Lophocolea* spp., whereas
(b) along the field boundary bryophytes can be indicative of semi-natural habitats such as woodland floor, moorland etc., e.g. *Hylocomium splendens, Hypnum cupressiforme, Mnium* spp., *Rhytidiadelphus* spp.

The OFF-FARM group was found to have significantly more semi-natural species than non-pluriactive farms (32% of species recorded in a quadrat would be semi-natural as opposed to 28%), whereas the BOTH group had significantly fewer agriculturally preferred species and significantly more bryophytes. The ON-FARM group had a significantly smaller proportion of agriculturally preferred species with slightly (i.e. non-significant) more occurrences of all types of non-agricultural species (Table A8.8).

Table A8.8. Percentage occurrence of each 'species type' within the field quadrats for each farm group. Figures are means ± SE per quadrat for a farm. The number of farms in each group are given in Table 8.1.

FARM GROUP (df)	Agriculturally preferred	Agricultural weeds	Semi-natural species	Bryophytes
Non-pluriactive	48.5 ± 1.1	17.2 ± 0.9	27.8 ± 0.9	6.5 ± 0.6
OFF-FARM pluriactivity (1,39)	46.8 ± 1.5	15.2 ± 1.1	32.2 ± 1.2*	5.8 ± 0.7
ON-FARM pluriactivity (1,33)	44.0 ± 1.7*	18.2 ± 1.3	30.2 ± 1.2	7.6 ± 0.8
BOTH pluriactivities (1,35)	42.7 ± 1.6**	20.5 ± 1.2	27.5 ± 1.2	9.3 ± 0.7**

*$P<0.05$, **$P<0.01$ level of significance between the non-pluriactive farms and each pluriactive group using a one-way ANOVA and angular transformed data.

As expected from both the multivariate analyses and species richness results, the non-pluriactive farms were maintaining swards consisting mainly of agriculturally-preferred species. The lower proportion of agriculturally preferred species within the ON-FARM group endorses the conclusion that fewer species are sown than within the non-pluriactive farms (as suggested in Tables A8.1 and A8.5). The greater proportion of semi-natural species within the OFF-FARM group, along with the presence of species indicative of poorer drainage, again suggests some form of low-intensity management. The greater proportion of bryophytes within the BOTH group suggests poor grassland management, such as overgrazing (in terms of either numbers of stock and/or grazing period), overcutting or failing to reseed as often as necessary, *etc.*

Again, it is concluded that the type of pluriactivity is associated with factors which over-ride the effect of field use in determining the *type* of species within a sward. But how typical are the species composition characteristics of grasslands in Grampian to the rest of Great Britiain? The life history strategy model of Grime (1974) was used to compare the level of fertility and disturbance of Grampian agricultural grasslands to those in the rest of Britain.

A8.4 *Life History Strategies of Species in Grass Fields*

The proportion of each life history strategy (using Grime, Hodgson & Hunt, 1988) was calculated across all quadrats of each farm group (instead of per quadrat) to ensure the inclusion of scarce species. The life history strategies of individual bryophyte species have not been published, so were excluded from the analyses and proportions were adjusted accordingly. Bryophytes are generally stress-tolerant ruderals (Grime, 1979) so are already recognised as being of significantly greater occurrence within the BOTH group.

About 46% of all species were competitive-ruderal and ruderal, indicating moderate disturbance and high nutrient (low-stress) management regimes across all farm groups, 46% were C-S-R-strategists and only 1-2% of the species within the swards were stress-tolerant. The number of species in each life-history strategy for each pluriactive group were compared to those within non-pluriactive farms using chi-square tests (Appendix 6A-3). Only the BOTH group differed significantly from the non-pluriactive farms with 56% more stress-tolerant ruderal and 37% more stress-tolerant occurrences than expected, and 25% fewer occurrences of competitive species than expected, even with the exclusion of bryophytes from the analyses (Fig. A8.6). Species classified between two life history strategies (e.g. C/CR) were counted as half in each of the two categories (J. Hodgson, *pers. comm.*).

The life history strategy composition in Fig. 8.6 most closely resembles that for grassland in lowland arable areas reported by the Ecological Consequences Of Land Use Change (ECOLUC) survey[4] (UCPE 1990), i.e. the most eutrophic and disturbed of all the four landscape types identified by ITE (see Fig. 3.1). That the proportion of ruderals were as high as those in arable areas for each farm group suggests that vegetation disturbance is particularly high in Grampian.

[4] the ECOLUC survey of grassland vegetation in lowland arable areas revealed: C=7, CR=26, R=20, CSR=40, SC=1, S=3 and SR=0. In comparison, lowland grassland areas revealed: C=7, CR= 22, R=17, CSR=43, SC=3, S=6, SR=3.

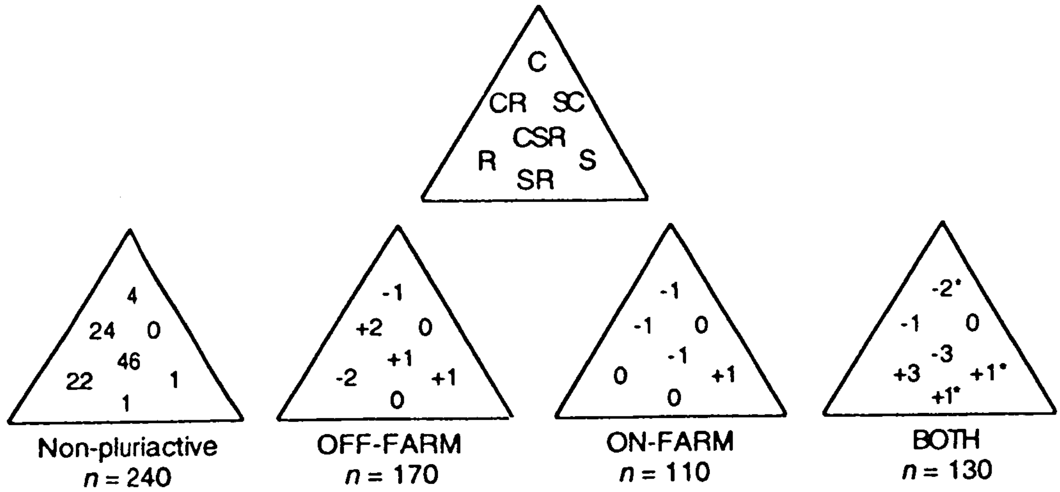


Fig. A8.6. The proportion of each life history strategy (*sensu* Grime, 1974) for *n* quadrats within each farm group. Figures for the non-pluriactive farms are percentages of vascular species; the differences from these are shown for each pluriactive group. A small number of species are not classified in Grime, Hodgson & Hunt (1988) so that figures do not add upto 100% (see Appendix 7A). C = competitive species, S = stress-tolerant species, R = ruderal species, CR = competitive ruderals, SR = stress-tolerant ruderals, SC = stress-tolerant competitors, CSR = C-S-R strategists. The definitions of each strategy were given in Chapter 1. *P<0.05 level of significance in species counts between the non-pluriactive farms and the pluriactive group using chi-square tests (Appendix 6A-3). Due to very low frequencies, SC strategists were excluded from the chi-square analyses.

In comparison to grasslands within the rest of Britain, swards in:

- non-pluriactive farms indicate low nutrient-stress and high disturbance;
- the OFF-FARM group indicate low nutrient-stress and moderate disturbance;
- the ON-FARM group indicate moderate nutrient-stress and high disturbance;
- the BOTH group indicate moderate nutrient-stress and very high disturbance.

A8.5 *The Distribution of Species in Grass Fields over the Farm*

The varying species richness between field uses (Fig. A8.4) indicated that the species distribution over a farm was not homogeneous. As well as this variation, it was possible that fields nearer to a pluriactive farm steading might continue to be managed at a level of intensity at or close to that of non-pluriactive farms whereas fields furthest from the steading might receive less management; Baudry (1989) noted that in the north-west of France the application of inorganic nitrogen and the proportion of meadows grazed declined with increasing distance from the farm steading. From Grime's (1979) 'hump-backed' model, this would mean that species richness would increase with distance from the steading, even between fields used for the same purpose.

Transects were not laid across the farm sites so that it was not possible to measure along a distance gradient to quantify species turnover. Therefore change is assessed using a measure which quantifies the degree to which the species richness varied over a farm, i.e. Whittaker's (1960) '*β-diversity*'. Whittaker's (1960) '*β-diversity*' considers the ratio of the total number of species represented in the samples (termed '*γ-diversity*') to the mean number of species per sample (termed '*α-diversity*') (Whittaker, 1972, 1977):

$\beta = \gamma / \alpha$	γ =	the number of species occurring at least once within the ten quadrats[5]
	α =	the mean number of species per quadrat per farm (i.e. species 'richness')

Even when an environmental gradient (usually assumed with other β-diversity measures) is not apparent, Whittaker's β index has been evaluated as being most efficient with presence-absence data (Wilson & Shmida, 1984).

A β-diversity of 1 indicates complete homogeneity of species distribution, higher ratios indicate greater degrees of heterogeneity although the magnitude of the ratio depends upon sample size (Whittaker, 1972). To account for variations in the sample sizes per farm group, mean β indices were therefore compared (Table A8.9). With the number of species varying from 9 to 34 per farm (the γ-diversities) and mean quadrat values between 4 and 11 (the α-diversities), the range of β-diversities may have been 1.0-8.5. This suggests that the values in Table A8.8 are low, i.e. that the distributions of species over grasslands were similarly heterogeneous. For any farm group, differences in levels of management were therefore generalised over a farm and not localised.

[5] Gamma (γ) diversity usually relates to landscape diversity but can relate to a set of samples including more than one kind of community (Whittaker, 1972, 1977); here it is taken to be the grassland area of a farm.

Table A8.9. The mean β-diversity for each farm group.

FARM GROUP	mean ± SE
Non-pluriactive	2.7 ± 0.1
OFF-FARM pluriactivity	2.6 ± 0.1^{NS}
ON-FARM pluriactivity	2.5 ± 0.1^{NS}
BOTH pluriactivities	2.6 ± 0.1^{NS}

NS - no significant difference between the non-pluriactive farms and the pluriactive group using a one-way ANOVA.

A8.6 *Summarising the Grass Field Sward Characteristics in Grampian*

Pluriactive farms generally have upto five more non-sown species per 4m^2 of grass field than non-pluriactive farms. However, at the national level, species richness is relatively low due to the highly fertile and moderate-to-high disturbance regimes on these farms. This is emphasised when the mean number of species per 4m^2 obtained for each ITE Land Class in this survey is compared to that obtained at the national level during the ITE 'Countryside Survey' in 1990 (see Barr *et al*, 1993) (Table A8.10).

Table A8.10. The mean number of species recorded within 2 x 2m nested quadrats of the 14 x 14m quadrats used in the ITE 'Countryside Survey' in 1990 ('CS90') (see Barr *et al*, 1993) for grasslands in the ITE Land Classes 25, 26, 27 and 28 (Hallam, *pers. comm.*). These are compared to the mean number of species recorded in the 2 x 2m quadrats placed in grass fields in the Grampian survey for the same land classes.

	All species recorded in the CS90 survey	Species consistently recorded in the CS90 survey (reported in Barr *et al*, 1993)	Grampian field survey
ITE Land Class	Mean ± SE	Mean ± SE	Mean ± SE
25	8.4 ± 0.7	6.7 ± 0.6	6.6 ± 0.2
26	9.6 ± 1.3	8.7 ± 1.1	7.6 ± 0.2
27	11.8 ± 1.0	9.4 ± 0.9	7.5 ± 0.2
28	11.0 ± 1.9	9.0 ± 1.6	8.5 ± 0.3

The number and type of species in swards were found to be characteristic of each farm group (pictorially represented in Fig. A8.7). Causative factors, other than field use, were associated with the type of pluriactivity. This is summarised in Table A8.11.

Non-pluriactive farms
Dactylis glomerata
Lolium perenne
Phleum pratense
Trifolium repens

OFF-FARM pluriactivity
Galium saxatile
Lolium perenne
Prunella vulgaris
Trifolium repens
Ranunculus repens

ON-FARM pluriactivity
Agrostis tenuis
Holcus lanatus
Lolium perenne
Trifolium repens
Veronica serpyllifolia

BOTH pluriactivities
Eurynchium spp.
Lolium perenne
Matricaria matricaroides
Phleum pratense
Trifolium repens

Fig. A8.7. Pictorial presentation of species in the field swards of each farm group. This is highly figurative since cutting regimes were maintaining homogeneous short swards.

Table A8.11. A summary of the grass sward characteristics of the open field for each farm group.

FARM GROUP	Dominant species (>20%)	N°. species ($4m^2$)	Associated type of non-sown species	% non-sown species recorded (quadrat)	Difference in life history strategy composition from non-pluriactive farms C	CR	R	S	Ecological interpretation and presumed level of land management at the national scale (comparisons to non-pluriactive farms)
Non-pluriactive	*Dactylis glomerata, Lolium spp., Phleum pratense, Trifolium repens*	4-8	-	51.5	4%	24%	22%	1%	Few non-sown species present in the sward. "Low nutrient stress, high disturbance"
OFF-FARM pluriactivity	*Lolium perenne, Trifolium repens*	7-11	Semi-natural*	53.2	-1	+2	-2	+1	A greater frequency and type of semi-natural species suggests more permanent, wetter pasture. "Low nutrient stress, moderate disturbance"
ON-FARM pluriactivity	*Agrostis tenuis, Holcus lanatus, Lolium perenne, Trifolium repens*	5-10	Together*: weeds, semi-natural, bryophytes	56.0	-1	-1	0	+1	2% fewer C+CR strategists and 1% more S strategists suggest slightly higher nutrient-stress. "Moderate nutrient-stress, high disturbance"
BOTH pluriactivities	*Lolium perenne, Phleum pratense, Trifolium repens*	7-11	Bryophytes**	57.3	-2	-1	+3	+1*	Significantly more S & SR strategists, 3% more R species, i.e. greater frequencies of bryophytes (and weeds) indicate "moderate nutrient-stress, very high disturbance = poor management"

*P<0.05, **P<0.01 level of significant increase from non-pluriactive farms within the pluriactive group.

Section B. Species Characteristics Along Grass Field Boundaries

B8.1 *Vegetation Groups along Grass Field Boundaries*

When the boundary vegetation data was analysed by TWINSPAN, four vegetation groups were defined at the second division. However, the last two groups had little to distinguish them so were amalgamated (Table B8.1).

Table B8.1. The three grassland vegetation groups defined by TWINSPAN using 325 boundary plot data. The number of plots that fell within each group are shown in brackets.

TWINSPAN group	Species cover: Dominant >20%	Species cover: Can occur at >10%	Species cover: Constant but sparse
Ba (25)	*Agrostis tenuis**, *Holcus lanatus* *Ulex europaeus*	*Anthoxanthum odoratum*	*Cerastium fontanum*, *Galium saxatile*
Bb (147)	*Agrostis tenuis*, *Dactylis glomerata*, *Festuca rubra*, *Lolium perenne**, *Poa annua*, *Trifolium repens*	*Holcus mollis*	*C. fontanum*, *H. mollis*, *Phleum pratense*, *Ranunculus repens*, *Rumex acetosa*
Bc (153)	*D. glomerata**, *F. rubra**, *H. mollis*, *L. perenne*	*A. stolonifera*, *Arrhenatherum elatius*, *Cirsium arvense*, *Elymus repens*, *R. obtusifolius*, *Urtica dioica*	*P. annua*, *R. repens*

* the constant dominant in the group which can cover upto 100%.

TWINSPAN group Ba was distinguished by the presence of gorse (*U. europaeus*) and accounted for only 8% of the boundary plots. Occasional species within the group were typical of drier and more upland grasslands; for example, *Campanula rotundifolia* and *Hypochoeris/Leontodon* spp. No corresponding grassland community was found in the National Vegetation Classification (Rodwell, 1992).

TWINSPAN groups Bb and Bc, however, contained vegetation similar to that within the field. Group Bb often appeared to be a part of the open field rather than a distinct (such as raised) field margin and was most like the mesotrophic grassland MG7 '*Lolium perenne-Poa pratensis*' with *L. perenne* and *D. glomerata* dominating, despite lacking *Poa pratensis* (Rodwell, 1992). However, Group Bc was 'cloddy and clumpy', tending to have a broken cover within which weeds were able to dominate, and most resembled the MG1 '*Arrhenatherum elatius*' grassland, *Festuca rubra* subcommunity (*A. elatius* as a non-dominant), one of the poorest British *Arrhenathereta* (Rodwell, 1992).

Using chi-square analyses, no boundary vegetation group was found to be associated with any farm group, field use or even type of boundary ($P>0.05$, df=6 and 10, Appendices 6B-2,3,4). However, these groups were defined primarily on the type of dominant species so that it was feasible that the number of species (the 'species richness') within the vegetation varied between the farm groups as seen within the field swards.

B8.2 *Species Richness along Grass Field Boundaries*

When the mean number of species per plot were compared between field use and farm group, similar trends to the open field were found. Although the order of decreasing values did not follow the same pattern of field uses as the open field, there were similarities in the order of values among the farm groups (Fig. B8.1).

The most significant observations are:

(1) non-pluriactive farms generally had lower values than pluriactive farms, typically 10-17 species per $10m^2$. The exceptions were for fields used for sheep+cattle, cattle and one-cut where the non-pluriactive farms had similar values to the OFF-FARM and BOTH groups, the ON-FARM group having the lowest values at 9-11 species per $10m^2$ - an identical trend to the open field, except more significant;

(2) the OFF-FARM and BOTH groups typically had 14-19 per $10m^2$, but were not consistently the greatest values unlike the trend seen within the open field;

(3) of the pluriactive groups, the ON-FARM group had the lowest values

for seven of the nine field uses which was consistent with the trend seen in the open field;

(4) the ON-FARM group had the greatest range, typically 9-21 species per $10m^2$, again consistent with the trend seen in the open field.

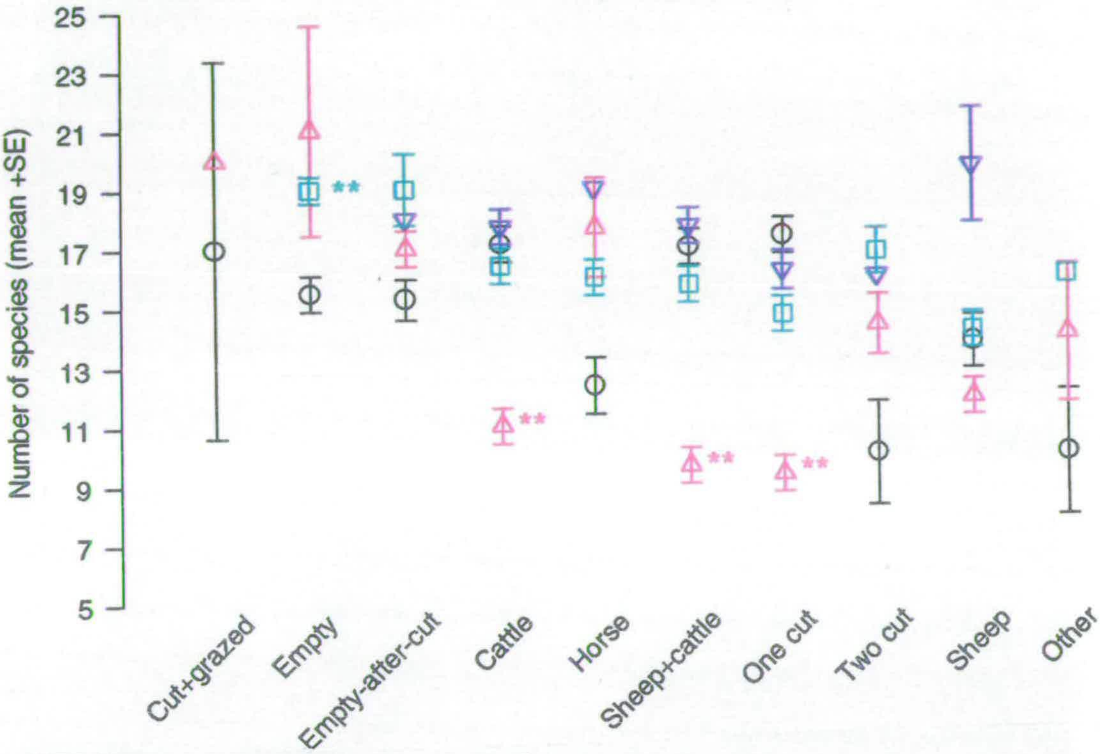


Fig. B8.1. Mean species richness per $10m^2$ grass field boundary plot for various field uses and each farm group. Non-pluriactive farms (○), OFF-FARM pluriactivity (▽), ON-FARM pluriactivity (△), BOTH types of pluriactivity (□). Bars indicate SE about the mean. *P<0.05, **P<0.01 level of significance between the non-pluriactive farms and the pluriactive group using a one-way ANOVA. The number of plots within each field use are given in Table 8.2.

This indicated that factors associated with the type of pluriactivity which determine the species richness of vegetation have a knock-on effect along the field boundary. However, these factors are less influential along the edges of fields. With species richness values similar to the field values for field uses associated with cattle within the ON-FARM group, it is presumed that this farm group manages such fields upto the boundary. It is not clear why there was a significantly higher value for empty fields within the BOTH group.

B8.3. *The 'Quality Composition' of the Grass Field Boundary Vegetation*

The categorisation of the 175 flowering and non-flowering plants recorded within the boundary plots, by species type and life history strategy, is given in Appendix 7B. The mean frequency of each 'species type' within a plot were calculated per farm in the same way as the field data and each pluriactive group compared to the non-pluriactive farms.

The BOTH group had significantly more occurrences of bryophytes within their vegetation, consistent with the trend seen within the open field. No other pluriactive group varied significantly from the non-pluriactive farms although there was a slight indication that the non-pluriactive farms had greater frequencies of agriculturally preferred species (by 1-2% per plot) and fewer occurrences of semi-natural species (by 1-3% per plot) (Table B8.1). It is tempting to conclude that the lack of statistical differences is the result of a relatively small sample but standard errors are similar in magnitude to those for the field data. It is therefore reasonable to conclude that the type of species within field boundary vegetation is relatively similar between farm groups.

Table B8.1. Percentage occurrence of each 'species type' within the boundary plots for each farm group. Figures are means ± SE per plot for a farm. The number of farms in each group are given in Table 8.1.

FARM GROUP	Agriculturally preferred	Agricultural weeds	Semi-natural species	Bryophytes
Non-pluriactive	23.1 ± 0.9	34.4 ± 1.1	38.6 ± 1.4	3.8 ± 0.4
OFF-FARM pluriactivity	21.6 ± 1.0	32.6 ± 1.2	41.2 ± 1.3	4.6 ± 0.7
ON-FARM pluriactivity	21.4 ± 1.4	33.5 ± 1.9	41.4 ± 1.8	3.7 ± 0.7
BOTH pluriactivities	20.2 ± 1.4	34.4 ± 1.6	38.6 ± 1.4	6.9 ± 0.9**

**$P<0.01$ level of significance between the non-pluriactive farms and the pluriactive group using a one-way ANOVA and angular transformed data.

All agriculturally preferred species recorded in the field were recorded along the field boundary although the number of recorded weeds increased by 32%, semi-natural species by 91% and bryophytes by 27% (Table B8.2).

Table B8.2. The number of species within grass fields and within the boundary vegetation and the proportion (%) of their occurrences, categorised by 'species type' (see Table A8.6). The list of species within each category are given in Appendix 7B.

Species type	Open field (650 2x2m² quadrats)		Boundary vegetation (325 1x10m² plots)		% difference*
	N°	%	N°	%	
Agriculturally preferred	6	5.7	6	3.4	0
Agricultural weeds	30	28.6	44	25.1	31.8
Semi-natural species	58	55.2	111	63.4	91.3
Bryophytes	11	10.5	14	8.0	27.3
Total	105	100	175	100	

* difference/field value x 100/1

All weeds recorded in the field were recorded along the boundary although seven of the semi-natural species recorded in the field were unique to the field[6]. This suggests that, although the boundary appears to be an important reserve of species for the field, species were still immigrating from the beyond the field boundary.

B8.4 *Life History Strategies of Sward Constituents along Grass Field Boundaries*

With small variation in the species composition along the field boundaries between the farm groups, little difference in their life history strategy composition was expected. The proportion of each life history strategy was calculated in the same way as the field data. Only the OFF-FARM group significantly differed from the non-pluriactive farms by having significantly fewer ($P<0.05$) occurrences of competitive species despite the overall proportion of these species being identical (Fig. B8.2, Appendix 6B-5).

[6] *Carex nigra, Carex ovalis, Erodium cicutarium, Glyceria declinata, Hypericum perforatum, Juncus bulbosus, Medicago lupulina.*

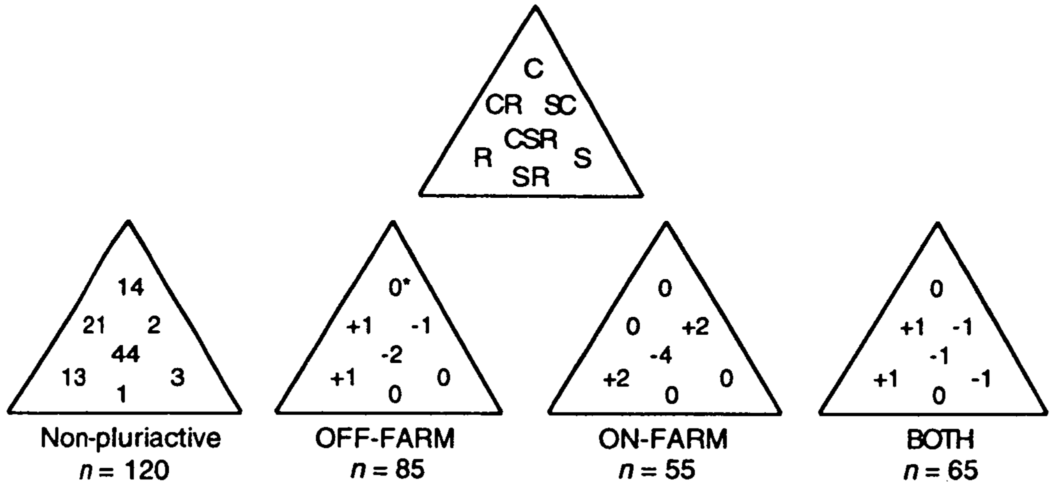


Fig. B8.2. The proportion (%) of each life history strategy (*sensu* Grime, 1974) for *n* boundary plots within each farm group. Figures for the non-pluriactive farms are percentages of vascular species; the differences from these are shown for each pluriactive group. A small number of species are not classified in Grime *et al* (1988) so that figures do not add up to 100% (see Appendix 7B). C = competitive species, S = stress-tolerant species, R = ruderal species, CR = competitive ruderals, SR = stress-tolerant ruderals, CS = stress-tolerant competitors, CSR = C-S-R strategists. The definitions for each strategy were given in Chapter 1. **P*<0.05 level of significance between the non-pluriactive farms and the pluriactive group using a chi-square test (Appendix 6B-5).

From constituting 2-4% of species in the field, competitive species accounted for 14% of species along the field boundary and the occurrence of ruderal species dropped from 20-25% to 13-15% indicating highly fertile and undisturbed (uncut, ungrazed, un-reseeded) habitats. According to Grime's (1979) 'hump-backed' model, species richness along the field boundary should therefore be lower than within the field. It was, but only just: 1.55 ± 0.03 species per $1m^2$ was calculated for the boundary vegetation and 1.88 ± 0.03 species per $1m^2$ for the open field (although these figures are derived from samples different in both size and shape and therefore must be viewed with caution).

B8.5 *Summarising the Species Characteristics along Grass Field Boundaries and their Comparison to the Species Characteristics in the Open Field*

Vegetation along field boundaries generally remain distinct from the open field sometimes extending into the field by 0.5-1.0 metres and remaining upto 15cm higher, having been undisturbed by the plough or mower for years. The vegetation would therefore be expected to be less affected by management regimes and to harbour species not seen within the field. It was not surprising then that the field boundary vegetation was similar across all types of farm, field use and boundary. However, it was surprising that there were significantly lower values for species richness in fields associated with cattle within the ON-FARM group which was similar to the trend seen within the open field. This suggested that, in this group of farms, cattle fields are managed more intensively than other field uses which, presumably, includes cutting, grazing and reseeding upto the field boundary.

Although the area surveyed along field boundaries (3250m²) was only 25% greater than the area surveyed within the open field (2600m²), the number of species recorded had increased by 73.4% with at least 70 species not seen within the field. However, as the result of tall 'competitive' grasses dominating the vegetation, the co-existence by other species was much reduced and the species density values were similar to those in the field.

8.1 *Overall Discussion of the Species Characteristics within and along the Boundaries of Grass Fields in Grampian*

The greatest differences between the farm groups were seen within the open field and indicated that the type of pluriactivity was associated with factors which obscured the affect of field use in determining the number and type of species within a sward.

However, most differences were seen within the sward (i.e. at the non-dominant level) with most grass swards being ryegrass-clover dominated, i.e. variations of the mesotrophic grassland MG7 '*Lolium perenne* leys' (Rodwell, 1992). Even where quadrats contained *Agrostis tenuis*, *L. perenne* covered more than 20% of the quadrat so that the third grade *Agrostis*-ryegrass pastures (with *L. perenne* covering 2-15% of the sward recorded in the English and Welsh surveys during the 1930's; Davies, 1941) were not seen.

The increase of *Lolium perenne* has been occurring at a national scale; in south-west England, Peel *et al* (1985) noted that *L. perenne* had increased in extent in swards of all ages from previous recorded levels in 1971-72; for example, from 35% to 51% in swards 5-8 years old, and from 17% to 31% in those aged over 20 years. However, some of the cover characteristics of the dominant constituents of the swards in this study have been lost through taking the default pseudospecies cut levels in the TWINSPAN analyses; for example, what was the mean cover of *L. perenne* in a quadrat for each farm group? More revealing pseudospecies might have been 1-5%, 5-10%, 10-20%, 20-50% and >50 %.

Grampian grasslands are, however, less species-rich than for equivalent grasslands (i.e. in ITE Land Classes 25, 26, 27 and 28) elsewhere in Britain. The ITE Land Classes 25-28 occur north of Northumberland and Cumbria so that latitude is unlikely to be of any great influence. It would seem likely that the relative impoverishment of the Grampian grasslands is therefore possibly due to the intensive management via relatively frequent reseeding, higher levels of nitrogen application, and well-managed cutting and grazing regimes. That agricultural grassland in Grampian region indicates high fertility and disturbance from cutting and grazing was shown by the similarity in the proportion of each life history to those typical of lowland arable areas within Britain (UCPE, 1990). Stress-tolerant species are possibly not frequent within Grampian due to their low powers of dispersal; intensive land management encourages species with good powers of dispersal (Hodgson & Grime, 1990). Species richness values did not reach more than 11 species per $4m^2$, even in hay fields (cf: 'traditional' hay fields with 15-20 species per $0.0625m^2$; Smith & Rushton, 1994).

That non-pluriactive farms had swards containing mainly agriculturally preferred species indicates the efficiency (not just the *intensity*) of full-time farm households over pluriactive (or 'part-time') farm households in the management of their grassland.

The association of 4-8 species per quadrat within non-pluriactive farms and the association of 5-11 species within pluriactive farms indicates that factors associated with pluriactivity could have an important role in slowing down or reversing the management intensity within grasslands in lowland areas over the whole of Britain. The number and type of species in swards of each farm group indicated that differing management characteristics were associated with the different types of pluriactivity.

- The greater occurrence of semi-natural species within the swards of the OFF-FARM group were possibly due to the more permanent nature of the grasslands (see Fig. 7.2a). The DECORANA output revealed significantly more species characteristic of wetter soils in swards of the OFF-FARM group than non-pluriactive farms, presumably permanent grasslands are less well-drained than those used in arable rotation.

- The ON-FARM group had the greatest proportion of fields where no fertiliser had been applied which was associated with dominating grass species indicative of lower-fertility (i.e. *Agrostis* spp. and *Holcus lanatus*) in the TWINSPAN analyses and the significantly lower DECORANA scores along the nutrient axis. However, this farm group also contained fields with the greatest levels of inorganic nitrogen applied and so appear to be targeting the amounts of fertiliser according to the field use (in this case the highest levels of nitrogen applied were associated with two-cut fields). The generally lower species richness is possibly due to the introduction of variants of ryegrass (*L. perenne*) and white clover (*Trifolium repens*) bred for differing uses and therefore planted more often than a general mixture including cocksfoot (*Dactylis glomerata*) and timothy (*Phleum pratense*) like the non-pluriactive group. Cattle and one-cut fields were being used more intensively than other field uses by implication of the lower numbers of species (Grime's, 1979, 'hump-backed model) and that the vegetation along the field boundaries was similar to that in the field. It is possible that these farms are targeting their energies into uses where there are greater economic returns; cattle are more valuable per head than sheep and other livestock (Scottish Agricultural College Management handbook, various years). It is also possible that cattle are grazed and silage cuts are taken only on the younger grass fields, i.e. those straight out of arable rotation.

- In the BOTH group the non-sown species were mainly bryophytes but weeds were noticeably (although not significantly in the analyses) constituting a greater proportion of each quadrat. This indicates mis-management such as over-grazing or poor-reseeding. Bunce and Jenkins (1989) noted that arable weeds were characteristic of short-term grasslands but the proportion of fields in the 1-4 year category (Fig. 7.2b) was least (at 45%) of all farm groups, with almost as many fields in the 5-8 year category. The significant increase in S and SR species suggests that mis-management may be partially explained by the decline in the use of fertiliser, and the notable (although not significant) increase in R species results from over-grazing with poaching and gap creation in the swards. The greater incidence of bryophytes in the BOTH group (within the open field and along the boundaries), however, may have resulted from undertaking the field survey for this group only during 1992 rather than the type of management. Al-Mufti *et al* (1977) noted an association between the appearance of bryophytes and the wetter seasons of autumn and spring; the possibility therefore existed that 1992 was wetter than 1991. Climatic data would need to be obtained from the Meteorological Office to verify this.

As has been made clear throughout this chapter, the non-involvement or type of involvement in pluriactivity is associated with factors which over-ride the impact of field use on the number and type of species occurring in agricultural grass swards. Such factors would immediately affect the species composition through the level of management (see Fig. 1.3). But what determines the level and type of management in these four farm groups? This is now explored in the next chapter.

CHAPTER 9

The Relationship between the Socio-economic Characteristics of the Farm Household, Land Management and the Botanical Richness of Agricultural Grass Swards

Introduction

Certain socio-economic characteristics are associated with the non-involvement or type of involvement in pluriactivity (Chapter 3; Gasson, 1988), and certain grassland management characteristics are associated with each of these farm groups (Chapter 7). More variation was then found in the number and type of botanical species in grass fields between non-pluriactive farms and each pluriactive group than between various field uses within a farm group (Chapter 8). The link between management intensity and botanical richness is defined in Grime's 'hump-backed' model (Fig. 1.5) - in moderately fertile areas, a low botanical richness indicates a greater management intensity and *vice versa.*

Within each farm group, which socio-economic characteristics (which underlie the varying emphases in land management) therefore most affect the botanical richness of grass fields? Within the pluriactive farm groups, does the differing allocation of time (and therefore energy) between farming and non-farming activities also affect the quality and level of land management and therefore botanical richness?

This chapter therefore examines the relationships of socio-economic and time allocation characteristics with the botanical richness of grassland on farms within each farm group (Fig. 9.1). Since, land management and species data were only collected for sixty-five farms (Tables 7.1 and 8.1), the socio-economic characteristics for these farms were selected from the datasets of the seventy-one farms, the summarised data of which is shown in Chapter 4.

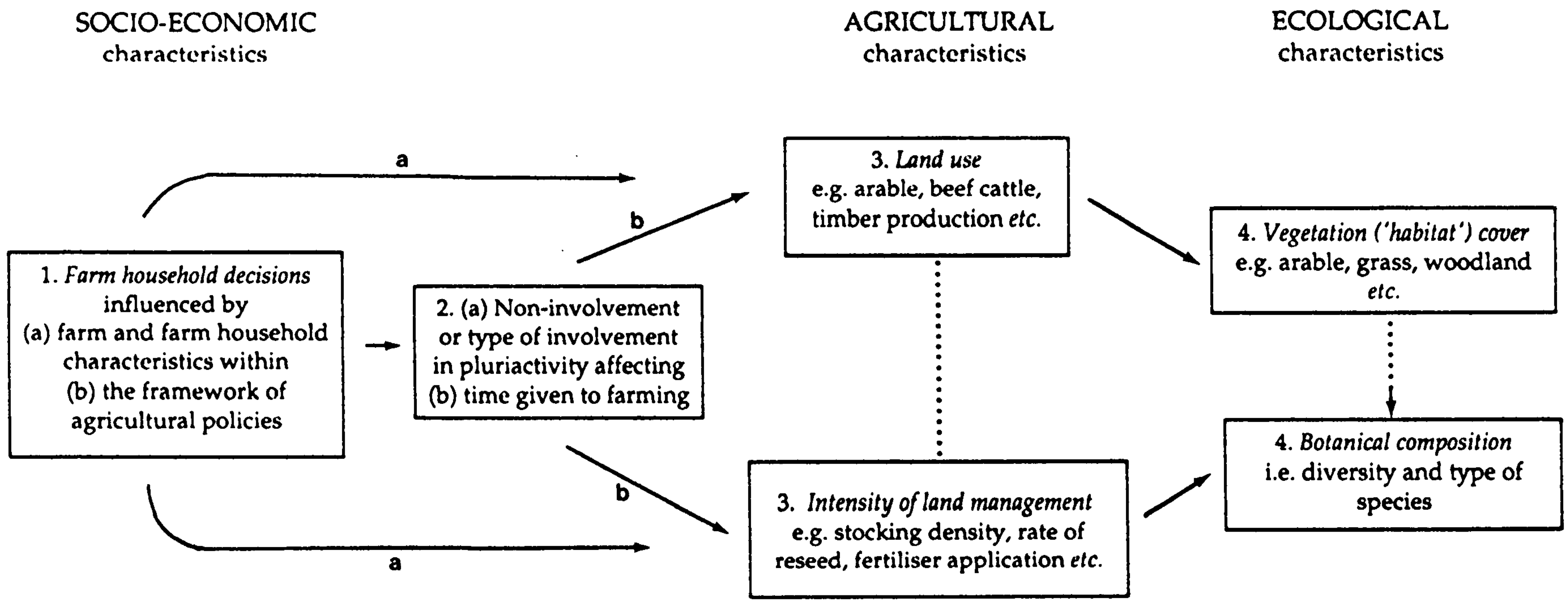


Fig. 9.1. A model of the 'chain of effects' from the socio-economic characteristics of the farm household to farmland vegetation cover and species composition (taken from Fig. 1.3). (a) Are the land management characteristics affected by the socio-economic characteristics of the farm household, and if so, which socio-economic characteristics? (b) Within pluriactive farms, does the differing allocation of time (and therefore energy) between farming and non-farming activities affect the level of management on a farm?

9.1 *Choosing the Most Appropriate Botanical Richness Value*

For each farm, species composition data were collected using ten quadrats. There were, therefore, two levels of botanical richness to consider associating with socio-economic characteristics and time allocation:

(1) the mean number of species per quadrat for a farm, i.e. $4m^2$

or (2) the total number of species found on a farm, i.e. for $40m^2$ of grassland covered by the 10 x $4m^2$ quadrats.

With the socio-economic, time allocation and land management characteristics described in this study at the farm scale, it seemed more reasonable to use the total number of species since this was also at the farm scale. The total number of species per farm varied between 9-34 species, in contrast to mean values of 4-11 species per quadrat (section A8.5), so was also considered to be a more sensitive measure to use.

9.2 *The Allocation of Time between Farming and Non-farming Activities*

Farms require varying inputs of labour according to the mix of crops and livestock. It was therefore not feasible to simply compare the *actual* time given to farming between the farms in order to explain the variations in botanical richness values within a farm group.

Agriculturalists assess the required number of *standard man days*[1] needed to manage a farm using published standard ('theoretical') labour requirements for various crops and livestock per unit area (MAFF, 1980). By comparing the actual time given to managing a farm to that theoretically required would therefore provide some measure of a farm's efficiency (see Gasson, 1988). However, to obtain the required number of standard man days for a farm using the June Census returns (from the Scottish Office) and to calculate the actual standard man days given at the farm (from the socio-economic questionnaire data) would

[1] a *standard man day* represents 8 hours work by an adult male worker under average conditions (MAFF, 1980).

have been unreasonably time-consuming.

The proportion of time allocated between farming/non-farming activities had been obtained directly from the farm household during the socio-economic survey interview. Although the allocation of time given to farming may change on a farm with the uptake of pluriactivity, the overall number of hours given to farming within the week may not change. Therefore the proportion of time given to farming may have little relation to actual farming time. However, there were significant differences in time allocation between the non-pluriactive farms and each pluriactive group (Table 9.1).

Table 9.1. The proportion (%) of time allocated to various activities within the week by the farm household (mean ± SE). The overall time (i.e. the 100%) is taken as the total number of hours reported to be worked by the farm household within a given week.

	% of time given to:		
FARM GROUP	Farming	Non-agricultural activities on the farm	Activities off the farm
Non-pluriactive farms	94.8 ± 2.4	0.3 ± 0.3	5.0 ± 2.4
OFF-FARM pluriactivity	61.9 ± 5.2**	0.7 ± 0.8	37.3 ± 5.0**
ON-FARM pluriactivity	81.8 ± 6.1*	16.1 ± 6.3**	2.1 ± 1.9
BOTH pluriactivities	43.7 ± 6.5**	12.6 ± 3.6**	43.7 ± 6.8**

*$P<0.05$, **$P<0.01$ level of significance between the non-pluriactive farms and the pluriactive group using a one-way ANOVA and angular transformed data.

All pluriactive groups allocated proportionally less time to farming activities per week than non-pluriactive farms. Off-farm activities accounted for more than double the time allocated to on-farm non-agricultural activities. As might have been expected, the BOTH group therefore gave the least proportion of time to farming - less than half the week. Proportional time given to farming was therefore a convenient (if not completely accurate) measure of time to use.

It was also possible to calculate the *actual* number of hours worked on a farm per vegetated area, i.e. excluding the area of buildings and roads. The number of hours worked by the farm household and employees was obtained from the socio-economic questionnaire and the hectarage of the farm from the field survey Arc/Info database. The area of grassland was not used (although it was the botanical richness of such that was to be accounted for) because the number of hours worked given in the socio-economic questionnaire was for the whole farm.

Although there was no significant difference between the mean number of hours worked per hectare of vegetation a week on a non-pluriactive farm compared to any pluriactive group, the range in values for the BOTH group revealed that these farms tended to afford a third less time to management than non-pluriactive farms (Table 9.2). Although the median value for the ON-FARM group was similar to that for non-pluriactive farms, the range in values indicates that this group could spend upto twice the time managing the land.

Table 9.2. The number of hours worked per hectare of a farm's vegetated area within a week by household members[a] and employees for each farm group (using the socio-economic survey data summarised in Tables 4.8 and 4.10, and the mean vegetated area of a farm obtained from the Arc/Info database which was usually the same as the recorded farm areas summarised in Table 4.4, although ten of the 65 farms had vegetated areas 1-6 hectares less than the total farm area).

FARM GROUP	Lower IQ	Median	Upper IQ
Non-pluriactive	0.75	1.13	1.72
OFF-FARM pluriactivity	0.94	1.08^{NS}	1.73
ON-FARM pluriactivity	0.65	1.10^{NS}	3.49
BOTH pluriactivities	0.56	0.76^{NS}	1.60

[a] the number of household members included all those over the age of 17 so may have over-estimated the number of hours per hectare within the OFF-FARM and BOTH groups where family members work wholly off the farm.
NS = no significant difference between the non-pluriactive farms and the pluriactive group using a one-way ANOVA and $\log_{(e)}$ transformed data.

9.3 *Selected Socio-economic and Land Management Variables*

Most of the socio-economic factors presented in Chapter 4 were used to account for the variation in the botanical richness values of grassland between farms. Discontinuous data (such as whether a farmer possessed a tertiary qualification and the type of tenancy) were not included. Selected land use and management factors presented in Chapter 7 were also used since the actual management is the outcome of the socio-economic characteristics and decision-making processes of the household upon the land. Land use/management factors which were collected as categories of data were converted into continuous variables; for example, when dealing with the rate of nitrogen application, the proportion of fields which had the lowest rate of nitrogen application on a farm were used (the lowest rate was taken since this was recorded on every farm whereas the higher rates were not).

The selected socio-economic and land management variables together with time allocation are listed in Table 9.3. Corresponding characteristics, such as the proportion of income gained from farming and that gained from pluriactivity, are represented by the farming component only.

Table 9.3. The socio-economic, time allocation and land management variables used to account for the variance in the botanical richness of grass fields for each farm group. Summary statistics for the socio-economic factors are given in Chapter 4, the proportion of farming time in Table 9.1 and hours per hectare in Table 9.2, the land management factors in Chapter 7 and the area of grass in Chapter 8.

SOCIO-ECONOMIC	TIME ALLOCATION
● age of the farmer	● no. of hours per hectare[a]
● mean age of the household	● % time given to farming per week[a]
● no. of household members	
● no. of children <17 years old	LAND MANAGEMENT
● mean income of the household	● the area of grass (hectares)
● % of income from farming	● % of fields with livestock
● no. of earners in the household	● % of fields with cattle
● British Size Unit (BSU) of the farm	● % of fields with sheep
● no. of employees	● % of fields reseeded <4 years ago
	● % of fields with 1-125 kg N/ha

[a] unlike the management variables listed these are of the whole farm area and not just the grassland cover.

9.4 *Determining the Relationships between the Selected Variables and the Botanical Richness of Grassland on a Farm*

Regression models are used to explain the variation in dependent (or 'y') variables upon a set of independent variables (which may be called 'explanatory' or 'x' variables). Unless the data come from carefully controlled experiments with adequate randomisation, however, the outcome of regression models cannot be assumed to outline causal relationships between the y and x variables (Mead & Curnow, 1983). The terms 'y' and 'x' variables are therefore referred to in this study in preference to 'dependent' and 'independent' variables. The botanical richness of a farm is therefore the y variable whilst the socio-economic, land management and time allocation variables (listed in Table 9.3) are the x variables.

Inter-dependence may occur between x variables in survey data. Correlations between all the variables listed in Table 9.3 are presented in Appendix 8 for each farm group. Multiple regression techniques are therefore considered superior to other statistical techniques in determining the influence of the x variables on the y variable since they take account of these correlations by considering combinations of x variables (Mead & Curnow, 1983). When multiple regressions are used to explore the relationship between variables, rather than to derive a predictive equation for the dependent variables, step-wise regressions are usually preferred (Grieg-Smith, 1983). Since step-wise regressions were chosen for this analysis, regression equations are not presented.

Files containing the variables listed in Table 9.3 for the 65 farms were therefore read into GENSTAT (Payne *et al*, 1987) and step-wise regressions were performed against the 65 values of botanical richness per farm for each farm group separately. The step-wise regression analysis selects a single x variable which gives the best fit (i.e. the variable which gives the most reduction in the residual sum of squares along the regression line) and then the best combination of a second x variable with this one is selected. Further x variables are added to the regression equation until the proportion of the variance of the dependent variable accounted for is considered adequate. The GENSTAT step-wise regression also tests the set of x variables at each step to see if any variable can be eliminated (i.e. to obtain the best combination of x variables with the smallest residual sum of squares) which is not always included in other statistical programs.

Although regression analyses indicate the combination of factors most associated with the variation in botanical richness they do not indicate the strength of associations between each x variable and the y variable. Correlations were therefore also examined between the variables listed in Table 9.3 and the 65 values of botanical richness, each farm group separately. Like step-wise regression analyses, however, correlations cannot be used for predictive purposes (Whittaker, 1972).

9.5 *The Results of the Regression Analyses*

Within the non-pluriactive farms botanical richness was most accounted for by land management factors which together accounted for 39% of the variance (Table 9.4). The number of employees together with the age of the farmer only increased the proportion of variance explained by 6% so that less than half the variance of botanical richness was explained using the variables listed in Table 9.3.

In contrast, nearly half of the botanical richness within the OFF-FARM group was accounted for by one variable - the proportion of time given to farming. The proportion of time given to farming in this group corresponded to the proportion of time spent away from the farm (Table 9.1). The number of children accounted for an extra 12% of the variability in botanical richness. All other factors increased the accountability of the botanical richness by 2-3% increments. The allocation of time given to farming therefore appeared to be of greatest importance to the botanical richness in the OFF-FARM group along with the number of children in the household. Land management characteristics accounted for only 8% of the variation in botanical richness.

Table 9.4. The results of the step-wise regression analysis for each farm group using GENSTAT 5 (Payne *et al*, 1987). The regression analysis was used to select the socio-economic, time allocation and land management factors which would most account for the botanical diversity in the grass fields. Correlations between the variables used in these analyses are presented in Appendix 8 for each farm group.

FARM GROUP	Variables	%	Variance ratio (df)	Probability level
Non-pluriactive	% of fields reseeded <4 years ago	26.3	8.85 (1, 21)	P<0.01
	no. of hours per hectare	31.4	6.02 (2, 20)	P<0.01
	% of fields with livestock	39.1	5.71 (3,19)	P<0.01
	no. of employees	42.3	5.03 (4,18)	P<0.01
	age of the farmer	45.3	4.65 (5,17)	P<0.01
OFF-FARM pluriactivity	% time given to farming per week	47.0	15.18 (1,15)	P<0.01
	no. of children <17 years old	59.2	12.59 (2,14)	P<0.01
	% of fields with 1-125 kg N/ha	64.4	10.67 (3,13)	P<0.01
	% of income from farming	66.8	9.07 (4,12)	P<0.01
	mean income of the household	67.7	7.70 (5,11)	P<0.01
	% of fields with cattle	70.0	7.21 (6,10)	P<0.01
	mean age of the household	72.7	7.09 (7,9)	P<0.01
	% of fields with livestock	74.9	6.94 (8,8)	P<0.01
ON-FARM pluriactivity	no. of employees	37.5	7.00 (1,9)	P<0.05
	% of income from farming	42.2	4.66 (2,8)	NS
	no. of children <17 years old	59.2	5.92 (3,7)	P<0.05
	% time given to farming per week	68.8	6.52 (4,6)	P<0.05
	% of fields with cattle	84.2	11.63 (5,5)	P<0.01
	% of fields with 1-125 kg N/ha	92.6	21.88 (6,4)	P<0.01
	% of fields reseeded <4 years ago	99.4	221.30 (7,3)	P<0.01
	mean age of the household	99.6	340.97 (8,2)	P<0.01
BOTH pluriactivities	no. of employees	18.2	3.44 (1,10)	P<0.05
	% of fields with cattle	18.5	2.29 (2,9)	NS
	no. of earners in the household	36.3	3.09 (3,8)	NS
	British Size Unit (BSU) of the farm	59.4	5.03 (4,7)	NS
	% of fields reseeded <4 years ago	90.0	20.71 (5,6)	P<0.01
	no. of hours per hectare	91.4	20.55 (6,5)	P<0.01
	% of fields with 1-125 kg N/ha	91.8	18.52 (7,4)	P<0.01
	% of fields with livestock	96.9	43.58 (8,3)	P<0.01

% = cumulative percentage of botanical diversity accounted for. df = degrees of freedom.
NS = no significant difference from what chance alone could account for.

Within the ON-FARM group over one-third of the variability in the botanical richness was accounted for by the number of employees alone. However, when combined with the proportion of income from farming the diversity explained was no greater than what chance alone could explain. Only when the number of children in the farm household was included the accountability became significant again. However, in comparison to the OFF-FARM group where the proportion of time given to farming explained 47% of the grassland diversity, upto 10% of the grassland diversity within the ON-FARM group was explained in this way but only in combination with other factors. It was also interesting that the proportion of cattle fields accounted for an additional 16% of botanical diversity in the ON-FARM group after the first four factors, which was a comparatively high increment. Figs. A8.4 and B8.1 showed that, in this farm group, cattle fields contained fewer species. Land management factors together therefore appeared to play a more important role in determining the botanical diversity in the ON-FARM group, particularly the number of employees.

Like the ON-FARM group, the single most important factor associated with the variability in botanical richness within the BOTH group was the number of employees which accounted for 18% of the variation. However, a combination of a number of factors did not significantly account for a greater variation in botanical richness from that caused by chance alone. After incorporating a number of socio-economic factors into the equation, land management factors together accounted for nearly 38% of the botanical diversity which is of similar proportion to that accounted for by land management factors within the non-pluriactive group.

9.6 *The Results of the Correlation Analyses*

Within the non-pluriactive farms only the proportion of young grass was significantly correlated with botanical richness - the greater the area of young grass the lower the botanical richness (Table 9.5).

The OFF-FARM group had the greatest number of significant correlations. An increase in the proportion of farming time was correlated with a decrease in botanical richness, since generally the greater the time given to farming the greater the management intensity which reduces botanical richness. However, an increase in the number of household members was associated with an increase in botanical richness. But why should a larger household have a greater

Table 9.5. Significant correlations between the number of species found within $40m^2$ of grassland per farm (the botanical richness) and socio-economic, time allocation and land management characteristics for each farm group. Correlations between all the variables used (see Table 9.3) are presented in Appendix 8 for each farm group. *n* = the number of farms in the group. Degrees of freedom were taken as *n*-2.

Non-pluriactive farms	(*n* = 24)					
Number of species	A	1.0				
% grass fields reseeded <4 years ago	B	-0.52**	1.0			
OFF-FARM pluriactivity	(*n* = 17)					
Number of species	A	1.0				
% time farming/week	B	-0.71**	1.0			
no. of household members	C	0.65**	-0.53*	1.0		
mean household age	D	-0.55*	0.31	-0.48*	1.0	
no. of earners in household	E	0.54*	-0.56*	0.90***	-0.17	1.0
ON-FARM pluriactivity	(*n* = 11)					
Number of species	A	1.0				
no. of employees	B	-0.66*	1.0			
		A	B	C	D	E
BOTH pluriactivities	(*n* = 13)					
there were no significant correlations						

*$P<0.05$, **$P<0.01$, ***$P<0.001$

number of species within their grass fields? It appears that there was also a strong positive correlation between the number of household members and the number of earners in the household - presumably these workers were working off the farm and not on the farm. In addition, and in contrast to the findings of the EDC (1973), older households were also associated with fewer species, i.e. more intensive management.

Within the ON-FARM group, only the number of employees was significantly correlated with botanical richness, with a greater number of employees associated with fewer species, i.e. a greater level of management intensity.

No significant correlations were seen within the BOTH group.

9.7 *Discussion of the Relationship between Socio-economic, Time Allocation and Land Management Characteristics with respect to the Botanical Richness of Grass Fields*

"Multiple regression analyses have shown that area alone accounts for most of the variation in species numbers on islands. But area itself is correlated with environmental diversity, which exerts a more direct effect on species numbers..." (MacArthur & Wilson, 1967).

The area of grass within these sixty-five farms, however, did not account for any of the variability in botanical richness between farms. Management was therefore over-riding the effect of environmental factors.

"at least in British habitats with a long history of human use, management considerations are much more important than island biogeography phenomena..." (Gibson, 1986; see also Hodgson, 1986).

But how have the socio-economic characteristics of farm households affected the type, quality and level of land management and, therefore, the botanical richness of grass fields in each farm group in Grampian?

The results of the regression analyses were specific to these Grampian farms; for example, for the *eleven* farms within the ON-FARM group *eight* variables were able to account for practically *all* the variability in botanical richness. The identified factors are therefore unlikely to be applicable elsewhere or even within Grampian at another time although the first variable identified by the regression analyses (and, therefore, the correlations) for each farm group may reveal the mechanism bearing upon the management of those grass fields. It is important to remember, however, that such factors do not necessarily indicate causation.

As expected, botanical richness within the non-pluriactive farms was most affected by the land management characteristics particularly, by the frequency of grassland reseeding. However, within the OFF-FARM group the single most important factor accounting for the greatest variability of botanical richness was the proportion of time given to farming, which is linked to the proportion of time working off the farm. Larger, younger households which, by their very nature contained a greater number of wage earners, were associated with greater values of botanical richness because these extra earners were working off the farm rather than on it. From the land use/management questionnaire data, this farm group had the most permanent grassland (see Fig. 7.2a) and just over half the grass fields on these farms were actually grazed by cattle and/or sheep (see Fig. 7.1) despite these farms being categorised as '*mainly* livestock' by the Scottish Office (in contrast to two-thirds of grass fields on non-pluriactive farms also categorised as 'mainly livestock by the Scottish Office). Does this reflect that:

(a) the cost of reseeding grassland and buying and maintaining livestock is more difficult on these small[2] farms

or (b) that there are too few labourers working on the farm?

Although Table 9.2 indicated that the average number of labourers per hectare is slightly less than that on non-pluriactive farms, the average number of labourers per hectare did not account for members that worked only off the farm, so it is possible that the average number of labourers per hectare within the OFF-FARM group is significantly less than that on non-pluriactive farms. Whatever the reasons underlying off-farm work, it can be concluded that an

---

[2] in terms of farm area <u>and</u> farm income (see Tables 4.4, 4.6, 4.7).

increase in the proportion of time worked off-farm in the OFF-FARM group affects land management in the form of less reseeding and/or stocking of grass fields and, consequently, a greater botanical richness.

The number of employees was identified as the single most associated factor with botanical richness in the ON-FARM and BOTH groups, although neither of these groups had more employees per farm than the non-pluriactive farms (Table 4.8). The association of the number of employees with botanical richness was significant within the ON-FARM group but not within the BOTH group, presumably because the BOTH group contained a greater variety of farms in terms of their socio-economic characteristics. However, whilst increasing the number of employees within the ON-FARM group reduced botanical richness, within the BOTH group this tended to increase botanical richness (see Appendix 8). From Chapter 8, it would appear that a lower botanical richness generally within the ON-FARM group is caused by the prevention of non-sown species appearing in the swards - that is, a higher level of management associated with increasing the number of employees on the land. Although analyses in Chapters 7 and 8 indicated that nitrogen application was lower on these farms this was mainly affecting the *type of species*.

In the BOTH group a greater botanical richness in grass fields resulted from the presence of weeds and bryophytes, the presence of which is not associated with a 'level' of management but a poorer 'quality' of management - in reseeding and/or grazing. Clearly the efficiency and expertise of extra farm labourers in land management is important. Gasson (1976) noted that the quality of employees depended on the farmer's own attitudes - whether s/he cared for agricultural expertise or local loyalty in choosing their employees.

Despite there being more farms within the non-pluriactive group than other farm groups within this sample, the non-pluriactive group needed at least five factors to account for the same proportion of variability in botanical richness explained by the first factor within the OFF-FARM group. Similarly, for the same proportion explained by one factor within the ON-FARM group, the non-pluriactive group needed three factors. Are non-pluriactive farms more varied in their approach to land management than the OFF-FARM and ON-FARM groups? The most varied group, however, was the BOTH group where (although there were two more farms within this group than within the ON-FARM group) four factors were needed to account significantly for the variability in botanical richness.

From this study, it is therefore concluded that socio-economic characteristics only appear to affect the type, quality and level of management on pluriactive farms with the largest farm households within the OFF-FARM group and farms within the ON-FARM group with the fewest number of employees associated with greater values of botanical richness. Only within the OFF-FARM group does the allocation of increasingly more time to non-agricultural activities during the week further reduce the level of management, thereby encouraging even greater botanical richness.

However, a number of socio-economic and land management characteristics have been omitted from these analyses; for example, stocking rate, education and farm household attitudes. Forbes *et al* (1980) reported that stocking rate alone accounted for 50-82% of a farm's productivity (higher productivity being associated with a lower botanical richness). Education and attitudes affect the type, quality and level of management but reports so far have been contradictory; Forbes *et al* (1980) noted that productivity was higher with farmers who had completed their education at the age of 16 or over although the EDC (1973) found no relationship between training and productivity. This study has indicated that the ON-FARM group, containing the most educated farmers and households (Tables 3.12 and 4.13), maintained roughly the same low level of botanical richness (i.e. high productivity) as non-pluriactive farms (Fig. A8.4) which were managed by older and less well educated farmers.

CHAPTER 10

Predicting Changes in the Ecological Characteristics of Grampian Farmland

Introduction

Chapters 3 and 4 indicated that a number of economic and household ('social') characteristics were associated with each farm group, e.g. older farm households tended to be non-pluriactive and the youngest pluriactive farm households were involved in on-farm non-agricultural activities (Table 10.1).

Table 10.1. The economic and household characteristics which have been significantly associated with the type of involvement in non-agricultural activities by farm households in this study.

Economic Characteristics	Farm Household Characteristics
BSU (Table 3.5)	Age of the farmer/farm household (Table 3.8)
% weekly income from pluriactivity (Table 3.6)	Number members/children in household (Table 3.9)
Number of employees (Table 9.4)	

It can therefore be concluded that socio-economic characteristics determine the type of involvement in pluriactivity (in agreement with Buttel, 1982, and Gasson, 1983) and that a change in the household managing a farm would be associated with differences in the ecological characteristics through alterations in the land management and time allocation characteristics (Chapter 9).

In this chapter, the socio-economic characteristics of each of the four farm groups are therefore discussed (section 10.1). The land management strategy and farmland ecology characteristics of each farm group are then summarised, bringing together the three levels of the field survey and placing them in context of the socio-economic characteristics (section 10.2).

With no economic model to predict the rate of change in farm occupants between each farm group, only the farm household characteristics provide an opportunity to assess the likely future scenarios in farm structure in the region. Since the death or retirement of the main farmer causes a change in the land manager and possibly a change in land management as well, farmer age is used to predict the rate of change in the farm occupants. The extent of land leaving and entering the management associated with each farm group is therefore tentatively quantified (section 10.3).

Lastly, the present land management strategy of each farm group is used to predict the type of response to policies encouraging further reductions in agricultural productivity (section 10.4).

10.1 *The Four Socio-economic Farm Groups*

The socio-economic characteristics of the non-pluriactive farms in this study are similar to those described in other studies, i.e. the farm business appears to be financially secure (Table 3.5) and the households are significantly older, smaller and less educated than households of pluriactive farms (Tables 3.8, 3.9, 3.12; Buttel, 1982; Gasson, 1983). There is therefore less incentive and less capability to find alternative enterprises on or off the farm.

Economists classify 'part-time' farms by their economic characteristics alone (i.e. whether the farm relies mainly on farming or non-agricultural supplementary income, e.g. OECD, 1978; Gasson, 1988) and tend to steer away from classifications based on "forms of pluriactivity" such as exists in this study (e.g. see Shucksmith *et al*, 1989). However, Munton, Whatmore and Marsden's (1989) classification, based on the economic *strategy* of a farm, recognised three part-time farming groups which appear to correspond to the farm groups identified in this study:

(1) 'survivors through diversification',

(2) 'accumulators'

and (3) 'hobby farms' (i.e. where 90% or more of the business comes from off-farm sources).

Munton *et al*'s 'survivors' appear mainly to correspond to the OFF-FARM group, although with 60.6% of these farms in Grampian having the farmer involved in off-farm work (Table 3.10), some might be classified as 'hobby farms'. However 93.3% of farmers in the BOTH group were involved in some non-agricultural activity and are more likely than the OFF-FARM group to correspond to Munton *et al's* 'hobby farms'. The higher proportion of farmer involvement in the BOTH group may be also due to households within the BOTH group being slightly younger (therefore lacking in older dependants that might work off the farm) and their farmers being slightly more educated than the OFF-FARM group (therefore having greater opportunity to become involved in non-farming work). Munton *et al*'s 'accumulators' appear to correspond to the ON-FARM group where extra income is obtained from 'job-making' rather than 'job-taking' (*sensu* Fuller & Brun, 1988).

The selection of farms for field-survey work from the main socio-economic survey was, however, biased towards older households and smaller farms due to the initial lack of farms to select from (section 4.1). This may have been expected to reveal ecological characteristics more typical of less intensive management than might otherwise be (see EDC, 1973); for example, more extensive grassland and a greater botanical richness. However, the non-pluriactive group had been subjected to the same degree of bias as the OFF-FARM and ON-FARM groups but the field survey work revealed that this group were intensively managing 97% of their land (i.e. as reseeded grass or arable) and had upto six species fewer per $4m^2$ in any grass field than any other farm group. The bias in the land management and ecological characteristics are therefore believed to be minimal.

10.2 *Summarising the Land Management and Farmland Ecology Characteristics of each Farm Group*

The proportion of each SOAFD farm type within each farm group indicated that the varying forms of pluriactivity were associated with differing types of agricultural enterprises; the non-pluriactive and OFF-FARM groups were livestock-orientated and the ON-FARM and BOTH groups were involved in cropping, mainly cereal (Table 3.1). The type of farm enterprise mix is also associated with the way that the farm is managed. Livestock farms tend to be family-run (EDC, 1973; Johnson & Bastiman, 1981) so that with reductions in farm income on these farms might encourage surplus labour to find work off the farm (EDC, 1973). Within the OFF-FARM group the multiple regression analyses identified the proportion of time spent away from the farm by household members as being the single most important factor affecting the botanical richness of grassland. Logically, it might be expected that the arable farms (i.e. the ON-FARM and BOTH groups) rely more on employees than household labour. Although the number of employees per farm did not significantly differ from those on non-pluriactive farms (Table 3.7), the multiple regression analyses identified the number of employees within the ON-FARM and BOTH groups as most affecting botanical richness (although in the correlations this was only significant for the ON-FARM group).

Non-pluriactive farms

Grampian has traditionally been farmed intensively. Because the household members of non-pluriactive farms are older than those within pluriactive farms, the management within non-pluriactive farms probably reveals the intensity to which most farms in the region have farmed (possibly from even before the 1940's) with 97% of the farm area covered by reseeded grass or arable crops. At least half the area of a farm was under grass and just over half of the grass was used intensively for non-suckler beef cattle. The most frequent plant species in the grass fields were agriculturally-preferred, totalling between 4-8 species per $4m^2$ - low in comparison to the average of 6-11 species per $4m^2$ for agricultural grasslands in the Land Classes 25, 26, 27 and 28 for Great Britain (Table A8.10).

These farms tended to reseed nearly 60% of their fields within four years, which reduces the botanical richness in the grass fields over a farm, the extent of 'young' (<4 years old) grass accounting for 26.3% of the variability in the botanical richness between non-pluriactive farms.

The OFF-FARM group

The OFF-FARM group was maintaining roughly the same proportion of grass but slightly less arable than the non-pluriactive farms, and had 7% more un-farmed land. These farms were, however, managing their grass at a lower intensity than non-pluriactive farms; there were significantly fewer fields used for cattle ($P<0.01$), noticeably more fields used for sheep and fewer grass fields used in arable rotation ($P<0.05$). As a result, grass swards had upto six more plant species for any given $4m^2$, which is more comparable to the 6-11 species per $4m^2$ found within agricultural grasslands of Land Classes 25, 26, 27 and 28 for the whole of Great Britain (Table A8.9). A greater botanical richness was associated with increasing proportions of time on the farm, i.e. the greater the proportion of time off-farm, the greater the botanical richness. The multivariate analyses revealed that the non-sown species in the OFF-FARM group were indicative of less efficient soil drainage (which is presumably linked to the greater proportion of permanent grass), and 32% of the grassland species were classified as 'semi-natural' (which was significantly ($P<0.01$) more than the proportion of semi-natural species within swards of non-pluriactive farms).

Using the agricultural June census return data from SOAFD for the farms in the socio-economic project in Scotland (Dent *et al*, 1993), Davies and Dalton (1993b) noted that stocking densities were lower on farms with off-farm work. The higher botanical richness associated with a greater frequency of semi-natural species in grasslands within the OFF-FARM group would support the idea that the OFF-FARM group have lower stocking densities.

The ON-FARM group

This group contained the largest farms with the greatest proportion of arable and the smallest share of land devoted to grass. Eighty-four per cent of the farmers within the ON-FARM group had obtained a tertiary qualification (Table 3.10) which may account for their greater initiative (the level of education of a farmer has been associated with the degree of innovation in other studies, e.g. EDC, 1973; Sinclair, 1983). Although the main arable farm group within Grampian, these farms had not taken up the 'cereal set-aside' scheme, possibly because the financial incentive to set land aside does not, under current circumstances, match that obtained from a good crop, i.e. compare the £80 per acre grant for set-aside land (Harvey & Bell, 1990) to the £120 which might be expected for a good crop of barley from the same area (Coulter, *pers. comm.*). However, land in this group was mainly taken out of farming with 10% covered by trees. Although the data collected by this survey does not conclusively indicate that this has been mainly from the planting of new trees, from observations in the field this seems likely. This has also been recorded by researchers in England:

"The most important factor deciding the scale of tree planting seems to be the farmers' inherent interest in trees which is likely to depend upon his interest in conservation, field sports and aesthetics. The farmers who like trees not only tend to occupy the farms with most cover but also tend to find the most opportunities for planting" (Westmacott & Worthington, 1984).

This group also had the greatest proportion of broadleaf species which have more wildlife conservation interest than coniferous species. It is difficult to know from this study whether the greater extent of broadleaves has arisen purely from an interest in non-agricultural enterprises on the farm (such as increasing the landscape value for the tourist industry or increasing game cover *etc.*), or from a more long-term financial perspective, or from an interest in wildlife conservation (see Westmacott & Worthington, 1984, quote above).

With 1-2 fewer non-sown species for any given $4m^2$ in cattle, sheep+cattle and one-cut fields than those used for other purposes, the ON-FARM group appeared to use these fields most intensively. Apart from cattle, sheep+cattle and one-cut fields, grass fields tended to be upto three species richer per $4m^2$ than those within non-pluriactive farms. It is possible that cattle were only grazed and silage only cut on grass newly reseeded from an arable crop thereby maintaining the low species richness. It is also possible that stocking densities were higher within cattle grazed fields although farmers within this group reported 44% of grass fields to be under-utilised. However, no analyses have been done to see whether the 56% fully-stocked fields correspond specifically to fields used for cattle or silage (one-cuts).

Wells and Sheail (1988) noted that the removal of grazing animals is likely to increase where grasslands become fragmented in an otherwise arable landscape. With scrub covering 2% of farmland within the ON-FARM group (although this was not significantly more than the 0.6% within the non-pluriactive farms) could this be attributed to lower stocking rates and/or the removal of animals altogether in certain areas of these large, arable farms? Although this was not significant, the ON-FARM group had the greatest proportion (8%) of grass fields empty at the time of the survey.

The BOTH group

In terms of the extensive coverage of arable (particularly cereal crops) and poor land maintenance standards (i.e. the presence of weeds and bryophytes within grasslands), farms within the BOTH group are also similar to the hobby farms described by Gasson (1988). Although there was 10% more un-farmed land than within non-pluriactive farms, this figure was 6.8% greater than it might have been due to one farm where the 'set-side' land had not been mown. Of the 2% woodland area the BOTH group had the greatest proportion of coniferous trees of any farm group. Coniferous species provide quicker economic returns than broadleaves but are of less value to wildlife.

Weeds and bryophytes accounted for upto six more species per $4m^2$ within a grass field than non-pluriactive farms. Weeds and bryophytes are indicative of over-grazing, either by over-stocking and/or extending the grazing period into autumn (Jones, 1933; Gibson, Watt & Brown, 1987), as well as of newly-reseeded grasslands (see Bunce & Jenkins, 1989). The farmers reported 40% of grass fields as being under-utilised so that any over-grazing was more likely to have been due to the combination of slightly lower fertiliser application regimes, slightly longer reseed rotations and, possibly, tardiness in moving stock between fields. Some of the weeds may have arisen from poor reseeding.

Synopsis

The purely 'agricultural landscape' developed by non-pluriactive farms is contrasted to that developed by pluriactive farms generally in Fig. 10.1. As changes in farm occupancy occur, the management of the landscape within Grampian will change. At the same time, agricultural policies are encouraging more extensive farming. Which farm group(s) will manage increasingly more of the Grampian countryside, and what will the response of these farms be to policies encouraging more extensive farming?

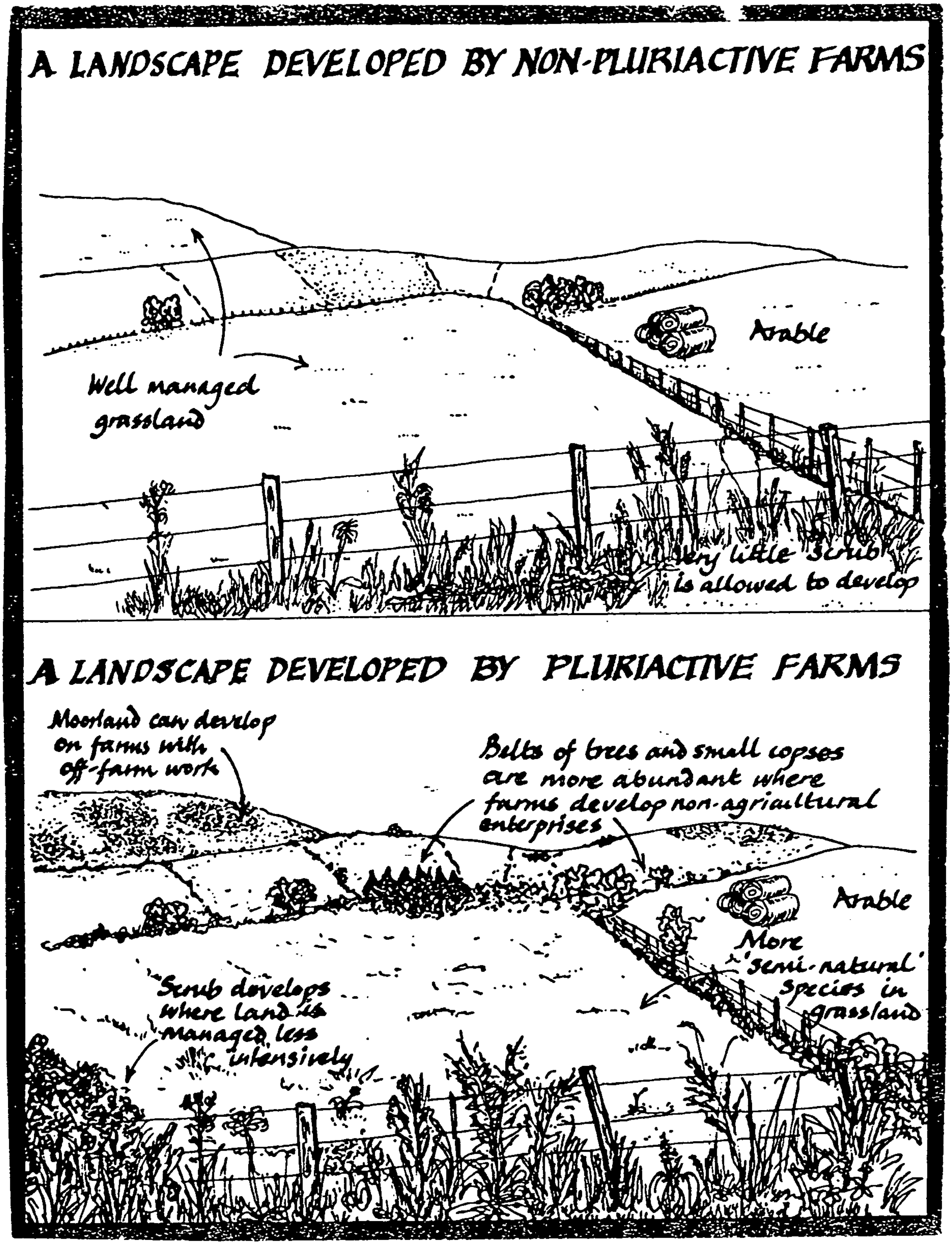


Fig. 10.2. A comparison of landscapes developed by non-pluriactive farms and pluriactive farms. Designed by Noranne Ellis. Drawn by Kate Corcoran.

10.3 *Predicting Future Vegetation Changes resultant from Farm Occupancy Changes*

"Prediction is the essential part of environmental assessment but it is the subject where the risks are greatest. Rural land use changes are rarely explicitly proposed and are largely determined by the advocacy of the national agencies and socio-economic factors" (Bunce & Heal, 1984).

Changes in agricultural policies and in the socio-economic characteristics of the farm households will cause changes in farmland ecology on Grampian farms during the 1990's.

- agricultural policies are presently encouraging less intensive farming practices and their aim is not expected to alter although the form of less intensive management may differ between the farm groups. These are discussed in the next section.
- socio-economic characteristics on a farm may, however, change through a change in farm occupancy either:

    (1) where the farmer is retiring or dies and a new occupier continues the management of the farm (see assumptions below), and/or

    (2) where farms reach a state of economic non-viability and are forced to sell to a new farmer or possibly out of farming.

These farm occupancy changes are discussed in this section.

A number of assumptions need to be made before scenarios of the future of the Grampian countryside can be considered. These are outlined and discussed in Table 10.2.

"Therefore these scenarios are not predictive in the statistical sense, but are rather projections following from a set of assumptions" (Bunce & Jenkins, 1989).

Table 10.2. The list of assumptions used to estimate the change in the proportion of land managed by each group between 1991 and 2001.

a.	*Farmer retirement occurs at 65 years.* Gasson (1966) and the EDC (1973) reported farmers to be reluctant to retire with some farmers continuing farming in their eighties. The oldest farmer within the Grampian field-survey was 82 years old. This assumption may lead to over-estimations in the extent of land leaving the management of a farm group.
b.	*The farmer age in each farm group is normally distributed.* This was found to be true for each farm group in Grampian.
c.	*The proportion of farms where a member of the family is expected to succeed in farming the land occurs as predicted,* i.e. as recorded by the socio-economic survey in 1991. This is unproven although any bias from this assumption may occur either way.
d.	*Family members who take over the management of the farm continue to manage the farm as before.* This is unproven but is used in this study for simplicity. It is feasible that younger members of the household will be better educated and will be possibly more inclined to alter management. This assumption may therefore over-estimate the extent of land remaining under the management of a group.
e.	*The median farm area remains constant.* This is unproven and is difficult to predict without an economic study.
f.	*No farms are assumed to change hands due to economic circumstances* since no economic model exists to indicate otherwise. Yet studies outside Grampian indicate that farmers are 'selling out' (LGC, 1986; Marsden & Symes, 1987; Munton, Whatmore & Marsden, 1989). It could be assumed that the rate of loss from each farm group is constant but, due to differing financial circumstances (see Table 3.5), this would be unlikely.

Using data from the socio-economic study (Dent *et al,* 1993), the average age of non-pluriactive farmers in 1991 indicated that within ten years half might retire and, similarly, about 25% of farmers within the OFF-FARM group. However, within this time period, no farmers within the ON-FARM and BOTH groups are expected to retire. At the same time, over half the farms within the non-pluriactive and OFF-FARM groups expect to be managed by a family member (from Table 3.11). Since it is assumed that succession by a family member would enable the management of a farm to continue unaltered[1], the proportion of farms expected to have family succession was subtracted from the proportion of farms where the farmer would reach 65 years of age by 2001. This produced the proportion of farms which would be 'lost'[2] to a group (Table 10.3).

[1] see Table 10.2.

[2] the term 'lost' is used throughout this chapter to indicate a discontinuation of management from a farm group.

The extent of land managed by each farm group in 1991 had been estimated using the median farm area and the projected number of farms in the region (Table 3.3).

Table 10.3. Farm change by 2001. The average farmer age, number of years for 50% of farmers to become 65 years old from 1991, proportion of farmers to reach 65 years by 2001, the proportion of farms where a family member expects to succeed in managing the farm and the proportion of farms which may be 'lost' from each farm group (socio-economic survey data).

FARM GROUP	median farmer age [a] (IQ range)	no. years for 50% of farmers to become 65 years old from 1991	% of farmers to reach 65 years of age by 2001	% farms where a family member expects to succeed [b]	% farms to be 'lost' from the farm group [c]
Non-pluriactive	56 (49-65)	9	50	55.6	22.2
OFF-FARM pluriactivity	50 (43-56)	15	25	57.2	10.7
ON-FARM pluriactivity	44 (38-54)	21	0	62.1	0
BOTH pluriactivities	48 (39-55)	17	0	67.7	0

[a] farmer age was normally distributed (Table 3.8); [b] from Table 3.11; [c] the % of farms 'lost' from each farm group was calculated from the proportion of farms to reach 65 years of age and are not expected to have a member of the family to continue to manage the farm (the unproven assumption being that a family member will continue to manage the farm in the same way).

The number of farms to remain within each group by 2001 was estimated from the proportion of farms to be lost from each group and subtracting from the 1991 figure. The extent of land managed by each farm group was therefore estimated for the year 2001 using the new projected number of farms for the region (assuming that the median farm areas will not alter[1]). The new hectarage was used to calculate the proportion of land that the group might manage in 2001 and, therefore, the regional proportional change (Table 10.4). The percentage of land 'lost' from a group is, of course, the same percentage of farms 'lost'.

Table 10.4. Estimating changes in the extent of land managed by each farm group in Grampian between 1991 and 2001. Figures are rounded up for farms and hectarages.

	1991			2001				
FARM GROUP	Projected number of farms in Grampian [a]	Range of extent in region (ha) [b]	% of farmland in Grampian [b]	Projected no. of farms in Grampian	Range of extent in region (ha)	% of farmland in Grampian	Loss of land (ha)	% change of Grampian farmland
Non-pluriactive	734	37,431 - 138,299	33.0 - 33.8	571	29,195 - 107,873	26.0 - 27.9	8,235 - 30,426	-7.3 - 7.5
OFF-FARM pluriactivity	1109	45,564 - 188,573	41.5 - 45.0	990	40,689 - 168,396	36.9 - 40.2	4,875 - 20,177	-4.4 - 4.8
ON-FARM pluriactivity	243	16,012 - 60,674	14.5	same?	greater?	>14.5?	-	+?
BOTH pluriactivities	243	11,281 - 31,829	7.6 - 10.2	same?	same?	?	-	??
Overall		110,287 - 419,376			110,287 - 419,376 [c]			

[a] using the proportion of farms within each group from the socio-economic survey and assuming that there are 2226 farms within Grampian (Scottish Office Department of Statistics; A. Reid, *pers. comm.*) (Table 3.2).
[b] using the inter-quartile range of farm area by the number of farms within the group (Table 3.3).
[c] assumed constant.

Table 10.4 shows a regional loss of about 7% and 5% of land managed by the non-pluriactive and OFF-FARM groups respectively but it is more difficult to assess where this 'loss' might be a 'gain'. Would the management of this land be taken on by the ON-FARM and BOTH groups?

Of the ON-FARM and BOTH groups, the ON-FARM group is the most financially secure in terms of *farm-income* (Tables 3.5 and 3.6). The ON-FARM group might therefore be expected to take on the greater part of this land. New farmers would also be a new 'market' for the land, be they from a farming or non-farming (town) background, as might be non-agricultural land users, e.g. recreational and forestry industries. However, these scenarios require economic and social information which are outside the scope of this project.

The general 'loss' of land from the non-pluriactive and OFF-FARM groups can, however, be subdivided as losses from arable and grassland since arable and grass account for 97% and 93% of the land managed by these groups respectively (Table 10.5).

Table 10.5. The loss (upper and lower estimates in hectares) of arable and grass from the management of the non-pluriactive and OFF-FARM groups between 1991 and 2001. The proportionate cover of arable and grass per farm of each group are taken from Table 6.1 (shown in brackets) assuming that the proportions of arable and grass remain as defined in 1991/2 for these groups throughout the 1990's. Hectarages are rounded up and refer to the agricultural land of Grampian.

	Non-pluriactive farms		OFF-FARM group	
YEAR	ARABLE hectarage (41.9%)	GRASSLAND hectarage (54.9%)	ARABLE hectarage (35.4%)	GRASSLAND hectarage (57.9%)
1991	15,683 - 57,947	20,549 - 75,926	16,130 - 66,755	26,382 - 109,484
2001	12,233 - 45,199	16,028 - 59,222	14,404 - 59,612	23,559 - 97,501
Loss (ha)	3,450 - 12,748	4,5201 - 16,704	1,726 - 7,143	2,823 - 11,683
% Grampian farmland	3.3	4.3	1.7	2.7-2.8

Assuming that the grassland remains as agriculturally managed grassland, the release of 4.3% of Grampian grass from management by non-pluriactive farms is most likely to allow an increase in botanical richness through less extensive reseeding. However, the loss of nearly 3% of the region's grassland managed by the OFF-FARM group is most likely to mean a loss in the number of semi-natural species characteristic of grasslands in this group. The degree of change in the number of species will depend on the new land use and management intensity exhibited by the new land managers. If the management of the land is taken on by any agricultural group the degree of impact on the species composition of grass swards will also depend upon how the agricultural policies encouraging less intensive forms of agriculture are taken up. This is now discussed in the next section. However, where the ON-FARM and BOTH groups continue the management of a farm, the extent of grassland would be most likely to decrease since these are predominantly arable farms (Table 6.1).

10.4 *Future Changes in the Species Composition of Grampian Grasslands Resulting from the Lack of or a Reduction in the Intensity of Management*

The management of grass fields within pluriactive farms in Grampian during 1991/2 was still intensive enough not to allow any noticeable increase in the cover (>10%) of non-sown species. However, continuing agricultural policies which encourage less intensive farming may allow an increase in the number of non-sown species indicative of less productive and less disturbed grassland habitats during the 1990's.

Changes within sown swards usually occur with the ingression of meadow grasses (*Poa* spp.) followed by bent grasses (*Agrostis* spp.), Yorkshire fog (*Holcus lanatus*) and then fescue grasses (*Festuca* spp.) over about twenty years (Morrison, 1979). Successional changes are theoretically most strongly influenced by the initial vegetation and soil seedbank (Schmidt, 1988). However:

"abandoned grasslands can keep their original species composition for many years. They change mainly in their dominance structure...Annuals rarely invade such grasslands. Most new species are woody plants which become important in the final succession stage" (Schmidt, 1988).

There are possibly two reasons for this:

(1) Ryegrass pastures and meadows are associated with small but persistent seedbanks. The constituent species of such seedbanks tend to be *Poa* spp. (i.e. the early sward invaders recognised by Morrison, 1979) and less likely to be species of less productive habitats (Hodgson & Grime, 1990). The diversity of species within intensively managed farmland where the seedbank has been depleted therefore relies on nearby 'species reserves', i.e. semi-natural areas and field boundaries. For example, Gibson *et al* (1987) noted that 57% of vascular plant species invading an ex-arable field came from semi-natural areas within 2km of the site; the seedbank within the field mainly contained arable-type weeds.

(2) Because of the complete coverage of the soil by vegetation, gaps for colonisation are lacking (Beckwith, 1954; Miles, 1974; Grubb, 1977). Beckwith (1954) noted that on abandoned hay fields the 'grass and other perennials' stage lasts much longer than succession on bare ground associated with ex-arable fields with dominance by shrubs occurring about ten years after abandonment in comparison to 5-10 years because of the complete coverage of the soil. Beckwith (1954) also noted that trees were not noticeable after twenty-one years in ex-hay fields whereas in ex-arable fields of the same age trees were noticeable.

Agricultural soils also retain their high fertility for decades (see Marrs & Gough, 1989; Gough and Marrs, 1990), so that dominance is likely to be a highly influential factor in maintaining a low botanical richness (Grime, 1979). Even with particular grazing regimes managed for the encouragement of semi-natural species onto ex-arable land on calcicolous soil, Gibson and Brown (1992) predicted that it would take nearly a century to produce a grassland which would resemble the former quality of the area.

Therefore where grass fields are abandoned, the higher soil fertility would be more likely to allow invasion by shrubs with competitive life history strategies rather than any available stress-tolerant species (Grime, 1977). Dominance by shrubs would therefore be more likely to occur, about ten years after abandonment (following Beckwith's, 1954, observation), with trees becoming dominant after another ten years at least (Fig. 10.2).

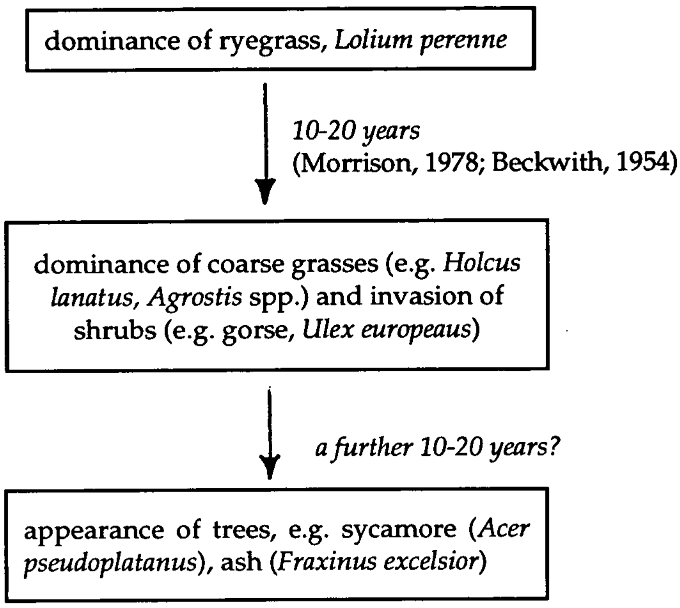


Fig. 10.2. A generalised prediction in the alteration of vegetation of grass fields in Grampian which may result from complete abandonment using literature cited in the text and observations made during the field surveys in 1991 and 1992.

However, if management is continued, the rate and direction of change will vary according to the intensity and type of management. Intensive management tends to reduce the rate of successional processes whilst the season and type of grazing (e.g. rotational) determines the type and diversity of species that are able to establish (see Jones, 1933; Gibson, Watt & Brown, 1987; Smith & Rushton, 1994). It is therefore not surprising that:

"Our ability to predict which species will be able to take advantage of any reduction in the intensity of land use is restricted. First, the practical effects of new agricultural policies on land use are uncertain...Second,...we have an inadequate appreciation of the dispersal and colonising abilities of species" (Hodgson & Grime, 1990).

It can be assumed that policies will continue to encourage less intensive forms of agriculture during the 1990's. However, the "practical effects of ... agricultural policies" (Hodgson & Grime, 1990) differs between the farm groups, at least within Grampian. Within the OFF-FARM group, the practical effect has been to reduce the intensity of reseeding (and possibly drainage and stocking rates) and to graze fewer fields with livestock; this has encouraged semi-natural species within swards and halted any succession (as shown in Fig. 10.2). Any further botanical enrichment of grasslands in Grampian may, however, be difficult:

(1) The vegetation mapping exercise did not identify any substantial 'semi-natural' areas within farm boundaries so it is unlikely that there were extensive patches of semi-natural grassland containing reserves of species within the lowland agricultural areas.

(2) Although fields adjacent to upland grasslands might benefit from their close proximity to a potential species source, species of unproductive grasslands (i.e. stress-tolerants, *sensu* Grime, 1974) lack obvious strategies of dispersal in time and space (Hodgson & Grime, 1990).

(3) Although field boundaries contained 73% more species in a sampled area only 25% greater than that sampled in the field and would therefore be expected to provide a species reserve for the open fields, stress-tolerant species constituted less than 3% of these species. Therefore if soil fertility were to decline in the field there would be few herbaceous species adapted to the less fertile conditions.

(4) As already mentioned, even if there was an abundant supply of stress-tolerant species, soil fertility (particularly available P) in the field is less likely to decline naturally in a short length of time (Gough & Marrs, 1990).

Within the ON-FARM group, however, there has been a reduction in the rate of fertiliser application and the number of fields grazed, thereby encouraging changes in the dominant grasses towards species indicative of semi-natural grasslands (*Agrostis* spp., *Holcus lanatus* and *Poa* spp. *etc.*). However, succession

(Fig. 10.3) will not progress as long as the grasslands of the whole farm remain in arable rotation although at the edges of fields left empty shrub (gorse) invasion may continue to occur. The BOTH group, as already discussed, differed in the *quality* of their management rather than the *level* of management, so it is perhaps more difficult to predict what is going to occur on these farms.

As Schmidt (1988) proposes, it seems as if Grampian agricultural grasslands may retain their original species composition (i.e. ryegrass, *Lolium perenne*, with some white clover, *Trifolium repens*) for many years. Succession within the agricultural grasslands of Grampian would therefore not follow the models outlined by Grime (1987) (described in Figs. 1.6a and b) with the incursion of 'C-S-R' strategists by stress-tolerant species and therefore not to a state which may be traditionally described as 'species-rich'.

10.5 *The Predicted Changes on Grampian Farmland in Relation to Those for the Rest of Britain*

In this study, the predicted land areas to change hands are small at the regional scale. However, it is possible that these figures over-estimate the true extent of land changing hands because it has been assumed that all farmers retire at 65 years of age whereas a number of farmers continue farming into their eighties. At the same time, these figures may under-estimate the true extent by assuming that farm succession ensures a continuation of the same type and intensity of management and that there will be no changes in farm occupancy due to economic non-viability. More importantly, the most under-estimation may be more likely to result from farms 'selling out' which is occurring elsewhere in Britain (LGC, 1986; Marsden & Symes, 1987; Munton *et al*, 1989). Ideally the figures in this study (i.e. Table 10.4) should be examined by agricultural economists and geographers for comments on their feasibility. However, it was necessary to attempt some projections as to which farm groups might take over the management of land 'lost' to other groups in order to reveal the type and extent of possible alterations in Grampian farmland ecology during the 1990's.

The ON-FARM group appears to be the most likely group recognised in this study to acquire some of the land leaving the management of the non-pluriactive and OFF-FARM groups. This land would appear to be acquired as additional farmland which would mean that farm areas in the ON-FARM group (already tending to be the greatest within Grampian) will increase further. The current trend in Britain is that the total number of farm businesses are declining whilst individual farms are becoming larger and more specialised (LGC, 1986; Marsden & Symes, 1987; Munton *et al,* 1989). This is therefore possibly continuing in Grampian and, with the ON-FARM group specialising in cereal, output of cereal would be expected to increase:

"Rises in cereal output give particular concern, and on current trends expenditure on cereal subsidies could double by the mid-1990's" (NCC, 1990).

Yet despite attempts by the EC to reduce the output of cereal within Europe using the 'cereal set-aside' scheme, this was not being taken up by the ON-FARM group in the early 1990's. However, the extraction of land from under cereal in the ON-FARM group may be occurring through involvement in farm woodland/forestry grant schemes with about 10% of the farmland under trees.

Only 37.5% of land within the ON-FARM group is presently under grass, so it is likely that the real extent of grass in Grampian will decrease as this group takes on more land. North (1990) predicted that the total UK agricultural grassland area may fall by 2-4 million hectares by the year 2015.

"The rate of loss of grassland and vegetated boundaries should be of particular concern to policy makers. In some locations the loss of grassland on 'change' land has been almost double the rate for 'core' land" (Munton & Marsden, 1991).

In other words, the loss of grassland is more likely to occur where the farm changes hands. Johnson and Bastiman (1981) also noted that the rate at which the area of livestock farms is increasing in England and Wales is lower than that of arable farms. This appears to be the case for Grampian too.

CHAPTER 11

Conclusions and Directions for Agricultural Policies in Grampian

11.1 *Conclusions from the Grampian Socio-economic and Field Surveys*

11.1.1 ***The main thesis was that involvement in non-agricultural activities by farm households ('pluriactivity') would be associated with an increase in the extent and number of semi-natural habitats and plant species within farmland.*** In comparison to non-pluriactive farms where 97% of the farmland was under arable crops or intensively managed grass, the three pluriactive groups identified within this study did have greater extents of non-agricultural habitats and/or greater numbers of non-sown plant species within grasslands. However, the type of non-agricultural habitats and the type of non-sown plant species in the grass fields varied according to the type of pluriactivity.

11.1.2 The non-involvement or type of involvement in pluriactivity (as defined by the *location* of the non-agricultural activities) was found to reflect the farm and farm household characteristics. It is therefore difficult to attribute differences in the main land use characteristics directly to involvement in pluriactivity since the main land use(s) on the farm may have pre-determined the type of involvement in pluriactivity (also see Gasson, 1988). From the Scottish Office classification of the farm and meeting the farm household members informally during the survey work, some speculations can be made:

- farms with only off-farm work (the OFF-FARM group) may have been more-intensive livestock farms which have decreased the number of livestock (whilst remaining 'livestock' farms) as a result of declining farm incomes.
- farms with exclusively on-farm non-agricultural activities (the

ON-FARM group) may be developing such activities as a result of initial capital (e.g. old farm cottages and land) being available. The extent of cereal and woodland may simply reflect the current availability in farming subsidies and grants (although these farms are classified as arable farms by the Scottish Office).

However, the greater extent of cereal on farms with non-agricultural activities BOTH off-farm and on-farm appears to be the result of "rationalising and simplifying their farming systems as far as possible" (Gasson, 1983) to accommodate the non-agricultural activities, i.e. the result of pluriactivity (but see below).

11.1.3 The affect of the land management strategy of a farm household and alterations in the proportion of time allocated between farming/non-farming activities, was found to over-ride the affect of varying land uses on the species composition of grasslands. However, the factors identified for each pluriactive farm group are likely to be 'surrogate' factors rather than 'causal', i.e. resulting from other factors which may not have been identified in this project. For example, within the OFF-FARM group an increase in the proportion of time spent away from the farm was associated with an increase in the number of plant species in the grasslands, but the proportion of time spent away from the farm may have resulted *after* farm profits had declined and caused a reduction in the incidence of reseeding and/or grazing of grass fields. In this case, the decline in farm income would have been the causative factor allowing the number of species in the swards to increase.

However, within the ON-FARM group an increase in the number of employees was associated with a decrease in the number of plant species within the grasslands which would appear to be a direct association with a greater number of employees increasing the level of management intensity.

That no factor was significantly associated with the number of grassland plant species within the BOTH group was believed to be the result of a heterogeneous group of farms and household characteristics. The increase in weed and bryophyte species within the BOTH group is believed to be the result of mis-management, the result of less than half the working week given to farming. But what was the causative factor here - lack of time, lack of education, attitude? The overall income to these farms, however, was greater than that in other farm groups.

11.1.4 The association of differing types of pluriactivity with variations in farmland ecology are therefore more likely to result from indirect socio-economic factors than from direct changes associated with land-based non-agricultural activities such as quarrying and golf courses.

11.1.5 Given the current trends, there is no evidence that there will be obvious changes in grasslands for each farm group over the next ten years.

11.1.6 Given the constraints of this project[1] it is therefore difficult to see how this study could have been done differently. A field study at the farm level was necessary to identify the ecological characteristics associated with socio-economic and land use/management characteristics:

(a) although there were differences in the extents of different vegetation cover types, the distinction between intensively-managed grass and arable crops is difficult using aerial photography at a scale with less detail than 1:10 000.

(b) the type of constituent species within vegetation cover types varied and for grasslands this was at the non-dominant level.

11.2 *Conclusions with Implications for Agricultural Policies in Grampian*

11.2.1 Policies and grants, even when aimed at the 'same' type of farmer (e.g. an arable farmer), have differing ecological impacts upon the farm. For

[1] this study had been set up to last 33 months but also depended on the availability of data from the socio-economic study which started at the same time.

example, the 'cereal set-aside' scheme (which had been introduced 3-4 years before the field surveys) had not been taken up by the thirteen large arable farms (the ON-FARM group) in this study although 8% of the grass fields were accounted for by the 'set-aside' scheme within the smaller arable farms (the BOTH group). Likewise, woodland grant schemes targeted to all farmers were mainly taken up by the largest farms (the ON-FARM group), particularly those incorporating broadleaf species which are of greater wildlife conservation value than the coniferous species associated with the smallest arable farms (the BOTH group).

11.2.2 If the fertility and cutting/grazing regimes in grass fields were to decline, there would be few species near-by able to utilise such conditions since 97-99% of non-sown species within the grass fields and along the field boundaries were not indicative of older, less intensive grassland (i.e. 'stress-tolerant' species *sensu* Grime, 1974). However, high fertility in agricultural soils is likely to take decades to fall (see Gough & Marrs, 1990) therefore succession by shrub (e.g. gorse) and trees (e.g. sycamore and ash) would appear more likely than the development of a species-rich pasture. The initial carpeting of the field with dense swards may reduce the rate of succession with trees usually appearing possibly upto 40 years after abandonment.

"Without the hand of the farmer most of Britain would revert quickly to a scrubby woodland of birch and eventually of oak, with pines on the poorer land. The beauty of the British countryside is for the most part man-made and needs the hand of man, especially the farmer, to keep it in order" (Stamp, 1946).

Therefore if species-rich grasslands were to be encouraged, species re-introductions would be needed (a conclusion also reached for grasslands in the north of England by Hodgson and Grime, 1990) as well as management to reduce soil fertility and cutting/grazing to reduce the dominance of competitive species (Grime, 1979). Haggar and Peel (1994) summarise studies on the management of grassland for nature conservation.

11.2.3 If farmers became more involved in non-agricultural activities in terms of the proportion of time given to these activities in a working week,

(a) either a greater extent of land may be ploughed under cereal - as in the case of the ON-FARM and BOTH groups (also see Gasson, 1966; 1983), or

(b) the low intensity of management seen within the OFF-FARM group may lead to land being abandoned to scrub and tree invasion (see Munton, Whatmore & Marsden, 1989).

Although abandonment will allow an increase in semi-natural habitats, the increase in cereal crops will not. Therefore agricultural policies need to encourage 'ecologically-sensitive' farming rather than a greater interest in alternative sources of employment. Schemes like the 'Environmentally Sensitive Area' scheme which encourages more extensive farming over the whole farm would be more beneficial than schemes like the 'Beef Extensification Scheme' which targets a reduction in the management intensity of grasslands only or the 'set-aside' scheme targeted only at cereal crops, both of which open the possibility that management elsewhere on the farm might be intensified; for example, the conversion of grassland to cereal in the short-term (see also the predictions of Jenkins, 1987). That hedgerows, old species-rich grasslands and wetlands are lacking in Grampian enforces the need for more active 'habitat creation' policies (see Newbold, 1989).

11.2.4 Munton *et al* (1989) wondered whether off-farm commitment in the face of deteriorating farming income would work against the implementation of conservation policies. In the light of this study, those farms where household members are only involved in off-farm work due to lack of available work on the farm (the OFF-FARM group), the resultant extensive management is more likely to encourage a passive form of conservation, such as more extensive grasslands under a less-intensive management regime; the lack of any active conservation, particularly tree planting, may, in part, be due to land management restrictions from the landlord (Coulter, *pers. comm.*). On farms where off-farm work is combined with on-farm non-agricultural activities (the BOTH group) the time away from farming does appear to work against the implementation of conservation policies as proposed by Munton *et al* (1989). However, the set-aside scheme was most popular with these 'hobby farms' which would indicate that long-term management agreements for conservation purposes on set-aside land requiring the minimum of management would be beneficial.

11.3 *The future of the Grampian Countryside*

11.3.1 With younger farmers and households on arable farms (the ON-FARM and BOTH groups) and with the largest arable farms (the ON-FARM group) most financially secure in terms of *farm-income,* suggests that larger arable farms may become more extensive during the 1990's. This may result in an increase in cereal (particularly barley), a decrease in the extent of grassland with an increased cover of grass species indicative of lowered fertility (but no evidence of an increase in the species richness), and an increase in the extent of broadleaf woodlands.

11.3.2 A farm level survey, however, cannot record the extent of land which has left agriculture although informal observations about Grampian suggests that this may be occurring to a small extent; for example, one farm had been converted to a water-theme park. Barr *et al* (1986) quantified the extent of land to leave agriculture between 1978 and 1984 from field surveys carried out by the Institute of Terrestrial Ecology. However, figures on land lost from agriculture obtained through a survey in 1990 have yet to be released (see Barr *et al*, 1993).

11.4 *Further Research*

The detailed documentation of these farms both within a Geographic Information System and a relational database would allow re-survey work (e.g. in 2001). The data from this study would provide a baseline for monitoring alterations in land management (and therefore farmland ecology) at the farm scale in Grampian. Re-survey would also allow the predictions made in this study to be verified.

Would these four socio-economic groups be recognised in other areas? Similarities in the socio-economic characteristics and the type of pluriactivity have been shown to exist between this Grampian study and others (e.g. Gasson, 1966 *et seq;* Buttel, 1982; Sinclair, 1983). But would the 'socio-economic - farmland ecology' associations from this Grampian study extrapolate well to other parts of Scotland, Britain or Europe? A number of similarities do exist with the results presented in this study and a number of studies outlined from southern England and Wales (Gasson, 1966 *et seq*; Munton *et al*, 1989; Sinclair, 1983) which suggest extrapolation is feasible at the vegetation cover level, at least within Britain. If this were the case, then Grampian might be a region where the impact of agricultural results on land use and therefore the vegetation cover level might be monitored at a smaller scale than a national survey (having obtained a baseline of data through the socio-economic and field surveys). However, with geographical variations in climate, soil, relief *etc.*, it is more difficult to believe that the type of land management exhibited by the four socio-economic groups would still produce similar grassland sward compositions wherever they exist, i.e. that farms elsewhere in Britain which share the same socio-economic characteristics as the OFF-FARM group in this study have 8-11 species for any given $4m^2$ of grassland and that the type of non-sown species tend to be 'semi-natural'. The comparisons made between the Institute of Terrestrial Ecology 1990 Countryside Survey (see Barr *et al*, 1993; Hallam, *pers. comm.*) and the results of this study illustrate this.

Although this study has concentrated on the vegetational aspects of farmland, further research may consider the impact of the somewhat trivial changes in grass swards reported in this study on the faunal populations associated with pastures and meadows. For example, how has the small increase in non-sown species in the grass fields of Grampian farms affected the distribution and abundance of invertebrates, small mammals and birds *etc.*? Further to this, what 'type' of faunal species, as perceived by the farmer, are associated with the plant 'types' defined within this study? For example, are the faunal species associated with the 'semi-natural' (or 'weed') plant species considered to be 'pest' species (i.e. likely to cause damage to neighbouring crops) or beneficial (i.e. help to control other faunal populations which are detrimental to crops).

Albrecht, D.E. & Murdoch, S.H. (1984) Towards a Human ecological perspective on part-time farming. *Rural Sociology*, **49(3)**, 389-411.

Al-Mufti, C.L., Sydes, S.B., Furness, S.B., Grime, J.P. & Band, S.R. (1977) A quantitative analysis of shoot phenology and dominance in herbaceous vegetation. *Journal of Ecology*, **65**, 759-791.

Arkleton (1985) *Part-time Farming in the Rural Development of Industrialised Countries*. Report of a seminar held in Scotland, 16-21 October, 1983. The Arkleton Trust.

Arkleton (1988) *Rural Change in Europe: Research Programme on Farm Structures and Pluriactivity*. Conference Proceedings, Waldkirchen, 18-21 September, 1988. The Arkleton Trust.

Bailey, N.T. (1983) *Statistical Methods in Biology*. Cambridge University Press.

Barr, C.J. (1990) *Field Handbook*. Grange-over-Sands: Institute of Terrestrial Ecology.

Barr, C.J., Benefield, C., Bunce, R.G.H., Risdale, H. & Whittaker, M. (1986) *Landscape Changes in Britain*. Institute of Terrestrial Ecology, Monks Wood.

Barr, C.J., Bunce, R.G.H., Clarke, R.T., Fuller, R.M., Firse, M.T., Gillespie, M.K., Groom, G.B., Hallam, C.J., Hornung, M., Howard, D.C. & Ness, M.J. (1993) *Countryside Survey 1990 Main Report*. Department of the Environment.

Baudry, J. (1984) Effects of Landscape Structure on Biological Communities: the case of Hedgerow Network Landscapes. *Methodology in Landscape Ecological Research and Planning* (eds Brandt J. & P. Aggar). The International Association for Landscape Ecology. Proceedings of the First International Seminar. Roskildellni.

Baudry, J. (1989) Interactions between agricultural and ecological systems at the landscape level. *Agriculture, Ecosystems and the Environment*, **27**, 119-130.

Beckwith, S. (1954) Ecological succession on abandoned farm lands and its relationship to wildlife. *Ecological Monographs*, **24**, 349-376.

Best, R. (1981) *Land Use and Living Space*. Methuen, London.

Bibby, J.S., Douglas, H.A., Thomasson, A.J. & Robertson, J.S. *Land Capability Classification for Agriculture*. Soil Survey of Scotland Monograph, Macaulay Institute of Soil Research, Aberdeen University Press.

Bond, W.J. (1983) On alpha diversity and the richness of the Cape flora. *Mediterranean-type Ecosystems: the Role of Nutrients* (eds F. Kruger, D.T. Mitchel & J. Jarvis), pp. 225-243. Springer, Berlin.

Bowers, J.K. & Cheshire, P. (1983) *Agriculture, the Countryside and Land Use*. Methuen, Andover, Herts.

Braun-Blanquet, J. (1921) Prinzipien einer systematik der pflanzengesellschaften auf floristischer grundlage. *St. Gallische Naturwissenschaftliche Gesellschaft*,

57, 305-351.
Budd, J. (1990) Monitoring Land Cover Change in the "Wider Countryside". *Evaluation of Land Resources in Scotland* (eds J.S. Bibby & M.F. Thomas), pp. 57-67. Macaulay Land Use Research Institute and Royal Scottish Geographical Society.
Bunce, R.G.H., Barr, C.J. & Whittaker, H.A. (1981) *Land Classes in Great Britain: Preliminary Descriptions for Users of the Merlewood Method of Land Classification.* Institute of Terrestrial Ecology Research and Development paper No. 86. Grange-over-Sands.
Bunce, R.G.H., Barr, C.J. & Whittaker, H.A. (1983) A Stratification System for Ecological Sampling. *Ecological Mapping from Land, Air and Space* (ed R.M. Fuller), pp. 39-46. Institute of Terrestrial Ecology Symposium No. 10, Cambridge.
Bunce, R.G.H. & Heal, O.W. (1984) Landscape Evaluation and the Impact of Changing Land-use on the Rural Environment: the Problem and an Approach. *Planning and Ecology* (eds R.D. Roberts & T.M. Roberts) pp. 164-188. Chapman and Hall.
Bunce, R.G.H. & Jenkins, N.R. (1989) Land potential for habitat reconstruction in Britain. *Biological Habitat Reconstruction* (ed G.P. Buckley), pp. 81-91. Belhaven Press, London.
Bunce, R.G.H. & Last, F.T. (1981) How to characterise the habitats of Scotland *Edinburgh Centre of Rural Economy, 34th Annual Report 1980-81.* The Edinburgh Centre of Rural Economy, Bush House, Penicuik, Midlothian.
Buttel, F.H. (1982) The political economy of part-time farming. *Geojournal,* **6(4)**, 293-300.
Church, B.M. & Lewis, D.A. (1977) Fertiliser use on farm crops in England and Wales: information from the survey of fertiliser practice, 1942-1976. *Outlook on Agriculture,* **9**, 186-197.
Clapham, A.R., Tutin, T.G. & Warburg, E.F. (1981) *Excursion Flora of the British Isles.* Third edition, Cambridge University Press.
Clapham, A.R., Tutin, T.G. & Moore, D.M. (1987) *Flora of the British Isles,* Third edition. Cambridge University Press.
Dalton, G.E. & Wilson, C.J. (1989) *Farm Diversification in Scotland.* Scottish Agricultural College Economic Report No. 12.
Davies A.S. & Dalton, G.E. (1993a) *Farm Households and Businesses: their Inter-relationship and Off-farm Pluriactivity.* Unpublished Joint Agriculture and Environment project report. Scottish Agricultural College, Aberdeen.
Davies A.S. & Dalton, G.E. (1993b) *The Effect of Off-farm Employment on Farming Activities in Scotland.* Unpublished Joint Agriculture and Environment project report. Scottish Agricultural College, Aberdeen.
Davies, W. (1941) *The grassland map of England and Wales, explanatory notes.* Agriculture, **40**, 112-121.
Dent, J.B., Bibby, J.S., Dalton, G.E., Davies, A.S., McGregor, M., Corcoran, K., Perkins, T., Doyle, C.J., Mitchell, M., Heal, O.W., Ellis, N.E., Crabtree, J.R.

and Edmond, H. (1993) *Pluriactivity in the Agricultural Sector in Scotland.* The Main Joint Agriculture and Environment Programme project report to the Economic and Social Research Council. University of Edinburgh, Scottish Agricultural Colleges, Macaulay Land Use Research Institute and Institute of Terrestrial Ecology.

ECOLUC (1988) *Ecological Consequences of Land Use Change.* A report prepared for the Department of the Environment by the Institute of Terrestrial Ecology.

EDC (1973) *Farm Productivity. A Report on Factors affecting Productivity at the Farm Level.* Prepared by the Agriculture Economic Development Committee. National Economic Development Office, London.

Efstratoglou-Todoulou, S. (1988) Current experiences in multiple job-holding in Greek farming, *Rural Change: Research Programme on Farm Structures and Pluriactivity* (Arkleton, 1988), pp. 181-191. The Arkleton Trust.

Elsmere, J.I. (1985) Use of fertilisers in England and Wales, 1985, *Rothamsted Experimental Station Report for 1985.* pp. 245-251. Harpenden, Lawes Agricultural Trust.

FAO (1978) *The State of Food and Agriculture 1977.* Food and Agriculture Organisation.

FAO (1979) *FAO Year Book - Production.* Volume 45. Food and Agriculture Organisation. Rome.

Fitter, R., Fitter, A. & Blamey, M. (1974) *The Wild Flowers of Britain and Northern Europe.* Second edition. Collins.

Forbes, T.J., Dibb, C., Green J.O., Hopkins, A. & Peel, S. (1980) *Permanent Grassland: Factors Affecting the Productivity of Permanent Grassland - A National Farm Study.* Joint Permanent Pasture Group (Agricultural Department and Advisory Services and the Grassland Research Institute).

Fuller, A.M. & Brun, A. (1988) Socio-economic aspects of pluriactivity in Western Europe, *Rural Change: Research Programme on Farm Structures and Pluriactivity* (Arkleton, 1988), pp. 147-169. The Arkleton Trust.

Fuller, R.M. (1986a) Historical aerial photographs as records of land-use changes: A case study of Ancaster and Normanton parishes, Lincolnshire. *East Midland Geographical,* **8**, 217-226.

Fuller, R.M. (1986b) Taking stock of changing Broadland, II. Status of semi-natural and man-made habitats. *Journal of Biogeography,* **13**, 327-337.

Fuller, R.M. (1987) The changing extent and conservation interest of lowland grasslands in England and Wales: a review of grassland surveys 1930-84. *Biological Conservation,* **40,** 281-300.

Gasson, R. (1966) *The Influence of Urbanisation on Farm Ownership and Practice.* Department of Agricultural Economics, Wye College, University of London.

Gasson, R. (1976) *The Future for Labour on the Land,* Proceedings of the 12th Annual Conference of the Farm Management Association.

Gasson, R. (1983) *Gainful Occupations of Farm Families.* Wye college, University of London.

Gasson, R. (1988) *The Economics of Part-time Farming.* Longman Scientific and Technical.

Gauch, H.G. Jr. (1982) *Multivariate Analysis in Community Ecology.* Cambridge Studies in Ecology. Cambridge University Press.

Gibson, C.W.D. (1986) Management history in relation to changes in the flora of different habitats on an Oxfordshire estate. *Biological Conservation,* **38,** 217-232.

Gibson, C.W.D., Hambler, C. & Brown, V.K. (1992) Changes in spider (Araneae) assemblages in relation to succession and grazing management. *Journal of Applied Ecology,* **29,** 132-142.

Gibson, C.W.D. & Brown, V.K. (1992) Grazing and vegetation change: deflected of modified succession? *Journal of Applied Ecology,* **29,** 120-131.

Gibson, C.W.D., Watt, T.A. & Brown, V.K. (1987) The use of sheep grazing to recreate species-rich grassland from abandoned arable land. *Biological Conservation,* **42,** 165-183.

Gough, M.W. & Marrs, R.H. (1990) A comparison of soil fertility between semi-natural and agricultural plant communities: implications of species-rich grassland on abandoned agricultural land. *Biological Conservation,* **51,** 83-96.

Green, B.H. & Burnham, C.P. (1989) Environmental opportunities offered by surplus agricultural production, *Biological Habitat Reconstruction* (ed G.F. Buckley), pp. 92-101. Belhaven Press.

Green, J.O. (1974) Grasslands surveys, *Silver Jubilee Report 1949-1974* (eds C.R.W. Spedding & R.D. Williams). Grassland Research Institute, Hurley.

Green, J.O. (1982) *A Sample Survey of Grassland in England and Wales 1970-1972* Internal Report, Grassland Research Institute, Hurley, No. 310.

Greig-Smith, P. (1983) *Quantitative Plant Ecology.* Third Edition. Studies in Ecology Volume 9, Blackwell Scientific Publications.

Grime, J.P. (1973) Competitive exclusion in herbaceous vegetation. *Nature,* **242,** 344-347.

Grime, J.P. (1974) Vegetation Classification by Reference to Strategies. *Nature,* **250,** 26-31.

Grime, J.P. (1979) *Plant Strategies and Vegetation Processes.* Wiley, New York.

Grime, J.P. (1987) Dominant and subordinate components of plant communities: implications for succession, stability and diversity, *Colonisation, Succession and Stability* (eds A.J. Gray, M.J. Crawley & P.J. Edwards), pp. 413-422. Blackwell Scientific Publications, Oxford.

Grime, J.P., Hodgson, J.G. & Hunt, R. (1988) *Comparative Plant Ecology: A Functional Approach to Common British Species.* Unwin Hyman.

Grubb, P.J. (1977) The maintenance of species-richness in plant communities: the importance of the regeneration niche. *Biological Review,* **52,** 107-145.

Haggar, R.J. & Peel, S. (eds) (1994) *Grassland Management and Nature Conservation.* British Grassland Society Occasional Symposium No. 28.

Harrison, A. (1966) *The Farms of Buckinghamshire: some Features of Farm Businesses in a County Adjoining Greater London.* Miscellaneous Studies No. 40, Department of Agricultural Economics, University of Reading.

Harrison, A. (1975) *Farmers and Farm Businesses in England.* Miscellaneous studies No. 63, Department of Agricultural Economics, Reading University.

Harvey, D. & Bell, M. (1990) The agricultural perspective, *Species Dispersal in agricultural Habitats* (eds R.G.H. Bunce & D. Howard), pp. 256-276. Belhaven Press.

Hill, B. and Gasson, R. (1985) Farm tenure and farming practice. *Journal of Agricultural Economics,* **36,** 187-199.

Hill, M.O. (1979a) *TWINSPAN - A Fortran Program for arranging Multivariate Data in an Ordered Two-way Table by Classification of Individuals and Attributes.* Cornell University, Ithaca, New York.

Hill, M.O. (1979b) *DECORANA - A Fortran Program for Detrended Correspondence Analysis and Reciprocal Averaging.* Cornell University, Ithaca, New York.

Hill, M.O., Bunce, R.G.H. & Shaw, M.W. (1975) Indicator species analysis, a divisive polythetic method of classification, and its application to a survey of native pinewoods in Scotland. *Journal of Ecology,* **63,** 597-613.

Hodgson, J.G. (1986) Commonness and rarity of plants with special reference to the British Flora II: the relative importance of climate, soils and land use. *Biological Conservation,* **36,** 253-274.

Hodgson, J.G. & Grime, J.P. (1990) The role of dispersal mechanisms, regenerative strategies and seedbanks in the vegetation dynamics of the British landscape, *Species Dispersal in Agricultural Habitats* (eds R.G.H. Bunce & D. Howard), pp. 65-81. Belhaven Press.

Hopkins, A. (1988) Distribution and management of grassland in the United Kingdom, *Environmental Management in Agriculture* (ed J.R. Park), pp. 178-185. Belhaven Press.

Hopkins, A., Matkin, E., Ellis, J. & Peel, S. (1985) South-west England grassland survey 1983. 1. Age structure and sward composition of permanent and arable grassland and their relation to manageability, fertiliser nitrogen and other management features. *Grass and Forage Science,* **40(3),** 349-359.

Huntings (1986) *Monitoring Landscape Change.* Huntings Surveys and Consultants Ltd. Department of the Environment and the Countryside Commission.

Hurlbert, S.H. (1971) The nonconcept of species diversity: a critique and alternative parameters. *Ecology,* **52,** 577-586.

Huston, M. (1979) A general hypothesis of species diversity. *American Naturalist,* **113,** 81-101.

Jenkins, N.R (1987) Paper 3. Ecological Changes Resulting from a Less-intensive Agriculture. *Farm Extensification: Implications of EC Regulation 1760/87*

(eds N.R. Jenkins & M. Bell), paper 3. Institute of Terrestrial Ecology Research and Development paper No. 112. Grange-over-Sands.
Johnson, J. & Bastiman, B. (1981) Social and Human factors in grassland farming, *Grassland in the British Economy* (ed J.L. Jollans), pp. 268-288. Paper 10, Centre for Agricultural Strategy. Reading.
Jones, M.G. (1933) *Empirical Journal of Experimental Agriculture*, **1**, 43-57, 122-128, 223-234, 361-367.
Laurence Gould Consultants Ltd. (1986) *Changes in Land Use in England, Scotland and Wales 1985 to 1990 and 2000.* Report to the Nature Conservancy Council.
Lloyd, M. & Ghelardi, R.J. (1964) A table for calculating the 'equitability' component of species diversity. *Journal of Animal Ecology*, **33**, 217-225.
MacArthur, R.H. & Wilson, E.O. (1963) An equilibrium theory of insular zoogeography, *Evolution*, **17(4)**, 373-387.
MacArthur, R.H. & Wilson, E.O. (1967) *The Theory of Island Biogeography.* Princeton University Press.
MAFF (1980) *Definition of Terms used in Agricultural Business Management.* Booklet 2269. Ministry of Agriculture, Fisheries and Food publications, Middlesex.
MAFF (1987) *Farming and Rural Enterprise.* Ministry of Agriculture, Fisheries and Food publications, HMSO, London.
Marrs, R.H. & Gough, M.W. (1989) Soil fertility - a potential problem for habitat restoration, *Biological Habitat Reconstruction* (ed G.P. Buckley), pp. 29-44. Belhaven Press, London.
Marsden, T. & Murdoch, J. (1990) *Restructuring Rurality: Key Areas for Development in Assessing Rural Change.* Economic and Social Research Council Countryside Initiative working paper No. 4. Countryside Change Centre, University College London.
Marsden, T., Murdoch, J., Lowe, P., Munton, R. & Flynn, A. (1993) *Constructing the Countryside.* Restructuring Rural Areas 1, London.
Marsden, T. & Symes, D. (1987) *The socio-economic Consequences of Agricultural Development in Europe.* United Kingdom analytical paper No. 2. Survival Strategies in Post-productionist Agriculture.
McIntosh, R.P. (1967) An index of diversity and the relation of certain concepts to diversity. *Ecology*, **48(3)**, 392-403.
McVean, D.N. & Ratcliffe, D.A. (1962) *Plant Communities of the Scottish Highlands.* Monographs of the Nature Conservancy No.1.
Mead, R. & Curnow, R.N. (1983) *Statistical Methods in Agriculture and Experimental Biology.* Chapman and Hall.
Miles, J. (1974) Effects of experimental interference with stand structure on establishment of seedlings in *Callunetum. Journal of Ecology*, **62**, 675-687.
Miles, J. (1979) *Vegetation Dynamics.* Outline Studies in Ecology. Chapman and Hall.
MLURI (1990) *The Land Cover of Scotland by Air Photo Interpretation.* Unpublished

contract specification for the Scottish Office. Macaulay Land Use Research Institute, Aberdeen.
Morrison, J. (1979) Botanical change in agricultural grassland in Britain. *Changes in Sward Composition and Productivity* (eds A.H. Charles & R.H. Haggar), pp.5-10. British Grassland Society Occasional Symposium No. 10.
Morrison, J. & Idle, A.A. (1972) *A pilot Survey of Grassland in South-East England: the Physical Features of Grassland and their relation to Age and Botanical Composition.* Technical Report No. 10, Grassland Research Institute.
Munton R.J.C. & Marsden, T.K. (1991) Occupancy change and the farmed landscape: an analysis of farm-level trends 1970-85. *Environment and Planning A*, **23**, 499-510.
Munton, R., Whatmore, S.J. & Marsden, T.K. (1989) Part-time farming and its implications for the rural landscape: a preliminary analysis. *Environment and Planning A*, **21**, 523-536.
Munton, R.J., Lowe, P. & Marsden, T. (1992) The social, economic and political context, *Land Use Change: the Causes and Consequences* (ed M.C. Whitby) Natural Environment Research Council, HMSO, London.
Nalson, J.S. (1968) *Mobility of Farm Families: a Study of Occupational and Residential Mobility in an Upland Area of England.* Manchester University Press.
NCC (1977) *Nature Conservation and Agriculture: Appraisals and Proposals by the NCC.* Nature Conservancy Council, London.
NCC (1984) *Nature Conservancy Council Tenth Report 1 April 1983-31 March 1984.* Appendix 14, pp. 102-112. Nature Conservancy Council.
NCC (1990) *Nature Conservation and Agricultural Change.* Focus on Nature Conservation No. 25. Nature Conservancy Council.
NCMS (1988) *National Countryside Monitoring Scheme, Scotland: Grampian.* Countryside Commission for Scotland and the Nature Conservancy Council, Perth.
Newbold, C. (1989) Semi-natural habitats or habitat recreation: conflict or partnership? *Biological Habitat Reconstruction* (ed G.P. Buckley), pp.9-17. Belhaven Press.
North, J. (1990) Future agricultural land use patterns, *Agriculture in Britain: Changing Pressures and Policies* (ed D. Britton), pp. 69-93. Wallingford.
Olfert, R.M. (1992) Nonfarm employment as a response to underemployment in agriculture. *Canadian Journal of Agricultural Economics*, **40**, 443-458.
OECD (1978) *Part-time Farming in OECD Countries.* Volume 3, pp. 3-6, General Report, Paris.
Payne, R.W., Lane, P.W., Ainsley, A.E., Bicknell, K.E., Digby, P.G.N., Hordin, S.A., Leech, P.K., Simpson, H.R., Todd, A.D., Verner, P.J. & White, R.P. (1987) *GENSTAT 5*, Committee of the Statistics Department, Rothamsted Experimental Station. Clarendon Press, Oxford.
Peel, S. & Forbes, T.J. (1978) *Permanent Grasslands 3. A study of Permanent Grassland Farms with Beef Suckler Herds.* Grassland Research Institute -

Agriculture and Development Advisory Services 'Joint Permanent Pasture Group'.
Peel, S., Matkin, E., Ellis, J.A. & Hopkins, A. (1985) South-west England grassland survey 1983. 2. Trends in cropping pattern, reseeding and sward composition 1970-1983. *Grass and Forage Science*, **40**, 467-472.
Peet, R.K. (1974) The measurement of species diversity. *Annual Review of Ecology and Systematics*, **5**, 285-307.
Perring, F.H. & Farrell, L. (1983) *British Red Data Books: 1. Vascular Plants.* Royal Society for Nature Conservation, Lincoln.
Piddington, H. (1981) *Land Management for shooting and Fishing: a study of practice on farms and estates in Great Britain during 1971-1976.* Occasional paper No. 13, Department of Land Economics, Cambridge University.
Rodwell, J.S. (ed) (1992) *British Plant Communities, Volume 3: Grasslands and Montane Communities.* Cambridge University Press.
Rozman, D. (1930) *Part-time Farming in Massachusetts.* Bulletin, No. 266, Massachusetts Agricultural Experimental Station.
Schmidt, W. (1988) An experimental study of old-field succession in relation to different environmental factors. *Vegetatio*, **77**, 103-114.
Shoard, M. (1980) *The Theft of the Countryside.* Temple Smith, London.
Shucksmith D.M., Bryden, J., Rosenthall P., Short, C. & Winter, M. (1989) Pluriactivity, farm structures and rural change. *Journal of Agricultural Economics*, **40(3)**, 345-360.
Sinclair, G. (ed.) (1983) *The Upland Landscapes Study.* Environment Information Services.
Sly, J.M.A. (1986) *Review of Usage of Pesticides in Agriculture, Horticulture and Animal Husbandry 1980-1983.* Survey Report 41, Agriculture and Development Services, Ministry of Agriculture, Fisheries and Food.
Spooner, G.M. (1963) On causes of the decline of the *Maculinea arion* L. (Lep. Lycaenidae) in Britain. *Entomologist*, **96**, 199-210.
Smith, R.S. & Rushton, S.P. (1994) The effects of grazing management on the vegetation of mesotrophic (meadow) grassland in Northern England. *Journal of Applied Ecology*, **31**, 13-24.
Stamp, L.D. (1946) *The Land of Britain and how it is Used.* Longmans, Green and Co, London.
Stamp, L.D. (1968) *Our Developing World.* Faber and Faber, London.
Stapledon, R.G. (1939) *The Plough-up Policy and Ley Farming.* Faber and Faber, London.
This Common Inheritance (1992) *The Second Year Report on the White Paper of 1990. Britain's Environmental Strategy.* HMSO, London.
UCPE (1990) *Report of the Unit of Comparative Plant Ecology 1988/1990.* Natural Environmental Research Council, Sheffield University.
Watson, E.V. (1981) *British Mosses and Liverworts.* Third edition. Cambridge University Press.
Wells, T.C.E. & Sheail J. (1988) The effects of agricultural change on the

wildlife interest of lowland grasslands, *Environmental Management in Agriculture* (ed J.R. Park), pp. 186-201. Belhaven Press.
Westmacott, R. & Worthington, T. (1984) *Agricultural Landscapes: A Second Look*. Countryside Commission Publication No. 168.
Whitaker's Almanac (1993). J. Whitaker & Sons Ltd. Dyott St., London.
Whittaker, R.H. (1960) Vegetation of the Siskiyou Mountains, Oregon and California. *Ecological Monographs*, **30**, 279-338.
Whittaker, R.H. (1972) Evolution and measurement of species diversity. *Taxon*, **21 (2/3)**, 213-251.
Whittaker, R.H. (1977) Evolution of species diversity in land communities. *Evolutionary Biology*, **10**, 1-67.
Williams, C.B. (1964) *Patterns in the Balance of Nature*. Academic Press.
Williams, W.T. & Gillard, P. (1971) Pattern analysis of a grazing experiment. *Australian Journal of Agricultural Research*, **22**, 245-260.
Wilson, M.V. & Shmida, A. (1984) Measuring beta diversity with presence-absence data. *Journal of Ecology*, **72**, 1055-1064.
Yates F. & Boyd D.A. (1965). Two decades of surveys of fertiliser practice. *Outlook* on Agriculture, **4**, 203-217.

APPENDIX 1

QUESTIONNAIRE ON THE USE OF GRASS FIELDS

Are the farm and field boundaries on this map correct?
Questions will be asked on current grass fields only.

1. **When did you last reseed the field?**

0-4 years ago	1
5-8 years ago	2
9-20 years ago	3
more than 20 years ago	4
not been reseeded	0

2. **In the last 10 years has the field been...**

(a) PERMANENTLY GRASS? .. the field has been grass for the last 10 years, even if grass-to-grass reseeding has taken place (include - 9 years in grass with 10th year in a forage crop, eg kale, turnips, *etc*).

(b) PART OF AN ARABLE ROTATION? ..the field has been used for 1 or more years tillage cropping within the last 10 years (i.e. cereals, potatoes or other cash crops or 2 or more years forage crop).

(c) USED FOR NON-AGRICULTURAL ACTIVITIES?

3. **What use(s) has the field been put to over the last 12 months?**

	1. Use?	2. Use?	3. Use?	4. Use?	5. Use?
Last year.. This year..	July/Aug.	Sept/Oct.	November-February	March-April	May-June

Cattle	C	Setaside	SA
Sheep	SH	Let	LET
Sheep with cattle	SHC	Empty	E
Silage	SG		
Hay	HY	Mixed stock (ie more than one)	M
Horses (with/without sheep)	HS	Poultry	PU
Goats	G	Other ...	
Pigs	P		
Donkeys	D	Unknown	*

4. If the field has been grazed, do you put as many livestock into the field as possible?

YES - the field is used to its potential	1
NO - the field is under-used	2

5. How much <u>inorganic</u> nitrogen have you applied to the field <u>over the last 12 months</u>?

	Units/acre	Kg/ha		
Bagged Nitrogen	1-99 100-199 200 +	1-124 125-249 250 +	Low Medium High	1 2 3

6. Which <u>organic</u> manures have you applied to the field <u>over the last 12 months</u>?

Bagged Nitrogen	Farmyard manure	M1
	12 month FIELD-STORED manure	M2
	Poultry-deep litter	M3
	Poultry-broiler	M4
	Slurry	M5
	Silage effluent	M6
	Other (eg Marinure)	M7
	None	*

7. If you sprayed any herbicide over the field <u>in the last 12 months</u> which one?

Grazon 90	H1
Broadshot	H2
Fette	H3
Garlon	H4
Legumex Extra	H5
Roundup	H6
Casoron G/G4	H7
Timbrel	H8
Dow Shields	H9
Nintx	H10
Alistell	H11
Asset	H12
Asulox	H13
Starane	H14
Other .. (please state)	

And now to the next field.

THANK YOU FOR YOUR HELP.

PLURIACTIVITY FIELD QUESTIONNAIRE

Date(s) of visit .... Farm code ....

Code	Code for answers: 1	Question (3): 1	2	3	4	5	2	3	4	5	6	7
a												
b												
c												
d												
e												
f												
g												
h												
j												
k												
l												
m												
n												
p												
q												
r												
s												
t												
u												
v												
w												
y												
z												

Code	Code for answers: 1	Question (3): 1	2	3	4	5	2	3	4	5	6	7
aa												
bb												
cc												
dd												
ee												
ff												
gg												
hh												
jj												
kk												
ll												
mm												
nn												
pp												
qq												
rr												
ss												
tt												
uu												
vv												
ww												
yy												
zz												

APPENDIX 2

THE LIST OF AREAL AND LINEAR VEGETATION COVER TYPES (AND THEIR CODES) USED WITHIN THE FIELD SURVEY

The definitions and codes are taken from the '1990 Countryside Survey Handbook' with permission from C.J.Barr (ITE, Merlewood).

Areal vegetation types

GRASSLAND

101. **Lowland agricultural grass:** includes any grass crop or pasture in a generally lowland, or enclosed, situation (i.e. most grass).

102. **Upland grass:** natural grassland (unimproved) in an upland situation but with a high proportion of palatable grasses and usually on a mineral soil. Typical species include *Festuca ovina, Agrostis tenuis, Anthoxanthum odoratum, Galium saxatile,* often with bracken.

103. **Moorland - grass:** coarse upland grass in a moorland setting, usually dominated by species such as *Nardus, Molinia, Deschampsia flexuosa, Juncus squarrosus.* Soils usually have a peaty top.

114. **Marsh:** nutrient-rich wetland on predominantly inorganic soil dominated by rushes or sedges.

ARABLE

117. **Wheat**

118. **Barley**

119. **Oats**

121. **Turnips/swedes/roots**

122. **Kale**

123. **Potatoes**

124. **Field beans**

128. **Oil seed rape**

129. **Other crops**

143. **Ploughed**: the crop harvested should be identified (from fragments that remain) and this code used as an extra description. [In this study, this code was only used if the harvested crop could not be identified at all.]

WOODLAND

204. **Belt of trees:** 2 or more trees wide with a width to length ratio of at least 1:5, parallel sided and with a maximum width of 50m.

205. **Clump of trees:** a small woodland or group of trees (6 or more) and of less than 0.25 ha.

206. **Woodland/forest:** an area of trees of more than 0.25 ha (but see belt) and a crown cover of more than 25%.

SCRUB

208. **Scattered scrub:** do not make a clump because their crowns are not contributing 25% cover of the mapped unit.

210. **Patch of scrub:** an area of continuous scrub (canopy >25%) of any size.

MOORLAND

104. **Moorland - shrub heath:** dominated by dwarf shrub spcies often growing on

peat, invariably dominated by *Calluna* or *Vaccinium.*

WASTE/WETLAND

134. **Tall herb vegetation:** semi-natural vegetation, often in wet or disturbed positions; dominated by tall herbs but with grasses present.
141. **Neglected:** agricultural land for which there is no obvious intended change of use, but where the former use has been temporarily neglected (for upto 3 years). **Fallow** land (which has been unused as part of an agricultural rotation) should be recorded here. **Set-aside** land should also be recorded here. [In this study set-aside was recorded in its true covertype, i.e. as being either grassland or within this category.]
142. **Abandonned:** agricultural land which has been neglected for more than 3 years and in which long-lived perennials and shrubby species are becoming established.
108. **Aquatic macrophytes:** major species characteristic of standing water such as *Typha, Ranunculus fluitans* and *Phragmites.*
109. **Aquatic marginal vegetation:** growing at the fringe of open water, e.g. *Valeriana, Epilobium hirsutum, Filipendula, Oenanthe croccata etc.*
113. **Fen:** lowland peat usually dominated by sedges or rushes often with alder or willow.

Linear vegetation types

203. **Line of trees:** must be a single tree width and be at least 20 m long with crown contact.
209. **Line of scrub:** as for trees.
217. **Hedgerow trees:** trees in a hedgerow which are twice the average height of the hedge, or where the hedge has been trimmed to favour the growth of a young tree.
322. **Hedge:** a woody vegetation that has been subject to a regime of cutting in order to maintain a linear shape.

Rules for distinguishing between Grassland and related Cover types

Rules, outlined by R.G.H. Bunce for the ITE's Countryside Survey in 1990, are summarised and more clearly defined, particularly for the ambiguity which sometimes exists for certain vegetation combinations on farmland (e.g. of aquatic marginal with grassland vegetation). These rules were used during the 1991 and 1992 field surveys and also used to check all 'punched in' computer data in November 1992 to ensure consistency of recording between the two years.

Where parcels[1] contain a mixture of indicator species from different vegetation cover types there is a priority system for the assigning of a cover type according to the proportions of the indicator species. Bunce's rules act as a priority system and have been extended to include vegetation typical of ditches and poorly-drained areas on

---

[1] *Parcel* - the term given to a discrete area of land outlined on the vegetation map (also referred to as the vegetation *unit*) to which a cover type code is assigned.

farmland according to their scarcity, i.e. the more scarce the cover type the greater the priority. The order, starting with the cover type of greatest priority, is:

Moorland-shrub heath
Moorland-grass
Upland grassland
Aquatic marginal vegetation
Tall herb vegetation
Lowland agricultural grassland
Marsh.

THE RULES FOR DEFINING EACH VEGETATION COVER TYPE

Indicator species most commonly found within the field survey are listed (in no priority).

104 - Moorland-shrub heath
Calluna vulgaris, Vaccinium myrtillus
The code 104 is given where 104 species constitute at least 25% of a parcel. If the cover of 104 species is {greater than/equal to} any other cover of species (101, 102, 103), the 104 code is given.

103 - Moorland-grass
Nardus stricta, Deschampsia flexuosa, Deschampsia caespitosa
The code 103 is given where species constitute at least 25% cover of a parcel. The priority if 103 > 102 > 101. If the cover of 103 species is {greater than/equal to} the cover of 102/101 species, the 103 code is given.

Where the cover of 102 species is greater than the cover of 103 species, the 102 code is given. Where species of 103, 102 and 101 cover types in more or less equal abundance, 'splitting-the-difference', the 102 code is given.

102 - Upland grassland
Festuca ovina, Agrostis tenuis, Anthoxanthum odoratum
The code 102 is given where species constitute at least 25% cover of a parcel. If the cover of 102 species is {greater than/equal to} the cover of 101 species the 102 code is given.

Where the cover of 101 species is greater than the cover of 102 species, the 101 code is given.

109 - Aquatic marginal vegetation
Filipendula ulmaria, Phalaris arundinacea
The code 109 is given where species constitute at least 25% cover of a parcel. Very often with 101 grasses.

134 - Tall herb vegetation
Chamaenerion angustifolium, Umbellifers (e.g. *Anthriscus sylvatica, Myrrhis odorata*)
The code 134 is given where species constitute at least 25% of a parcel. Very often with

101 grasses.

101 - Lowland agricultural grassland

Lolium perenne, Trifolium repens, Phleum pratense, Dactylis glomerata, Holcus lanatus, Cynosurus cristatus, Festuca rubra, Agrostis stolonifera, Poa spp.

Rules defined for cover types above over-ride these species. However where the cover of 101 species is {greater than/equal to} the cover of 114 species, the 101 code is given. The term "ley" has been applied to 'new' grasslands. In practice an older ley and an intensively managed grassland are very difficult to distinguish. A "ley" cover type was identified for the ITE Countryside Survey 1990 but in practice was not often used. The general consensus among agricultural advisors at the Scottish Agricultural College (Edinburgh) is that the term "ley" has become obsolete. Therefore the code 101 was used for all Lowland Agricultural Grassland fields within this survey in preference to the "ley" (136) code used within the ITE surveys.

114 - Marsh

Juncus effusus, J. articulatus, J. acutiflorus, Moss presence.

The code 114 is given where species constitute at least 50% of a parcel. However the code 114 was given where *Juncus* spp. was the only major constituent at 25-50%, the ground being wet and uncolonised. The presence of *Holcus lanatus* was not taken to be a 101 indicator when it was the only grass species (even at 25-50%).

APPENDIX 3

CALIBRATION OF ARC/INFO AREA/LENGTH READINGS TO KM²/KM

Method

AREA CALIBRATION

1. Five temporary files were created within Arc/Info. Within each a 1000 m^2 square, a 500 m^2 square and a 100 m^2 square were digitised using five copies of the 1:10 000 scale OS maps used for the vegetation mapping. This therefore included the error due to distortion inherent with photocopying.
2. The Arc/Info figures produced were extracted from the Polygon Attribute Table (.PAT) file.
3. Mean readings for 100 m^2 was calculated for each file.

FOR LENGTH

4. A further six files were created. Within each, 1000 m, 500 m and 100 m lengths were digitised using two of the same farms plus four more vegetation maps.
5. Readings were taken from the Arc Attribute Table (.AAT) file.

Results

The Arc/Info readings are presented and the means ± SEs are presented for 100m^2 and 100m. The mean figures are then used to convert Arc/Info readings for farm areas and lengths into hectares and metres.

AREA CALIBRATION

Table A3.1. The Arc/Info readings for digitised areas and conversions to 100m^2.

Farm code of Veg map used	**.PAT file reading**			**Conversions to 100 m^2 (1 ha)**	
	1000 m^2	500 m^2	100 m^2	1000 m^2 to 100 m^2	500 m^2 to 100 m^2
GR005	13.826	-	-	0.138	-
GR007	15.776	3.878	0.150	0.158	0.155
GN013C	15.384	3.871	0.155	0.154	0.155
GN054	15.577	3.851	0.147	0.156	0.154
GN086	15.377	3.819	0.143	0.154	0.152

For the thirteen 100 m^2 (1 ha) estimates:

$$\text{Mean} \pm \text{SE} = 0.1516 \pm 0.022$$

Therefore to convert .PAT file readings into hectares, figures are multiplied by 0.1516.

LENGTH CALIBRATION

Table A3.2. The Arc/Info readings for digitised lines and conversions to 100m.

Farm code of Veg map used	.AAT file reading			Conversions to 100 m	
	1000 m	500 m	100 m	1000 m to 100 m	500 m to 100 m
GR005	3.733	1.882	0.390	0.373	0.376
GR007	3.919	1.957	0.388	0.392	0.391
GR058	3.932	1.967	0.405	0.393	0.393
GN042	3.914	1.966	0.407	0.391	0.393
GN054	3.874	1.928	0.389	0.387	0.386
GN063	3.976	2.015	0.417	0.398	0.403

For the eighteen 100 m estimates:

Mean ± SE = 0.393 ± 0.024 i.e. 0.00393 for one metre.

Therefore, to convert .AAT files into metre lengths, the figures are multiplied by 0.0039.

VERIFICATION

Six random .PAT readings for whole farm coverages were converted to hectares by dividing by 0.1516. These areas were compared to the area recorded by the socio-economic survey which were, theoretically, the same as the SOAFD June Census returns.

Table A3.3. Comparison of the calculated Arc/Info farm areas with the socio-economic survey (hectares).

Farm code	.PAT reading	Calculated area (ha)	Recorded area (ha)
GR910	5.674	37.43	38.9
GR1120	17.219	113.58	119.4
GR056	44.829	295.71	154.0
GR122	12.058	79.54	78.9
GN008	13.514	89.14	89.6
GR064	27.406	180.78	192.0

DISCUSSION

The ARC/INFO readings only include vegetated areas, i.e. they do not include the farm steading or areas of roads. Therefore farm areas were expected to be below the recorded area of the socio-economic survey. This was true for four farms with digitised areas between 0.36 and 11.2 hectares less than the recorded areas.

However, one farm (GR122) had a digitised area slightly above the recorded area (by 0.8%) but roughly estimating the area on the map by counting squares covered under an acetate grid (0.1 ha section) it appeared not infeasible that the recorded area may have been under-estimated.

The recorded area for GR056 was a gross undervaluation. The estimate of the farm area using an acetate grid, was 290-300 ha.

The mean area of the ecology sample farms was calculated using the .PAT readings and the recorded areas from the socio-economic survey. These are compared in Table A3.4.

Table A3.4. Comparison of mean areas calculated from Arc/Info .PAT files and the recorded areas from the socio-economic survey.

Ecology sample farms	Calculated area from Arc/Info readings	Recorded area from the socio-economic survey
	mean (ha) SE	mean (ha) SE
All farms	110.21 ± 1.27	117.84 ± 1.28
Non pluriactive	120.00 ± 2.49	129.45 ± 2.53
Pluriactive farms	103.40 ± 1.33	109.79 ± 1.36

APPENDIX 4

QUALITY CHECK ON VEGETATION MAPPING

Nine 1991-surveyed farms were to be re-visited at three separate times over the summer of 1992. However only five were re-visited during the 19th and 20th August 1992 due to the re-organisation of the farm visit timetable during the survey:

- one was a non-pluriactive farm
- three were from the OFF-FARM group
- one was from the ON-FARM group.

The uneven distribution was due to the lack of time to re-visit the other two farms within the non-pluriactive and ON-FARM groups respectively. Farms within the BOTH group had not been selected during 1991.

Thirty-six parcels were re-mapped, eleven fields and twenty-five adjacent areas such as ditches, verges, headlands or woodland (Table A4.1).

Table A4.1. The number of re-visited parcels within each farm group whether within an open field or an adjacent area such as a ditch, verge, headland or woodland.

Location of vegetation parcel	Non-pluriactive	OFF-FARM pluriactivity	ON-FARM pluriactivity	Total
Open field	2	6	3	11
Adjacent to field	5	15	5	25
Total	7	21	8	36

Differences are classified in 3 groups:

(a) error in observation and/or recording,
(b) management change,
(c) successional change

and at 3 levels:

(1) the delimitation of the vegetation parcel,
(2) the vegetation cover type code,
(3) the determination of the dominant species (i.e. those >25% cover).

Therefore differences are classed as a1, a2, a3... c3.

The description for each survey year are presented in Table A4.2 and summarised in Table A4.3.

Table A4.2. Descriptions obtained for thirty-six vegetation parcels recorded in 1991 and re-visited in 1992. (i) the vegetation cover type, (ii) the dominant species. Percentage covers for each species are not presented (except for forbs and blatant differences) since these will have altered in herbaceous vegetation. Identical descriptions are recorded by a dash.

Farm	Parcel	Description 1991	Description 1992	Explanation
GR004, OFF-FARM pluriactivity	1. Field 1	i) agricultural grass ii) *Lolium perenne* *Trifolium repens*	i) - ii) *Lolium perenne* *Trifolium repens* *Phleum pratense*	a3
	2. Ditch, field 1	i) agricultural grass ii) forbs >25% *A. elatius*	i) - ii) forbs >25%	a3 &/or c3
	3. Field 2	i) agricultural grass ii) *Lolium perenne*	i) - ii) *Lolium perenne* *Holcus lanatus*	c3
	4. Weed infestation, field 2	i) agriultural grass ii) *Holcus lanatus* forbs >25%	i) - ii) docks forbs >10%	c3
	5. Ditch, field 3	i) agricultural grass ii) forbs >50% *Urtica dioica*	i) - ii) -	IDENTICAL
GR007 Non-pluriactive	6. Field 1	i) agricultural grass ii) *Lolium perenne* *Poa annua*	i) - ii) *Lolium perenne* *Trifolium repens*	b3
	7.Woodland, field 1	i) woodland ii) mixed deciduous	i) - ii) -	IDENTICAL
	8. Ditch, field 1	i) agricultural grass ii) *Myrrhis odorata*	i) - ii) *Myrrhis odorata* *A. elatius* forbs >25%	a3 (not c3)
	9. Field 2	i) agricultural grass (3 parcels) ii) bare ground *Poa annua*	i) (1 parcel) ii) *Poa annua* *Lolium perenne* forbs >10%	c1 and c3
	10. Ditch, field 2	i) agricultural grass ii) *Holcus lanatus*	i) - ii) *Holcus mollis* *Dactylis glomerata* forbs >10%	a3
	11.Scrub, field 2	i) agricultural grass & patch of scrub ii) gorse	i) mosaic of scattered scrub & agric. grass ii) -	IDENTICAL
	12. Wood, field 2	i) woodland ii) Mixed deciduous	i) - ii) -	IDENTICAL

Table 4.2. cont

Farm	Parcel	Description 1991	Description 1992	Explanation
GR010 ON-FARM pluriactivity	13. Field 1	i) agricultural grass ii) *Lolium perenne* *Poa annua*	i) - ii) *Lolium perenne*	b3 (silage cut)
	14. Ditch, field 1	i) Scattered scrub ii) gorse and broom	No record. There was no fence on the other side of the ditch, i.e. it is another farm.	a1
	15. Scrub field 1	i) Line of scrub ii) gorse & broom	i) scattered scrub over a wider area ii) -	a2
	16. Scrub field 1	i) Line of scrub ii) gorse	i) patch of scrub ii) gorse	a2
	17.Neglected area, field 1	i) mosaic of agricultural grass & scattered scrub ii) gorse	i) - ii) -	IDENTICAL
	18. Field 2	i) agricultural grass ii) *Lolium perenne* *Trifolium repens*	i) - ii) -	IDENTICAL
	19. Field 3	i) agricultural grass ii) *Lolium perenne* *Trifolium repens*	i) - ii) -	IDENTICAL
	20. corner, field 3	i) neglected ii) bare ground (95-100%)	i) agricultural grass ii) *Matricaria matricaroides* (25-50%)	c2 & c3

Table 4.2. cont

Farm	Parcel	Description 1991	Description 1992	Explanation
GR077 OFF-FARM pluriactivity	21. Field 1	i) agricultural grass ii) *Lolium perenne*	i) - ii) -	IDENTICAL
	22. west of field 1	i) agricultural grass ii) *Lolium perenne*	i) - ii) -	IDENTICAL
	23. Scrub/ boulders area, field 1	not recorded	i) scattered scrub ii) broom	a1
	24. Trees, field 1	i) mosaic of agricultural grass with a belt of trees	i) mosaic of scattered scrub with scattered trees	a2
	25. Verge, field 1	not recorded	i) agricultural grass ii) forbs >50%	a1
	26. Scrub, field 1	i) scattered scrub ii) gorse *Holcus lanatus*	i) line of scrub ii) gorse	a2 & a3
	27. Trees and scrub field 1	i) mosaic of mixed deciduous trees & scattered scrub	Two parcels: i) Clump of trees ii) birch & mixed deciduous. i) scattered scrub & agricultural grass	a2 & a3
	28. Field 2	i) agricultural grass ii) *Lolium perenne*	i) - ii) -	IDENTICAL
	29. Edge field 2	i) line of scrub ii) Hawthorn Gorse	i) - ii) -	IDENTICAL
	30.Shelter break	i) line of trees ii) beech	i) - ii) -	IDENTICAL

Table 4.2. cont

Farm	Parcel	Description 1991	Description 1992	Explanation
GR151 OFF-FARM pluriactivity	31. Field 1	i) Agricultural grass ii) *Lolium perenne* *Trifolium repens*	i) - ii) *Lolium perenne* *Trifolium repens*	IDENTICAL
	32. Scrub, field 1	i) Line of scrub ii) Gorse	i) - ii) -	IDENTICAL
	33. Ditch, first field	i) Agricultural grass ii) *Holcus lanatus*	i) - ii) *Mimulus guttatus* Forbs >10%	a3
	34. Field 2	i) Agricultural grass ii) *Lolium perenne* *Trifolium repens*	i) - ii) *Lolium perenne* *Trifolium repens* *Phleum pratense*	IDENTICAL
	35. Verge, field 2	i) Agricultural grass ii) Forbs >25%	i) - ii) *Holcus mollis* Forbs >25%	a3
	36. Rail banking	i) Agricultural grass ii) Forbs >25%	i) - ii) Forbs >25% *A. elatius* *Chamaenerium angustifolium*	a3

Table A4.3. Summary of each type explanation for recording differences between 1991 and 1992. Where the explanantion was divided between two, each was counted as half in the respective categories.

Explanation	1) Parcel delimitation	2) Vegetation cover type code	3) Identifying the dominant species	Overall
a) Observation/recording	3	4	7.5	14.5
b) Management change	0	0	1	1
c) Successional change	1	1	4.5	6.5
Total	4	5	13	22

Discussion

Fifteen parcels were identified as being identical, including those where descriptions were not exact but either the 1991 or the 1992 description would have been equally likely to be correct (e.g parcel 11). No comparison between the farm groups is made because of the predominance of the OFF-FARM group. However some points are made regarding the recording/observation errors.

One parcel delimitation error, however, (parcel 14) was due to the lack of distinction of the farm boundary in the field. Farm boundaries can be ditches, fences, lines of scrub, lines of trees *etc.* On a number of occassions the completed vegetation map was taken back to the farmer at the end of the day and closed questions were posed, such as:

"Does this line of trees belong to your neighbour or yourself?"

Additions sometimes occurred (such as a belt of trees along a farm track) but most cases were of removal, e.g. lines of trees or scrub, in one case five fields!! In the case of ditches an assumption was made that the farmer managed one side and that the centre of the ditch was the farm boundary.

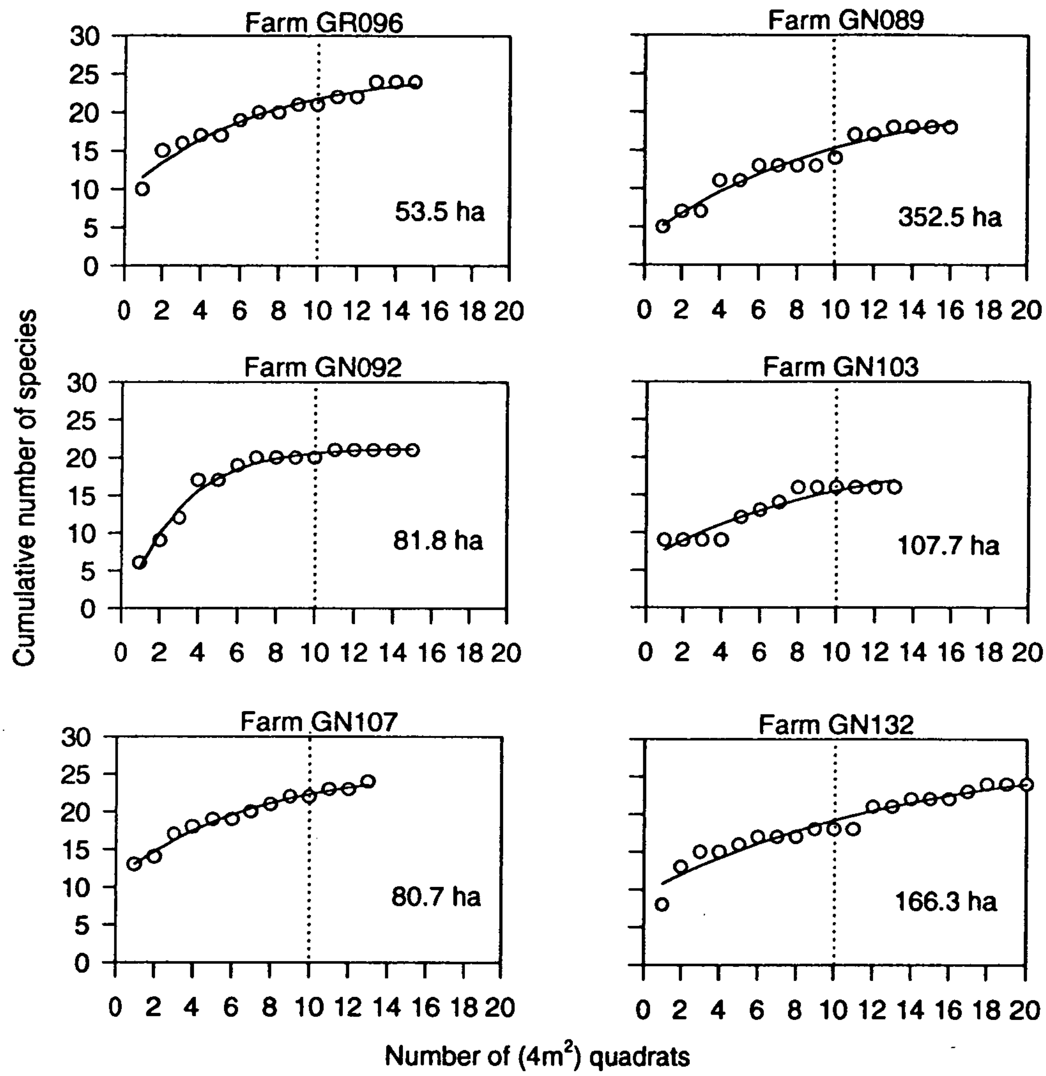
One-third of the observation/recording errors (parcels 15, 16 and 26) was the difficulty in distinguishing between the various categories of scrub. Scrub was mainly gorse. Individual bushes of scrub are difficult to distinguish particularly lines of scrub and long, thin polygons of scattered scrub. The elimination of this error was an acquired skill in the field but, in the above examples, was an error which could go either way.

Another misclassification (parcel 24) involved the writing down of the wrong code; the codes for 'belt of trees' and 'scattered trees' are similar. Some areas (although very few) are just difficult (parcel 27). The need to constantly check the code sheet in the 1992 survey was given even more emphasis as was the checking of the completed vegetation map.

It is likely that the recording of errors in determining dominant species is pessimistic since these can radically alter within a field where management is intensive (and most of Grampian is farmed intensively), for example for *Phleum pratense* to be just under 25% one year but to increase to 30% the next (parcels 1 and 34). The lack of management of herbaceous vegetation in adjacent areas will also allow species composition to alter through natural succession (parcels 10, 33, 35 and 36). However, the dominant species were not used quantitatively in any analyses but used to indicate the most predominant species in each vegetation cover. Although the most frequent discrepancy between the two years, this will therefore not have affected the results presented within the thesis in any way.

HOW EFFICIENT WAS THE USE OF TEN QUADRATS PER FARM WHERE FARMS DIFFERED IN AREA?

Ten quadrats were always placed within the grassland of a farm whatever the area of the grassland or farm. In 1992, extra quadrats were placed on six farms. The number of extra quadrats placed within a farm varied according to the available time.



The curve fitted to the cumulative number of species used the equation $y=a+br^x$ from the GENSTAT (Payne *et al*, 1987) curve fitting program.

The hectares (ha) shown are of the grassland area of the farm. There appears to be no relation to the number of quadrats where the curve of species numbers levels off and the grassland area.

Only two farms appear to have had most of their species recorded from the grasslands using ten quadrats. From these graphs, it would seem that 15-20 quadrats would have been sufficient in obtaining 90-100% of the species in the grasslands for five of these farms.

APPENDIX 6

CHI-SQUARE (X^2) ANALYSES FOR CHAPTER 8.

$X = (\text{obs-exp})^2/\text{exp}$, $X^2 = \Sigma(X)$

All figures have been rounded up to one decimal place from original analyses.

Table 6A-1. The observed and expected frequencies of quadrats between each farm group and each management class.

Farm group	1. Intensive management obs	exp	X	2. Moderately intensive obs	exp	X	3. Moderate management obs	exp	X	4. Low-intensity management obs	exp	X	Σ (obs)
Non-pluriactive	46	31.4	6.8	69	82.0	2.1	105	97.1	0.6	20	29.5	3.1	240
OFF-FARM pluriactivity	17	22.2	1.2	55	58.1	0.2	77	68.8	1.0	21	20.9	0	170
ON-FARM pluriactivity	18	14.4	1.1	33	37.6	0.6	324	44.5	2.5	25	13.5	9.8	110
BOTH pluriactivities	4	17.0	9.9	65	44.4	9.6	47	52.6	0.6	14	16.0	0.3	130
Σ (obs)	85			222			263			80			650

$X^2 = 49.2$, df=9, $P<0.001$

Table 6A-2. The observed and expected frequencies of quadrats between different field uses and each management class.

Cattle	37	33.4	0.4	84	87.1	0.1	107	103.2	0.1	27	31.4	0.6	255
One-cut	18	19.2	0.1	57	50.2	0.9	48	59.5	2.3	24	18.1	1.9	147
Sheep+Cattle	9	11.9	0.7	24	31.1	1.6	49	36.8	4.1	9	11.2	0.4	91
Sheep	8	6.2	0.5	11	16.1	1.6	19	19.0	0	9	5.8	1.8	47
all other uses	13	14.4	0.1	46	37.6	1.9	40	44.5	0.5	11	13.5	0.5	110
Σ (obs)	85			222			263			80			650

$X^2 = 20.1$, df=12, NS

Table 6A-3. The observed and expected frequencies of species within each farm group and each life history strategy (LHS) category for the ***field quadrats***[1].

LHS	Non-pluriactive Obs	exp	X^2 OFF	ON	BOTH	OFF-FARM Obs	exp	X^2	Σ	ON-FARM Obs	exp	X^2	Σ	BOTH Obs	exp	X^2	Σ (obs)
CR	380.5	394.5	0.5	0.1	0.4	318.0	304.0	0.7	698.5	186.5	189.5	0.1	567.0	219.0	223.6	0.1	599.5
CSR	733.0	737.0	0.0	0.3	0.5	572.0	568.0	0	1305.0	363.5	366.4	0	1096.5	413.5	427.6	0.5	1146.5
C	54.0	47.7	0.8	1.0	4.8	30.5	36.8	1.0	84.5	21.0	25.1	0.7	75.0	21.0	28.0	1.8	75.0
R	355.0	340.0	0.7	0.6	0.1	247.0	262.0	0.4	602	182.0	179.5	0	537.0	234.0	219.7	0.9	589.0
SR	12.5	12.7	0	2.1	0.3	10.0	9.8	0	22.5	10.2	7.6	0.9	22.7	17.5	11.2	3.5	30.0
S	17.0	20.0	0.5	1.1	0.1	18.5	15.5	0.6	35.5	15.5	10.9	1.9	32.5	18.0	13.1	1.8	35.0
Σ	1552					1196			2748	779			2331	923			2475
						$X^2 = 5.6$, df=5, NS				$X^2 = 5.4$, df=5, NS				$X^2 = 13.8$, df=5, $P<0.05$			

Table 6B-5. The observed and expected frequencies of species within each farm group and each life history strategy (CSR) category for the ***boundary plots***[1].

LHS	Non-pluriactive Obs	exp	X^2 OFF	ON	BOTH	OFF-FARM Obs	exp	X^2	Σ	ON-FARM Obs	exp	X^2	Σ	BOTH Obs	exp	X^2	Σ (obs)
CR	436.5	450.2	0.4	0.4	0.5	322.5	308.8	0.6	759	167.5	180.6	1.0	604.0	207.5	222.3	1.0	644
CSR	727.0	746.4	0.5	0.1	0.4	531.5	512.1	0.7	1258.5	297.5	306.4	0.3	1024.5	408.5	392.0	0.7	1135.5
C	253.0	220.6	4.8	0	0	119.0	151.4	6.9	372.0	110.5	108.7	0	363.5	135.5	134.1	0	388.5
R	237.0	242.3	0.1	0.4	0.3	171.5	166.2	0.2	408.5	115.5	105.4	1.0	352.5	137.0	129.1	0.5	374.0
SC	32.5	29.4	0.3	2.5	0.5	17.0	20.1	0.5	49.5	28.5	18.2	5.8	61.0	11.5	15.2	0.9	44.0
SR	16.5	16.0	0	0	0.3	10.5	11.0	0	27.0	8.0	7.3	0	24.5	5.5	7.6	0.6	22.0
S	55.5	53.1	0.1	0	0.5	34.0	36.4	0.2	89.5	22.5	23.3	0	78.0	21.5	26.6	1.0	77.0
Σ	1758					1206			2964	750			2508	927			2685
						$X^2 = 15.4$, df=6, $P<0.05$				$X^2 = 11.6$, df=6, NS				$X^2 = 7.1$, df=6, NS			

[1] SC strategists were excluded since expected frequencies ranged between 0.9-5.3; all figures were amended for their exclusion. Where a species was allocated between two life history strategy categories (e.g., C/CR), '0.5' was recorded in both categories.

Table 6B-1. The frequency of boundary plots along each type of boundary and within each farm group.

	Fence	Stone wall	Electric fence	Ditch	Total
Non-pluriactive	86	29	1	2	118
OFF-FARM pluriactivity	55	17	6	2	80
ON-FARM pluriactivity	32	12	4	0	48
BOTH pluriactivities	34	22	3	0	59
Total	207	80	14	4	305

Chi-square analyses were performed on the fence and stone wall data alone. The formula used included Yate's correction factor for 2 X 2 contingency tables.:

$$X^2 = n\{\,|ad\text{-}bc|\,\text{-}½n\} \;/\; (a+b)(ac+d)(a+c)(b+d)$$

where | | indicated absolute values (i.e. not negative) and the characters as shown below:

	Fence	Stone wall	Total
Non-pluriactive farms	a	b	a+b
the pluriactive group	c	d	c+d
Total	a+c	b+d	n

OFF-FARM pluriactivity = 1.7 $\times 10^{-3}$
ON-FARM pluriactivity = 3.9 $\times 10^{-3}$
BOTH pluriactivities = 2.92

No significant difference was seen between any pluriactive group and the non-pluriactive farms; df=1; $P>0.05$.

Table B6-2. The observed and expected frequencies of boundary plots between farm groups and each TWINSPAN group.

	TWINSPAN Ba			TWINSPAN Bb			TWINSPAN Bc			
Farm group	**obs**	**exp**	X^2	**obs**	**exp**	X^2	**obs**	**exp**	X^2	Σ (obs)
Non-pluriactive	7	9.2	0.5	54	54.3	0	59	56.5	0.1	120
OFF-FARM pluriactivity	7	6.5	0	41	38.5	0.2	37	40.0	0.2	85
ON-FARM pluriactivity	5	4.2	0.2	30	24.9	1.1	20	25.9	1.3	55
BOTH pluriactivities	6	5.0	0.2	22	29.4	1.9	37	30.6	1.3	65
Σ (obs)	25			147			153			325

$X^2 = 7.0$, df=6, NS

Table B6-3. The observed and expected frequencies of boundary plots between different field uses and each TWINSPAN group.

Cattle	12	9.4	0.7	54	55.2	0	56	57.4	0	122
One-cut	8	5.7	0.9	29	33.5	0.6	37	34.8	0.1	74
Sheep+Cattle	2	3.6	0.7	25	21.3	0.6	20	22.1	0.2	47
Sheep	2	2.0	0	11	11.8	0.1	13	12.2	0.1	26
all other uses	1	4.3	2.5	30	25.3	0.9	27	26.4	0	56
Σ (obs)	25			147			153			325

$X^2 = 7.5$, df=8, NS

Table B6-4. The observed and expected frequencies of boundary plots falling against different boundary types within each TWINSPAN group.

	TWINSPAN Ba			TWINSPAN Bb			TWINSPAN Bc			
	obs	**exp**	X^2	**obs**	**exp**	X^2	**obs**	**exp**	X^2	Σ (obs)
Wire fence	17	16.2	0	100	92.2	0.7	90	98.3	0.7	207
Stone wall	5	6.2	0.2	30	35.2	0.8	44	37.5	1.1	79
Electric fence	2	1.8	0	4	6.7	1.1	9	7.1	0.5	15
{Ditch/unrecorded}	{1}			{3}			{10}			{24}
Σ (obs)	24			134			143			301

{} = not used in the chi-square analysis

$X^2 = 5.1$, df=4, NS

APPENDIX 7

Species nomenclature follows Clapham, Tutin and Moore (1987) and that of bryophytes, Watson (1981). CR = competitive-ruderals; CSR = 'C-S-R strategists'; C = competitors; R = ruderals; SC = stress-tolerant competitors; SR = stress-tolerant ruderals; S = stress-tolerators (Grime *et al.*,1988).

7A. CLASSIFICATION OF THE FIELD QUADRAT SPECIES INTO 'SPECIES TYPES' AND LIFE HISTORY STRATEGY

Agriculturally Preferred (species sown/encouraged by the farmer)

CSR
Phleum pratense L.
Trifolium pratense L.

C/CSR
Dactylis glomerata L.

CR/CSR
Lolium perenne L.
Trifolium repens L.

Unclassified
Lolium multiflorum Lam.

Agricultural Weeds (species associated with arable fields and poorly managed grasslands)

CR
Agrostis stolonifera L.
Cirsium vulgare (Savi) Ten.
Rumex obtusifolius L.

CSR
Holcus lanatus L.

C
Cirsium arvense (L.) Scop.
Holcus mollis L.
Urtica dioica L.

R
Capsella bursa-pastoris L. Medic.
Gnaphalium uliginosum L.
Matricaria matricaroides (Less.) Porter
Polygonum aviculare agg.
Polygonum persicaria L.
Sagina agg.
Sinapis arvensis L.
Spergula arvensis L.
Stellaria media (L.) Vill
Viola arvensis Murray

SR
Veronica arvensis L.

C/CR
Elymus repens (L.) Gould

R/CR
Chenopodium album L.
Rumex crispus L.
Senecio jacobaea L.
Senecio vulgaris L.
Urtica urens L.

R/CSR
Cerastium fontanum Baumg.
Taraxacum agg.

R/SR
Myosotis arvensis (L.) Hill

Unclassified...
Brassica sp.
Hordeum vulgare L.
Solanum tuberosum

Semi-natural Species (species which are part of semi-natural grassland, i.e. not 'agricultural')

CR
Alopecurus geniculatus
Anthriscus sylvestris (L.) Hoffm.
Equisetum arvense L.
Heracleum sphondylium L.
Ranunculus repens L.

CSR
Agrostis canina L.
Agrostis tenuis Sibth.
Cynosurus cristatus L.
Festuca rubra L.
Glyceria declinata Breb
Plantago lanceolata L.
Poa pratensis L.
Prunella vulgaris L.
Ranunculus acris L.
Rumex acetosella L.
Stellaria holostea L.

C
Fraxinus excelsior L.

R
Juncus bufonius agg.
Lamium purpureum L.
Poa annua L.
Tripleurospermum inodorum (L.) Shulz Bip.

SC
Juncus articulatus/acutiflorus
Lonicera pericylmenum L.

SR
Erodium cicutarium (L.) L'Herit.
Euphrasia spp.

S
Carex ovalis Good
Galium saxatile L.

CR/ CSR
Achillea millefolium L.
Achillea ptarmica L.
Hypericum perforatum L.
Poa trivialis L.
Stellaria alsine Grimm

C/CR
Angelica sylvestris L.

C/CSR
Alopecurus pratensis L.
Vicia cracca L.

C/SC
Acer pseudoplatanus L.
Juncus effusus L.

R/CR
Galeopsis tetrahit L.

R/CSR
Bellis perennis L.
Cardamine pratensis L.,sens.lat
Plantago major L.
Veronica serpyllifolia L.

R/SR
Cardamine hirsuta L.
Crepis capillaris L.
Geranium dissectum L.
Medicago lupulina L.
Trifolium dubium Sibth

SC/CSR
Deschampsia cespitosa (L.) Beauv.

SR/CSR
Anthoxanthum odoratum L.
Juncus bulbosus L.
Rumex acetosa L.

S/CSR
Centaurea nigra L.
Lotus corniculatus L.
Veronica chamaedrys L.
Veronica officinalis L.

S/SC
Carex nigra (L.) Reitchard

Unclassifieds...
Galeopsis speciosa Miller
Hypochoeris spp.

Bryophytes

Brachythecium sp.
Calliergon cuspidatum (Hedw.) Kindb.
Ceratodon sp.
Dicranella sp.
Eurynchium spp.
Hylocomium splendens (Hedw.) B. S. & G.
Hypnum cupressiforme Hedw.
Mnium hornum Hedw.
Philonotis fontana (Hedw.) Brid
Plagiomnium undulatum (Hedw.) Kop
Rhytidiadelphus squarrosus (Hedw.) Warnst

7B. CLASSIFICATION OF THE BOUNDARY PLOT SPECIES INTO 'SPECIES TYPES' AND LIFE-HISTORY STRATEGY

Agriculturally Preferred (species sown/encouraged by the farmer)

same as the field data

Agricultural Weeds (species associated with arable fields and poorly managed grasslands)

CR
Agrostis gigantea Roth.
Agrostis stolonifera L.
Cirsium vulgare (Savi) Ten.
Galium aparine L.
Rumex obtusifolius L.

CSR
Holcus lanatus L.

C
Cirsium arvense (L.) Scop.
Holcus mollis L.
Urtica dioica L.

R
Atriplex patula L.
Bromus hordeaceus L.
Capsella bursa-pastoris (L.) Medic.
Euphorbia agg.
Gnaphalium uliginosum L.
Matricaria matricaroides (Less.) Porter
Polygonum aviculare agg.
Polygonum persicaria L.
Raphanus raphanistrum L.
Sagina agg.
Senecio vulgaris L.
Sinapis arvensis L.
Spergula arvensis L.
Stellaria media (L.) Vill.
Tripleurospermum spp.
Viola arvensis Murray

SR
Veronica arvensis L.

Unclassified...
Avena fatua L.
Avena sativa L.
Brassica napus L.
Hordeum vulgare L.
Solanum tuberosum

C/CR
Elymus repens (L.) Gould

C/CSR
Arrhenatherum elatius (L.) Beauv. ex J. & C. Presl
Elymus caninus (L.) L.

R/CR
Chenopodium album L.
Rumex crispus L.
Senecio jacobaea L.
Sonchus asper (L.) Hill
Sonchus oleraceus L.
Urtica urens L.

R/CSR
Cerastium fontanum Baumg.
Taraxacum agg.

R/SR
Myosotis arvensis (L.) Hill
Viola tricolor L.

Bryophytes

Brachythecium sp.
Calliergon cuspidatum (Hedw.) Kindb.
Ceratodon sp.
Dicranum scoparium Hedw.
Eurynchium spp.
Hylocomium splendens (Hedw.) B. S. & G.
Hypnum cupressiforme Hedw.
Lophocolea spp.
Mnium hornum Hedw.
Pseudoscleropodium purum (Hedw.) Fleisch
Plagiomnium undulatum (Hedw.) Kop
Plagiothecium undulatum (Hedw.) R., S. & G.
Rhytidiadelphus squarrosus (Hedw.) Warnst
Rhytidiadelphus loreus (Hedw.) Warnst.

Semi-natural Species (species which are part of semi-natural grassland, i.e. not 'agricultural')

CR
Alopecurus geniculatus L.
Anthriscus sylvestris (L.) Hoffm.
Equisetum arvense L.
Glyceria fluitans (L.) R.Br.
Heracleum sphondylium L.
Ranunculus repens L.
Tussilago farfara L.

CSR
Agrostis canina L.
Agrostis tenuis Sibth.
Chrysosplenium oppositifolium L.
Cirsium palustre (L.) Scop.
Cynosurus cristatus L.
Epilobium montanum L.
Festuca rubra L.
Glechoma hederacea L.
Lathyrus pratensis L.
Plantago lanceolata L.
Poa pratensis L.
Prunella vulgaris L.
Ranunculus acris L.
Rumex acetosa L.
Silene dioica (L.) Clairv.
Stellaria graminea L.
Stellaria holostea L.

C
Chamaenerion angustifolium (L.) Scop.
Fraxinus excelsior L.
Phalaris arundinacea L..

R
Juncus bufonius agg.
Lamium purpureum L.
Poa annua L.

SC
Calluna vulgaris (L.) Hull
Crataegus monogyna Jacq.
Fagus sylvatica L.
Lonicera pericylmenum L.
Lotus uliginosus Schkuhr
Quercus petraea (Mattuschka) Liebl.
Rubus fruticosus sens. lat.
Rubus idaeus L.
Ulex europeaus L.
Vaccinium myrtillus L.

SR
Euphrasia agg.
Sherardia arvensis L.

S
Campanula rotundifolia L.
Carex spp.
Erica tetralix L.
Festuca ovina L.
Galium saxatile L.
Juncus squarrosus L.
Nardus stricta L.
Primula vulgaris Hudson
Succisa pratensis Moench
Viola riviana/reichenbachiana

CR/CSR
Achillea millefolium L.
Achillea ptarmica L.
Aegopodium podagraria L.
Digitalis purpurea L.
Potentilla anserina L.
Stellaria alsine Grimm.
Poa trivialis L.

C/CR
Angelica sylvestris L.
Mentha spp.
Stachys sylvatica L.

C/CSR
Alopecurus pratensis L.
Vicia cracca L.
Vicia sepium L
Myrrhis odorata (L.) Scop.

C/SC
Acer pseudoplatanus L.
Athyrium filix-femina (L.) Roth
Filipendula ulmaria (L.) Maxim.
Juncus effusus L.

R/CR
Galeopsis tetrahit L.
Lapsana communis L.

R/CSR
Bellis perennis L.
Cardamine pratensis L., sens lat.
Plantago major L.
Veronica serpyllifolia L.

R/SR
Cardamine hirsuta L.
Crepis capillaris (L.) Wallr.
Geranium dissectum L.
Trifolium dubium Sibth.

SC/CSR
Deschampsia cespitosa (L.) Beauv.
Dryopteris dilatata (Hoffman) A. Gray
Galium verum L.
Juncus articulatus/acutiflorus

SR/CSR
Anthoxanthum odoratum L.
Rumex acetosella L.

S/CSR
Alchemilla vulgaris sens. lat.
Centaurea nigra L.
Conopodium majus (Gouan) Lonet
Epilobium palustre L.
Hieracium pilosella L.
Lotus corniculatus L.
Luzula multiflora (Retz.) Lej.
Potentilla erecta (L.) Rauschel
Veronica chamaedrys L.
Veronica officinalis L.

S/SC
Deschampsia flexuosa (L.) Trin
Unclassifieds...
Brassica oleracea L.
Cochlearia officinalis L.
Crepis paludosa (L.) Moench
Crepis spp.
Cytisus scoparius (L.) Link
Epilobium tetragonum L.
Equisetum sp.
Galeopsis speciosa ler
Hypochoeris spp.
Lamium amplexicaule L.
Myosotis spp.
Prunus avium (L.) L
Symphoricarpus albus (L.) S.F.Blake

APPENDIX 8

CORRELATION MATRICES BETWEEN THE SOCIO-ECONOMIC, TIME ALLOCATION AND LAND MANAGEMENT FACTORS WITH THE TOTAL SPECIES RICHNESS OF GRASS FIELDS ON A FARM

The correlation matrices are presented for each farm group using the list of variables outlined in Table 9.3 which are referred to below.

Reference number:
1 = the number of plant species per $40m^2$ of grassland per farm using 10 x $4m^2$ quadrats
2 = the age of the farmer
3 = the mean age of the household
4 = the number of household members
5 = the number of children under the age of 17
6 = the mean income for the farm household members
7 = the proportion of income gained from farming
8 = the number of wage earners in the household
9 = the British Size Unit (BSU), an economic measure of farm size
10 = the number of employees, i.e. workers employed by the farm; full-time = 1; part-time = 0.5; casual/seasonal = 0.25
11 = the average proportion of time given to farming within the week by the household members
12 = the area of grass (ha)
13 = the number of hours given to each hectare of the farmland per week, by farm household members and employees
14 = the proportion of fields stocked with livestock
15 = the proportion of fields stocked with cattle
16 = the proportion of fields stocked with sheep
17 = the proportion of fields which had been reseeded upto 4 years ago from the summer of the survey
18 = the proportion of fields which had received 1-125 kg N/ha over the previous 12 months (referred to as 'young grass')

Non-pluriactive farms
$n = 24$; df = 22
$P<0.05 \geq 0.42$; $P<0.01 \geq 0.54$; $P<0.001 \geq 0.65$

*** Correlation matrix ***

1.	1.000																	
2.	-0.366	1.000																
3.	-0.216	0.811	1.000															
4.	-0.146	-0.213	-0.442	1.000														
5.	-0.032	-0.207	-0.628	0.516	1.000													
6.	0.046	0.381	0.266	-0.011	0.039	1.000												
7.	-0.079	0.161	0.171	-0.175	0.171	-0.102	1.000											
8.	-0.105	-0.038	0.009	0.544	-0.270	0.045	-0.445	1.000										
9.	0.080	-0.130	-0.013	0.474	-0.135	0.234	-0.059	0.569	1.000									
10.	-0.157	-0.075	-0.026	0.350	-0.100	0.223	0.168	0.352	0.819	1.000								
11.	-0.103	0.234	0.326	-0.365	-0.051	-0.043	0.769	-0.458	-0.354	-0.100	1.000							
12.	0.300	-0.389	-0.178	0.523	-0.024	0.107	-0.114	0.576	0.696	0.461	-0.362	1.000						
13.	-0.319	0.235	0.115	-0.085	-0.196	-0.415	-0.157	0.150	-0.442	-0.326	0.030	-0.357	1.000					
14.	-0.254	-0.117	-0.267	0.220	0.184	0.100	-0.186	0.091	0.122	0.047	-0.301	-0.098	-0.258	1.000				
15.	-0.043	0.166	0.113	-0.137	-0.004	-0.264	0.500	-0.188	0.007	-0.015	0.242	-0.243	0.100	0.026	1.000			
16.	0.163	-0.101	-0.279	0.010	0.391	-0.022	0.058	-0.291	-0.349	-0.320	0.150	-0.204	-0.084	0.236	-0.489	1.000		
17.	-0.545	0.222	0.138	0.048	0.131	0.009	0.305	-0.068	-0.196	0.090	0.383	-0.267	0.069	0.047	0.148	-0.069	1.000	
18.	-0.079	-0.004	0.109	-0.007	0.181	-0.183	0.357	-0.332	-0.386	-0.392	0.566	-0.130	-0.059	-0.095	-0.030	0.261	0.319	1.000
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.

OFF-FARM pluriactivity
$n = 17$; df = 15
$P<0.05 \geq 0.46$; $P<0.01 \geq 0.58$; $P<0.001 \geq 0.69$

*** Correlation matrix ***

1.	1.000																	
2.	0.065	1.000																
3.	-0.551	0.378	1.000															
4.	0.645	-0.034	-0.477	1.000														
5.	0.332	-0.210	-0.725	0.370	1.000													
6.	-0.247	0.411	0.305	0.007	-0.044	1.000												
7.	-0.463	0.050	0.502	-0.350	-0.216	0.288	1.000											
8.	0.536	0.076	-0.168	0.898	-0.022	0.115	-0.183	1.000										
9.	-0.089	0.160	-0.070	0.228	-0.093	0.238	-0.207	0.224	1.000									
10.	0.062	0.222	0.037	0.352	-0.181	0.225	-0.362	0.386	0.863	1.000								
11.	-0.709	-0.163	0.312	-0.537	0.058	0.043	0.690	-0.560	-0.143	-0.351	1.000							
12.	0.272	0.232	-0.059	0.787	0.000	0.328	-0.066	0.853	0.603	0.650	-0.323	1.000						
13.	-0.098	0.147	-0.054	-0.117	0.046	-0.456	-0.258	-0.193	-0.402	-0.280	0.066	-0.329	1.000					
14.	-0.270	0.203	0.191	0.117	-0.050	0.325	0.012	0.070	0.229	0.068	0.157	0.277	0.093	1.000				
15.	-0.364	0.373	0.565	-0.268	-0.203	0.393	0.185	-0.239	0.403	0.401	0.341	0.121	-0.343	0.360	1.000			
16.	0.196	-0.306	-0.431	0.358	0.296	0.319	0.034	0.319	-0.034	-0.094	-0.128	0.201	-0.207	0.093	-0.498	1.000		
17.	-0.207	0.028	0.403	-0.204	-0.168	-0.109	0.427	-0.115	-0.224	-0.384	0.401	-0.121	-0.008	0.263	0.229	-0.325	1.000	
18.	0.447	0.000	-0.223	0.136	0.117	-0.517	-0.224	0.089	-0.439	-0.508	-0.204	-0.149	0.410	0.137	-0.440	0.033	0.211	1.0
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.

ON-FARM pluriactivity

$n = 11$; df = 9

$P<0.05 \geq 0.60$; $P<0.01 \geq 0.74$; $P<0.001 \geq 0.85$

*** Correlation matrix ***

1.	1.000																	
2.	-0.091	1.000																
3.	-0.060	0.235	1.000															
4.	0.098	-0.088	-0.752	1.000														
5.	0.121	-0.160	-0.829	0.832	1.000													
6.	-0.444	0.214	0.064	-0.181	-0.025	1.000												
7.	-0.093	-0.310	-0.334	0.349	0.473	0.113	1.000											
8.	-0.045	-0.001	-0.305	0.719	0.230	-0.223	-0.021	1.000										
9.	-0.475	0.083	-0.583	0.700	0.594	0.399	0.413	0.512	1.000									
10.	-0.661	0.230	-0.241	-0.010	0.101	0.224	-0.315	-0.058	0.389	1.000								
11.	0.054	0.172	0.294	0.130	0.140	0.346	0.265	-0.003	0.108	-0.458	1.000							
12.	-0.213	-0.224	-0.356	0.600	0.361	0.279	0.405	0.656	0.756	-0.057	0.085	1.000						
13.	-0.015	0.460	0.216	-0.332	-0.383	-0.232	-0.687	-0.156	-0.397	0.229	-0.209	-0.532	1.000					
14.	0.057	-0.182	-0.091	-0.008	-0.164	-0.567	0.104	0.092	-0.258	-0.273	-0.269	-0.140	0.465	1.000				
15.	0.034	-0.372	-0.562	0.511	0.387	-0.396	0.402	0.478	0.226	-0.070	-0.478	0.415	-0.331	0.348	1.000			
16.	-0.044	-0.463	-0.056	0.209	0.072	-0.103	-0.185	0.287	0.104	0.068	0.186	0.037	-0.212	-0.191	-0.213	1.000		
17.	-0.399	0.038	-0.166	0.070	0.041	0.373	-0.166	0.198	0.460	0.662	-0.396	0.326	-0.369	-0.666	0.086	0.196	1.000	
18.	-0.492	-0.276	-0.225	-0.062	-0.120	0.409	-0.305	0.121	0.351	0.553	-0.392	0.323	0.096	-0.079	-0.075	0.343	0.526	1.0
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.

BOTH pluriactivities

$n = 13$; df = 11

$P<0.05 \geq 0.55$; $P<0.01 \geq 0.68$; $P<0.001 \geq 0.80$

*** Correlation matrix ***

1.	1.000																	
2.	0.169	1.000																
3.	0.464	0.434	1.000															
4.	0.008	0.575	-0.288	1.000														
5.	-0.314	0.101	-0.673	0.672	1.000													
6.	-0.016	0.194	0.590	-0.543	-0.601	1.000												
7.	0.300	0.364	0.615	-0.009	-0.289	0.505	1.000											
8.	0.258	0.306	-0.046	0.549	0.063	-0.550	-0.029	1.000										
9.	0.142	0.454	0.088	0.432	0.281	-0.130	0.500	0.493	1.000									
10.	0.506	0.396	0.541	0.159	-0.156	0.164	0.493	0.000	0.431	1.000								
11.	0.239	0.188	0.157	0.412	-0.008	0.013	0.676	0.183	0.343	0.507	1.000							
12.	0.186	0.305	0.285	0.331	0.183	-0.163	0.503	0.235	0.636	0.515	0.402	1.000						
13.	-0.194	-0.074	-0.509	0.582	0.304	-0.548	-0.338	0.375	-0.155	-0.092	0.411	-0.237	1.000					
14.	-0.017	0.439	0.242	0.467	0.144	-0.274	0.206	0.182	0.006	0.199	0.354	0.340	0.297	1.000				
15.	-0.225	0.026	-0.313	0.585	0.311	-0.591	-0.385	0.474	0.059	0.113	0.223	0.182	0.759	0.251	1.000			
16.	0.356	0.156	0.579	-0.346	-0.615	0.525	0.566	-0.244	0.011	0.507	0.355	-0.034	-0.189	0.209	-0.411	1.000		
17.	-0.320	0.236	0.133	-0.154	-0.410	0.326	0.082	0.031	-0.194	-0.269	-0.045	-0.370	0.071	0.311	-0.234	0.429	1.000	
18.	0.069	-0.139	-0.277	0.342	0.498	-0.381	0.191	0.003	0.068	-0.066	0.447	-0.037	0.355	0.323	-0.029	-0.055	-0.219	1.0
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.

APPENDIX 9

PUBLISHED PAPER, REPRODUCED WITH PERMISSION FROM THE BRITISH GRASSLAND SOCIETY.

In: *Grassland Management and Nature Conservation* (eds R.J. Haggar & S. Peel), pp 261-263. British Grassland Society Occasional Symposium No. 28.

Biodiversity, Land Use and Management: the Role of the Farm Household

N.E. ELLIS AND O.W.HEAL
Institute of Terrestrial Ecology, Bush Estate, Penicuik, Midlothian EH26 OQB

INTRODUCTION

In 1991, a socio-economic survey of Grampian farm households revealed that farms earning non-agricultural income, i.e. 'pluriactive' farms (Dent, 1993), have trebled in number since 1980. Pluriactive farms were grouped into three types: farms earning extra income exclusively 'OFF-FARM', farms earning non-agricultural income exclusively 'ON-FARM' (e.g. Bed and Breakfast) and farms earning non-agricultural income 'BOTH' off-farm and on-farm. This study was designed to assess the effect of type of pluriactivity on land use and plant species diversity. A vegetation survey was carried out on seventy-one farms which were stratified by type of pluriactivity and by the Institute of Terrestrial Ecology (ITE)'s Land Classification system, which takes into account the physical characteristics of the land (Bunce and Heal, 1984).

METHOD

Occupier interviews provided details for 694 grass fields: whether the field was permanent grass or in arable rotation, its current use, year of last reseed and rate of inorganic nitrogen application. The extent of grassland was obtained by producing habitat maps of each farm at 1:10 000. Species data were collected from 414 grass fields using 10 randomly-placed 2 x 2m quadrats per farm. The proportion of grassland and of grass fields within each land use/management category and the mean number of species per field quadrat were compared between the type of pluriactivity and non-pluriactive farms using analyses of variance.

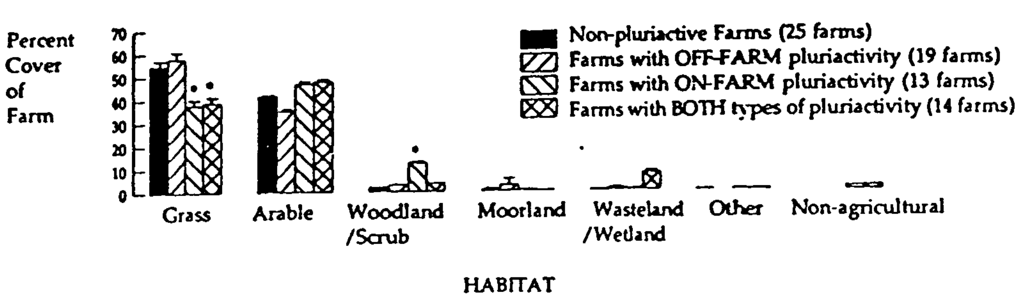


Fig. 1. Pluriactivity and land use as represented by the proportion of each habitat
Bars indicate s.e. about the mean. *$P<0.05$ significance between type of pluriactivity and non-pluriactive farms.

RESULTS

ON-FARM and BOTH had proportionally less grass ($P<0.05$) than non-pluriactive farms (Fig. 1) and OFF-FARM had less grass in arable rotation ($P<0.05$).

OFF-FARM and BOTH had a greater proportion of fields classified as 'sheep' and 'sheep with cattle' ($P<0.05$) whilst ON-FARM had the least number of fields with livestock. There was a tendency for OFF-FARM and BOTH to have older grass swards and ON-FARM to have most grass under four years. All pluriactive farms tended to use less inorganic nitrogen. Even when the same use is applied to a field, plant species diversity was generally greater within OFF-FARM and least within non-pluriactive and ON-FARM (Fig. 2). Farms with BOTH types of pluriactivity were found to have significantly ($P<0.05$) more weed species.

The socio-economic survey revealed that farmers within non-pluriactive farms were older than those from pluriactive farms ($P<0.05$) whilst farmers within OFF-FARM were older than other pluriactive farmers ($P<0.05$). Sixty percent of household members working off-farm (OFF-FARM and BOTH) were *not* the farmer although 54% of household members involved in ON-FARM pluriactivity were the farmer and were well educated.

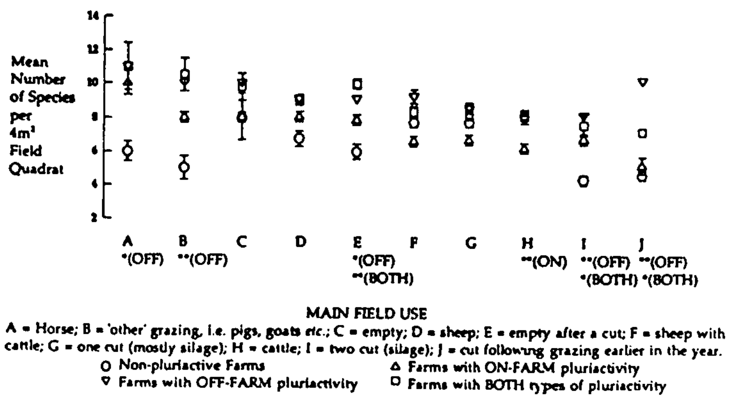


Fig. 2. Plant species diversity in relation to pluriactivity and grassland use shown by the mean number of species within the grass field quadrats.

CONCLUSIONS

Differences in farmland ecology and the type of pluriactivity taken up are attributed to the socio-economic characteristics of the household. Farmers with the most extensive and species-rich grasslands appear to have few successors to continue farm management with off-farm work appearing to be more attractive than a future on the farm. The younger farmers appear to be reducing the extent of grassland and either managing grass fields more intensively, which reduces species diversity, or with less diligence, increasing weed populations.

ACKNOWLEDGEMENTS

This project was funded by the Economic and Social Research Council as part of the Joint Agriculture and Environment Programme (JAEP).

REFERENCES

BUNCE R.G.H. and HEAL O.W. (1984) Landscape evaluation and the impact of changing land use on the rural environment: the problem and an approach. In: Roberts R. D. and Roberts, T. M. (eds) *Planning and Ecology*, pp.164-188. Chapman and Hall.

DENT J.B. (1993) *Pluriactivity in the Agricultural Sector, Scotland*. JAEP Final Report to the Economic and Social Research Council.