Extensive livestock systems and biodiversity: The case of Islay

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ABSTRACT

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The relationship between extensive livestock systems and biodiversity has been examined in a case study on the Island of Islay (UK). As an introduction literature and relevant policy regulations have been reviewed. Farmers have been interviewed on agricultural, ecological and socio-economic aspects of extensive livestock farming. Requirements of typical bird species have been matched with land-use, farming practices and consequent habitat diversity. Variation within and between fields appears to be an important condition for typical bird species. Vegetation has been described by means of quadrate sampling in five different grazing situations. Occurrence of typical species of wet acid grass- and moorland appears to be linked to grazing with low livestock density. Analysis results show that such typical species may be lost due to either intensification or abandonment of grazing on rough grazing fields. Recent agricultural policy measures appear to have been effective in impeding the increase of livestock numbers of the last ten years. Both rural development and environmental policy have become very important in terms of the income they provide for farmers. Recent and future changes in the CAP (Common Agricultural Policy) and LFASS (Less Favoured Area Support Scheme), however, yet seem to favour intensive farms over extensive ones.

Keywords: agricultural policy, biodiversity, bird ecology, cattle grazing, environmental policy, extensive land-use, farmers' income, livestock farming, pastoralism, vegetation ecology

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Contents

Annexes

Preface

The present study has been performed in the context of the EU-Concerted Action project PASTORAL (2000-2003): The agricultural, ecological and socio-economic importance of free ranging livestock rearing in Europe. The project aims at understanding how such extensive livestock systems function, how agricultural practices and ecological conditions interact and how policy driving forces influence such systems. Concerning the latter aim, the Concerted Action may contribute to an improvement in the appropriateness and effectiveness of agricultural policies targeted at the existing large remnants of pasture lands used for extensive livestock rearing. It will also highlight areas of Europe which are being abandoned by other types of farming systems and where the introduction of pastoralism might provide a viable sustainable alternative to maintain rural communities and benefit the environment.

One of the activities consists of four workshops, all of which being held in important regions for extensive livestock farming. Participants from many countries have visited farms and farmers to learn about farm and livestock management, effects on grazing and abandonment of grazing on nature, and social and economic conditions for the continuity of this way of land-use. The third workshop was held at the Scottish Island of Islay, in July 2002. The questions to be answered at this workshop were:

- How should we quantify the nature conservation importance of extensive livestock systems?
- How do the ecological components interact with the agricultural management aspects and what socio-economic and policy drivers are affecting them?
- What are the current effects of policy on the viability of these agricultural systems and on what aspects of management in particular?

Bastiaan Brak and Lammert Hilarides explored those questions in a case study on Islay as a preparation for this workshop, in the context of their study for a Masters degree at Wageningen University and Research Centre. The study has been performed at Alterra Green World Research, under supervision of Dr. Berien Elbersen and Dr. Walter van Wingerden. In order to support the hypothesis that extensive livestock farming is a precondition for high diversity systems, the relationship between typical birds and plant species and extensive livestock farming has been studied in detail. During the workshop results have been presented on the impact of farming practices and farmland diversity on bird fauna by Lammert. Bastiaan presented results on the effect of grazing on plant species composition in pasture fields differing in area, history, grazing management and grazing pressure. After the workshop they produced the present report that includes not only a comprehensive description of their joint ecological and interview study, but also reviews of literature on the effects of grazing on nature as well as on relevant policy regulations. It was concluded at the third workshop already that their approach presents applicable methods for studying and explaining how landscape and nature

values are influenced by land-use and land-use intensity. Moreover, that it contributed greatly to the results of this workshop and the PASTORAL project as well.

The authors thank farmers at Islay for their readiness to participate in the interviews and give extensive information. Workshop participants and colleagues at Alterra are greatly acknowledged for discussion and information. Special thanks go to: Eric and Sue Bignal, ecologists and farmers at Islay, for their hospitality, practical help, advice and comments; to Sally Huband, Pastoral project officer, for her inexhaustible enthusiasm and support; and to Dr. David Kleijn for supervision on behalf of the Nature Conservation and Plant Ecology Group of Wageningen University. The study has been supported by the before mentioned EU-supported Concerted Action Project PASTORAL, the DWK-Research Programmes of the Dutch Ministery of Agriculture, Nature and Food Quality 382: Regional Identity and Nature- and Landscape Development (co-ordinator Dr. Kees Hendriks) and 383: Biodiversity Research (Dr. Rienk-Jan Bijlsma).

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Summary

This study focuses on the relationship between extensive livestock systems and biodiversity. This relationship has been studied by reviewing literature and policy regulations, and performing a case study on the Scottish Island of Islay. This case study consists of interviewing experts and farmers on land-use, farming practices, farm economics and income under current and future regulations. Secondly, bird data from literature have been linked to the before mentioned land-use and farm management data. Thirdly, effects of grazing on vegetation have been studied in the field.

The first question to be answered is: How does extensive livestock farming contribute to high nature value? It is concluded that the quite strong natural diversity at Islay is further enhanced by the variation created by extensive livestock farming, as demonstrated by the division of farmland into permanent grassland, rotational arable cropping and rough grazing fields. Each of those habitats has its own bird species. Moreover, many bird species need more than one habitat, often a combination of natural and (different) agricultural habitats. So, both, different types as well as different intensity of land-use are a landscape precondition for high bird habitat diversity c.q. species diversity.

From the vegetation data it has been concluded that grazing influences plant species composition, and that this influence depends on the intensity of grazing, soil conditions and their interaction. Typical plant species associated to the relevant habitat: *Northern Atlantic wet heaths* with *Erica tetralix* (EU-Habitat directive) have been described in a large rough grazing field on deep peaty soils and where stocking densities were relatively low as well. Higher stocking levels generally were associated with vegetation rich in grasses and sedges, but poor in such typical species. The absence of grazing was found to affect vegetation composition as well; particularly on 'dry heath patches' where *Calluna vulgaris* shrubs are not suppressed by grazing and by coastal winds this species develops so dominantly that less vigorous plants and bryophytes are likely to disappear. The latter two situations reflect the possible future development of extensive livestock farming to either more intensive farming, or abandonment, respectively.

Specific conditions which have contributed to high biodiversity level at Islay, are a low input of artificial fertilizer on permanent grassland and rough grazing fields, low stocking densities on the permanent grasslands and the rough grazing, little drainage, late cutting of hay or silage, large rough grazing fields with large gradients in grazing pressure, the presence of livestock carcasses, spring sowing of cereals, a restricted use of pesticides, and – last but not least – a high diversity in farmland habitats. All those conditions are linked to extensive livestock farming and enhance both farmland- and species-diversity.

Both intensification and abandonment will lead to loss of farmland diversity, and consequently to loss of habitat diversity which in turn implies loss of habitat types, and therefore a loss of species, c.q. biodiversity. This process will lead to a more uniform and species-poor agricultural landscape. It has been concluded that extensive livestock farming creates a diverse and species-rich agricultural landscape, by variation in land-use, by differences in land-use intensity between fields, and by intensity gradients within fields.

The second question to answer is: What are the effects of policy on extensive livestock farming on Islay? It has been concluded that recent agricultural policy measures have been effective in impeding the steady increase in livestock numbers of the past ten years. Also, the LFASS, agri-environment schemes and environment schemes make up for a significant part of farmers incomes and therefore are to be considered as an important precondition of today extensive farming. The recent changes in the LFA scheme, especially the introduction of Grazing Categories, and the reform of the CAP, where the payment is based on a reference period, still seem to favour intensive farms over extensive ones.

1 Introduction

1.1 Context and problem statement

The present European landscape is considered to be the outcome of a long interdependent relationship between the natural environment and the activities of man (Tubbs, 1997; Vera, 2000). Within this man-influenced environment, agriculture is the principal land-use activity. More than half of the territory of Europe is currently managed by farmers (Vidal, 1999). In particular, grazing by free-ranging herbivores has been an important factor in the development of cultural landscapes and many semi-natural habitats are still present in large areas of Europe (Vera, 2000; Bignal & McCracken, 1996).

Ever since the introduction of the Common Agricultural Policy (CAP) in 1957, agriculture in the European Union Member States has been intensified with the introduction and increased use of high energy inputs through e.g. agro-chemicals, concentrates and machinery. The original aims of the CAP were to ensure food supplies and agricultural incomes in Member States. It has resulted in farm specialisation, with increase in average farm size and reduction of the labour force. This process of intensification and modernisation has been accompanied by the spatial polarisation of agricultural land-use, with modernisation in most of the favourable locations at the one hand and abandonment of farming in unfavourable locations at the other hand (Goss et al*.,* 1998). In certain regions, the wild and remote ones, low-intensity pastoral and mixed farming systems have remained practically unchanged (Beaufoy et al., 1994).

Low intensity pastoralism can be defined as "farming systems which are heavily dependent upon vegetation composed of wild plant species for grazing or fodder production" (Hopkins, 1991). The definition given by the European Environment Agency (Internet: EEA) for 'extensive farming' is: "a farming system often practised on larger farms, characterised by low levels of inputs per unit area of land; in such situations the stocking rate, the number of livestock units per area, is low." In the 'Nature of Farming' (Beaufoy et al., 1994) it was estimated that the area with extensive livestock farming in Europe could well exceed over 30 million hectares. Most of these areas are situated in mountain areas of Europe and a very large part of these are concentrated in the central and Eastern European countries. In the UK we find most of the extensive livestock farming systems in the western parts of Scotland. Islay, one of the inner Hebrides Islands, is an example of a region in which the majority of farm land is used for extensive grazing.

Both the large proportion of semi-natural vegetation used for grazing *and* the low stocking density are the main attributes of the extensive livestock systems on Islay, being the central topic of this study. Other typical characteristics of these extensive livestock systems are: lack of fundamental alteration of the land, adaptation of the management to natural constraints and generally low levels of external inputs such as fertilisers and agrochemicals (Elbersen, 2001).

There are several arguments for addressing the important link between extensive livestock farming and high nature values both in European research *and* in policy. Firstly, several studies have shown that biodiversity tends to decline in areas where traditional extensive farming systems have been replaced by more intensive farming systems (e.g. Dunford and Feehan, 2001; Heath et al., 2000; Bignal & McCracken, 1996 & 2000; Diemont, 1996; Schaminée and Meertens, 1992; Miles, 1981). This has contributed to the argument that these extensive systems are of high nature value and need to be conserved. Secondly, recent research (e.g. Bunzel-Druke et al., 2002; Dirkx, 2002; Vera, 2000) shows that the native vegetation has been adapted to grazing over a very long period of time. In former times, large herbivores were a natural component of the ecosystem. Most present day open habitats have been created and maintained by grazing. Therefore, it seems logical that these habitats and all of their functional components have developed under the influence of grazing animals. The importance of these grazed habitats is further underlined by the large number of species of different biota that rely on these habitats (see e.g. Bignal & McCracken, 1996 & 2000 and Tucker and Evans, 1997).

For many years, nature conservation in Europe focused on sites of special interest, such as National Parks and wetlands. However, it has become increasingly apparent that, to sustain regional biodiversity effectively, conservation measures should extend beyond the boundaries of these sites to cover the wider countryside (Fletcher, 1990 and Lucas, 1992). It is now recognised by the European Union that extensive farming systems are associated with a large proportion of Europe's high nature value landscapes and moreover, that they should be maintained, not only because of high nature value, but also for their cultural and aesthetic values (e.g. Wascher, 2000).

Until about ten years ago, agricultural policy measures throughout the European Union mainly consisted of production-supporting measures in the form of market price support and direct payments to the farmers. Since 1992 however, a number of reforms of the CAP have taken place, acknowledging the need to discourage further increases in production and intensification. An important Regulation (92/2078) has been introduced in this period as a consequence of which member states could implement a number of agri-environmental schemes. In the next reform, Agenda 2000 in 1999, increasing emphasis has been placed on environmental management as an objective of agriculture policy. Following the European Commissions' Mid Term Review of the CAP in 2003 a further decoupling of price support from production and an increase in funds for Rural Development Regulation measures has been accepted by the Council of Agriculture Ministers. The current emphasis on "extensification" underpins the increased interest in conserving the wider environment, the landscape and the species diversity. The link between these landscape and biodiversity values and extensive farming also supports the concept of a multifunctional 'European model of farming' which implies that farming does not only provide food but also other benefits. This is also a reason why the issue of high nature value farming has been brought into the discussion on agri-environmental indicators for monitoring the integration of environmental concerns into the Common Agricultural Policy (CEC, 2000).

Being concerned with the rapid decline and loss of extensive livestock farming and related biodiversity, organisations such as the European Forum on Nature Conservation and Pastoralism (EFNCP) raise awareness for the high nature value of extensive farming systems amongst policy-makers in Brussels (Internet: EFNCP). Another linked initiative is 'PASTORAL', a European Commission funded Concerted Action, which brings together ecologists, socio-economists, policy experts, farmers and agricultural extension workers. The overall objective of this project is to identify the main gaps in knowledge that need to be filled before practicable (policy) solutions can be found to support the survival of extensive livestock farming that is of high nature value. A series of four workshops provided a comprehensive pan European overview of the present knowledge and information gaps (see Internet: Pastoral project) in relation to high nature value farming.

This is the report of a case study undertaken as part of the PASTORAL project in preparation of the third workshop, held on the Hebridean island 'Islay', Scotland, in June/July 2002. The workshop was focused on the importance of pastoral farming for maintaining biodiversity values. This study provides an example of the interdependent relationship between extensive livestock farming and biodiversity values on Islay especially in relation to birds and vegetation diversity.

1.2 Research questions and structure of the study

The overall objective of this study is to create a better understanding of the relationship between extensive livestock systems and biodiversity on Islay. In order to do so, the following questions need to be answered:

1. How does extensive livestock farming contribute to high nature value?
We will focus on the relationship between livestock farming practices *and* vegetation and bird diversity. Two more detailed questions will be studied:
- *What is the importance of extensive livestock farming for birds?*
- *What are the effects of grazing on the vegetation?*

The second research question is related to the policies which affect farming and therefore directly and indirectly influences biodiversity on Islay:

2. What are the effects of policy on extensive livestock farming on Islay?
In the next chapter the approach of this study is further discussed.

1.3 Research approach

In this study it is expected that there is a positive relationship between extensive livestock farming practices and biodiversity and landscape values. Since the policy measures in the field of the CAP and rural development, as well as nature conservation policies influence a farmer's decision, it is also assumed that there is an important indirect influence of policy measures on farm land biodiversity. The extensive farming systems, biodiversity and landscape and policy can therefore be regarded as the main ingredients of this integrated assessment study.

The assumed positive relationship between extensive livestock farming practices, biodiversity and landscape values is the reason why these farming systems are considered to be of 'high conservation value' (Anger et al., 2002; Bignal and McCracken, 1996; de Miguel & de Miguel, 1999; Nagy, 2002), not only in the case of Islay but every where in Europe where these farming systems remain. The landscape values these farming systems are assumed to be influencing on are especially related to characteristics such as openness, diversity, and presence of specific cultural and historical elements. The former include hedges, stonewalls, traditional buildings but also long established traditional farming which involve practices such as shepherding, transhumance, and the use of traditional breeds. The biodiversity values, or high nature values, resulting from extensive farming practices are the result of a more complex system in which farming practices are assumed to be adding to the presence and quality of certain habitats and ecological niches which are of importance for different species of different biota. In this study the focus will especially be on the relationship between extensive livestock farming practices and birds and plant diversity. This is a conscious choice based on the fact that the presence of a large number of birds and a large range of different natural and semi-natural vegetation communities are the most important assets of Islay.

A conceptual overview for the situation on Islay, in which the relationships between extensive livestock farming, high conservation value and policy are schematically presented, is given in Figure 1.1. On the one side, the high conservation value is determined by the way livestock farming influences the landscape values. This aspect is important for the cultural and aesthetic values and appreciation of landscapes. On the other side, the conservation value of extensive livestock farming is also related to the high nature values associated to the extensive livestock practices. It is this relationship with nature value which is the central focus of this study. It is studied through looking more specifically to birds and vegetation diversity on the Island of Islay and relating it to specific past, present and future farming practices.

It should be realised that the term "high nature value" is strongly related with and can sometimes be replaced by the wider term biodiversity. Biodiversity is often used to refer to species diversity and in particular, species richness. However this only gives a partial indication of biodiversity. For example: some habitats are naturally species-poor, but are still valuable as they support a variety of rare plant and animal species which are adapted and restricted to this habitat (Inskipp, 2000). On the other hand, some woodland plant communities are naturally relative rich in species, while the community itself cannot be considered of specific natural interest.

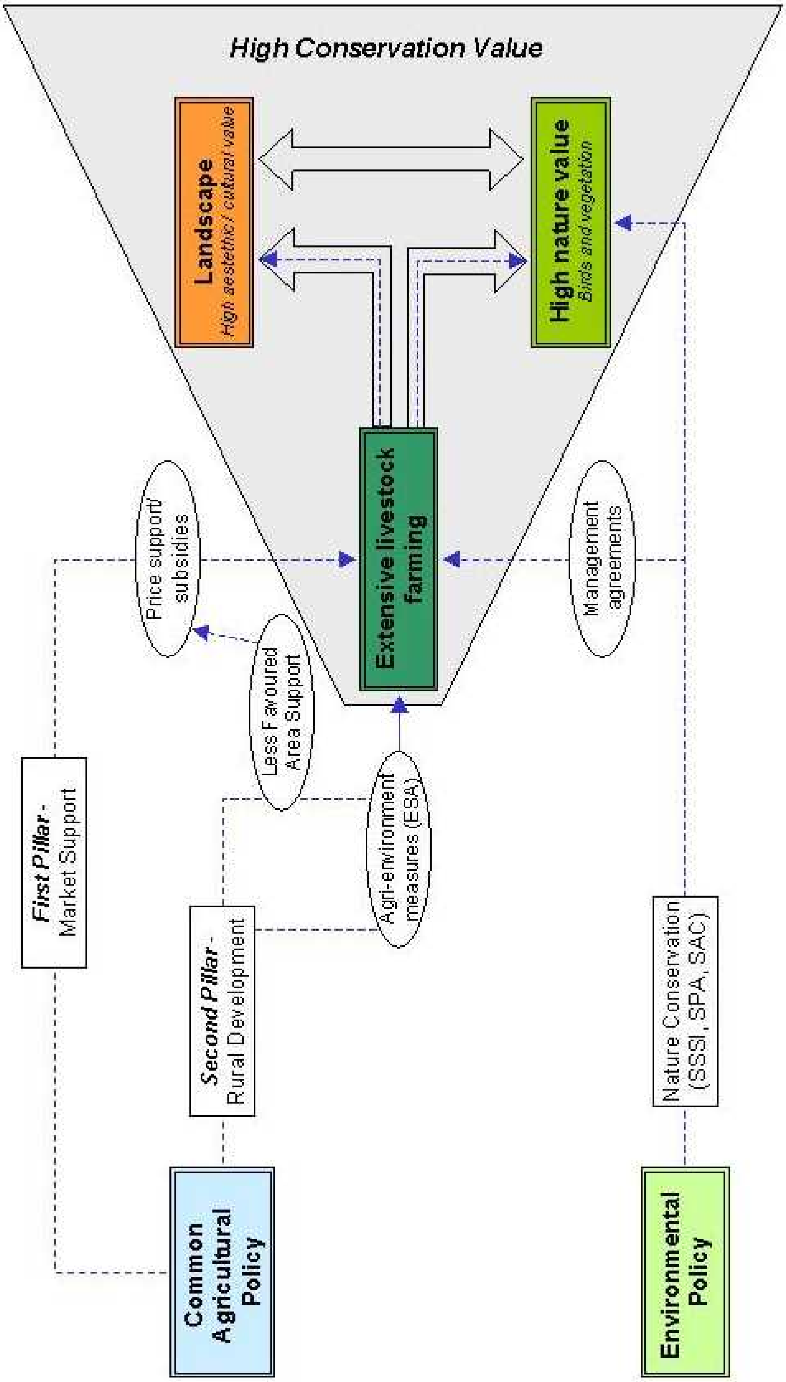

Figure 1.1 Schematic overview of the relationship between extensive livestock farming and high nature values

The influence of policy on the relationship between farming practices and high nature value is also analysed in this study. Figure 1.1 shows that in this study a distinction is made between agricultural policy and environmental policy. Each type of policies affects the 'High Conservation Value' indirectly by influencing on the farming practices and especially the changes in these practices. The Common Agricultural Policy consists of two 'pillars'; the first pillar is formed by all market support arrangements of which the livestock premia are the most relevant to Islay farmers.

The second pillar is formed by Rural Development Measures like the special support measures for farmers in Less Favoured Areas (LFAs) and the agri-environment measures. Since its introduction in 1975, LFA policy was perceived as a structural policy aimed at prevention of land abandonment and population decline and conservation of the countryside (Dax and Hellegers, 2000). Payments came in the form of compensatory allowances to offset natural handicaps in agriculture. Other specific measures included the investment aids for farm modernisation and complementary livestock premia. Since the Island of Islay is located within the Scottish LFA area farmers qualify for these extra support payments.

The second group of policy measures are for nature conservation. They are aimed at designating areas for the protection, enhancement or re-establishment of natural values. These designations can be based on regional, national and international policy and are relevant for farming if farmed land is located in the designated areas. They qualify farmers for management agreements, of which the contents may be rather similar to some agri-environmental measures.

One of the key elements within the Agenda 2000 reform and the current Mid Term Review is the shift in support (modulation) from production-linked subsidies ('Pillar 1' of the CAP) to wider agri-environment and rural development measures ('Pillar 2'). In addition, there is a trend towards linking agricultural policy to nature conservation policy through compulsory agri-environmental tiers. In this sense the Good Farming Practises rules were introduced in which direct payments will be conditional to respecting statutory legal standards and keeping land in good agricultural conditions (Scottish Executive, 2002). This is known as 'cross compliance'. Agri-environmental schemes are very important for and are now being implemented in the key priorities of the Natura 2000 network and the Biodiversity Action Plan (BAP) (see also section 3.5).

Since this study had to be carried out in a very short period of time, there was only limited time available to collect empirical data in the field. Part of the study is therefore based on existing data and literature sources. The following steps were followed:

- Firstly, a literature review was carried out to identify the positive and negative effects of different aspects of extensive livestock farming practices on a selection birds and plant communities. This was especially necessary for birds since long-term bird records for Islay are hardly available and collecting field data was not possible given the limited time and financial resources.
- Secondly, data were collected on the effects of grazing on plant diversity by sampling vegetation plots with different levels of grazing intensity.
- Thirdly, the information derived from the vegetation survey in the field and the literature review was then used to design a questionnaire for farmers in Islay in order to derive empirical information on farm land practices and the influence of policies on farming.

- Fourthly, using the questionnaire, 14 out of a total of 120 farmers were then interviewed. To link present and future policy through farming practices to biodiversity, the farmers were also asked several questions about income support measures, their participation in agri-environment programmes and the way they would respond to future policy changes.
- Finally, all results were analysed, integrated and reported. The results are described in this report in chapter 5.

1.4 Report structure

This report has six chapters. In the second chapter the main characteristics of the case study area are discussed to get a better understanding of the geographic, physical, historical, socio-economic and political context that influences extensive livestock farming on Islay. In chapter three a literature review is given, covering the theoretical aspects of the relationship between extensive livestock farming practices and farmland birds and vegetation. Much attention is given to the mechanisms of grazing and its influence on vegetation. In this chapter the policies that influence farming on Islay are also discussed extensively. In chapter four the empirical research approach is described. This approach is driven by the theoretical findings given in chapter three and the specific situation on Islay as described in chapter two. In chapter five the empirical research results are presented. Answers are given to the two main research questions of this study. In chapter six the main conclusions are discussed and recommendations are made in relation to policy formulation and further research.

2 Study area

2.1 Introduction; the Isle of Islay

The Isle of Islay is located off the west coast of Scotland. It has been called 'The Queen of the Hebrides' for its natural resources, mild climate and scenic beauty. It is the most southerly of the Inner Hebridean islands and its 3500 inhabitants are spread throughout the island's 600 km^2. The climate is very oceanic with a precipitation of 1300 mm/year (Storrie, 1997). Figure 2.1 shows Islay's distinctive shape; it is almost divided in half by two sea lochs, Loch Gruinart and Loch Indaal. Erosion along the 'Loch Gruinart Fault', running from north to south, resulted in the formation of these two sea lochs. The part west of the lochs is known as 'The Rhinns of Islay' and the southern peninsula is called 'The Oa'.

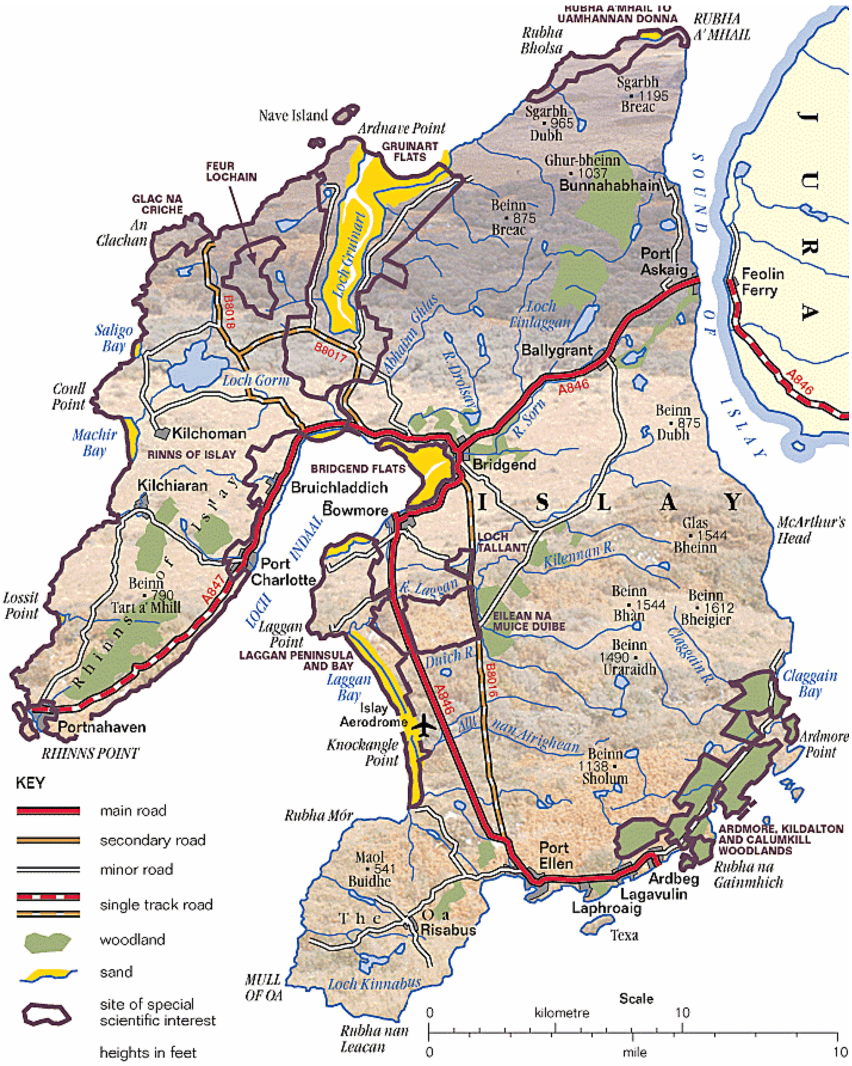

Figure 2.1 Map of Islay (from www.ileach.co.uk)

Islay is renowned for its single malt whiskies. Currently there are seven working distilleries on the island, once there were over twenty. The main reason for the prevalence of whisky production on Islay is the soft and peaty water. In the past, much of the barley for whisky production was grown locally, but now most of it comes from eastern Scotland.

The main land use on the island is agriculture and crofting still occurs on the southern part of the island. The crofting system is a traditional farming activity in Scotland's Highlands and Islands, which developed during the 19th century. The system evolved during the 'Highland Clearances' of the 19th century whereby landlords forced communities off productive land onto more marginal lands. Small communities developed in coastal areas, consisting of several individual crofts, some arable cropping fields and a common grazing area (Caird, 1987). Many farms still have this division of land into permanent grassland, arable land (together referred to as 'inbye' and usually situated near the farmhouse) and rough grazing, which is also known as 'the hill land' (figure 2.2). During the last hundred years there has been a shift away from arable cropping in the Highlands and Islands towards specialisation in livestock farming, mainly sheep and beef cattle. However, due to the island's remoteness and natural conditions, farming has remained quite extensive and large areas of semi-natural vegetation are still used for grazing.

Apart from the whisky, Islay is also famous for its birds, especially for the large numbers of over-wintering barnacle geese (*Branta leucopsis*), greenland white-fronted geese (*Anser albifrons flavirostris*) and rare species such as the chough (*Pyrrhocorax pyrrhocorax*), corncrake (*Crex crex*)and golden eagle (*Aquila chrysaetos*). Other common animals that attract wildlife tourists to the island are otters (*Lutra lutra*), grey seals (*Halichoerus grypus*), dolphins (e.g. *Tursiops truncatus*) and whales. On top of this large wildlife diversity the island has over nine hundred species of flowering plants (Ogilvie, 1995).

Figure 2.2 Inbye fields usually are situated near the farm whereas rough pastures are further away on rocky, steeper areas.

2.2 Farming on Islay

Farms on Islay are mostly livestock farms, with sheep and beef cattle. There are still crofts on the island and even plans to setup new ones to keep young farmers on the land. The creamery on the island closed a few years ago and now there is only one dairy farm left, which sells its products locally. A typical feature of Islay farms is that many feed 'draff', which is a side-product of the whisky distilleries on the island. Draff can make up a significant part of the winter-fodder, making the farm less dependent on 'home-grown' winter-fodder, which is quite unique for a remote place like Islay. This may partly explain the decrease in the area of arable cropping in the last fifty years. Most external inputs for farms have to come from the mainland and must be transported to the island by ferry, which makes the use of them relatively more expensive than on the mainland. Because of this, the use of external inputs on farms is relatively low, with the exception of 'draff' feed. To get an idea of what farming on Islay is like, a short description of an average farm is given in the following based on information derived from the farm survey carried out in this study (see also chapter 4 and 5 and Annex II for full results of survey). In real life there is a large variation between farms, most farms are still quite extensive but some can be qualified as intensive.

An average Islay farm has an area of around 550 ha, divided into 100 hectares of 'permanent grassland' (100 ha), 50 hectares of 'rotational arable cropping', which includes arable land and rotational grassland, and 400 hectares of 'rough grazing land' or 'hill'. Livestock consists of 75 suckler cows and 620 sheep. During lambing and calving period the livestock is mostly concentrated on the permanent grassland, where the farmer can keep a closer eye on the animals. The rest of the year the livestock is grazing on the rough grazing land, but in-wintering of livestock is becoming a more common practice. Nitrogen gifts through artificial fertilizer inputs are on average 60 kg N/ha/yr to permanent grassland and 120 kg N/ha/yr to rotational arable cropping land. It is not usual for Islay farmers to apply artificial fertilizer to the rough grazing. The rotational arable cropping is mostly used for growing silage, but other fodder crops such as cereals and rape seed are produced as well. The silage is cut between June and August. In case of a first cut in August this is usually related to the existence of a management agreement on late cutting. The rough grazing land is usually fenced into several compartments. Burning of the rough grazing is quite common. Because of the large size of both the rough grazing area and the herd, 'disappearance' of some lambs is hard to avoid. Their carcasses are important food for scavengers. The farm is quite self-sufficient in providing its own silage, but a few tons of hay and straw may be bought in every year. Apart from silage and hay, concentrates are also fed to the livestock. Draff, sugar beet pulp, cow cobs and sheep rolls are commonly fed. There is often a goose-agreement, to compensate for the damage done by wintering geese, and an agri-environment scheme with Scottish Natural Heritage (SNH) for the conservation of the chough population. This conservation scheme is the most common for farms in the Rhinns. The average age of the farmer is around 52 years and there is one fulltime and one part-time job on the farm. Farming accounts usually for not more than half of the family income. The other half usually comes from the farmer's partner's job and/or off-farm diversification activities. In most cases half of the farm income consists of subsidies.

2.3 Policy context

Farming on Islay is influenced to a large extent by a range of policy measures that are based on UK and EU legislation. The relevant EU legislation is rooted in the CAP, which covers market support and rural development. The environmental support measures are usually based on nature conservation policy. An important part of the market support is the income support that is provided to farmers. This comes from several premium schemes, like the Sheep Annual Premium Scheme, Suckler Cow Premium Scheme, Beef Special Premium Scheme and the Extensification Payment Scheme. Rural development policy provides income support through the Less Favoured Area Support Scheme (LFASS). 85% of Scotland's agricultural area has been designated as a Less Favoured Area (LFA), which reflects the constraints the environment is imposing on agriculture. Equally important, and reflecting the high nature value of Islay, was the designation of Islay as an Environmentally Sensitive Area (ESA), which made agri-environmental measures possible under the old ESA scheme. This scheme has now been replaced by the Rural Stewardship Scheme (RSS), but because the ESA agreements last up to ten years many farmers are still in the ESA scheme.

Nature conservation policy comes largely from EU environmental legislation, such as the Birds Directive and the Habitats Directive. On Islay large areas have been designated as Sites of Special Scientific Interest (SSSI). The western half of the island, which is also known as "The Rhinns of Islay", is almost completely designated as a SSSI. Many SSSI areas have also been designated as a Special Protection Area (SPA) for threatened birds and their habitats under the EU Birds Directive, and some have been designated as a Special Area of Conservation (SAC) for threatened habitats under the EU Habitats Directive. Besides this several places have also been designated as "wetlands of international importance" under the RAMSAR convention of 1971.

Scottish legislation entitles Scottish Natural Heritage (SNH) to enter into environmental management agreements with farmers. Financial losses, caused by constraints on farming because of these designations, are compensated for by SNH. An important management scheme is the *wintering geese agreement* enabling a payment to farmers to compensate for damage done by geese. The Royal Society for the Protection of Birds (RSPB) also owns farmland on Islay. For this land the RSPB has management agreements with individual farmers in which strict conditions for farming specific to certain bird-species, such as the corncrake, are determined.

Crofting has long held a special place in Scotland's heritage. In addition to the main EU funded livestock and arable schemes, support is provided to crofters via the Crofters Building Grants and Loans Scheme, Crofting Counties Agricultural Grant Scheme, and the Crofters Livestock Improvement Schemes.

2.4 High nature value

Islay supports many rare species and habitats, many of which are recorded in the EU Birds- and Habitats Directives. It is often mentioned as a 'hotspot for biodiversity' with consequent Biodiversity Action Plans made for several habitats and species (Smythe, 2002). This is also reflected in the nature conservation designations applied to large parts of the island. The most typical birds and vegetation types on Islay are described in detail below. Species such as marsh-fritillary butterfly, chough, corncrake and wintering barnacle- and Greenland white-fronted geese are some of the species whose presence supports the high nature value of Islay.

2.4.1 Birds

Islay is famous for the enormous numbers of wintering barnacle geese and Greenland white-fronted geese. But it is important for many more bird species, resident, breeding, passaging and wintering ones. There are 175 bird species to be seen on the island, not counting the vagrant ones (Internet: Islay Natural History Trust). Out of the total 181 species on Annex I of the EU-Birds Directive, Islay is important for 28.

Loch Indaal and Loch Gruinart, both with intertidal mudflats and the latter an RSPB reserve, are important places for wintering geese, waders, divers, grebes and sea ducks. Even some of the highest densities of breeding waders in the world were counted on the so called *Machairs,* sandy coastal grasslands (RSPB, 1993 and 1995). The Rhinns and the Oa provide attractive habitats for birds of prey, like the golden eagle, buzzard, hen harrier, peregrine, merlin and kestrel. The cliffs have seabird colonies of common and black guillemots, razorbill, kittiwake, fulmar and shag, while choughs and rock-doves use these cliffs for nesting. Islay houses 85% of the Scottish breeding population of chough (Bignal et al., 1997), and large proportions of the population of the rare corncrake as well (Internet: Corncrake Net).

2.4.2 Vegetation

Due to its mild, oceanic climate and its diverse geology, a range of vegetation-types are found on Islay. They comprise of coastal grasslands (including *Machairs*), vegetated sea cliffs, dune systems, heathlands, woodlands, moorlands and blanket bogs. In addition, many of these open vegetation types are used as rough pasture and marginal hill land and the grazing of these areas delivers an important contribution to the overall ecological complexity. Together with their associated animal populations, some vegetation-types form highly valued biotopes or habitats, listed on the Annex I of the EU Habitats Directive. Three of these Annex I habitats are abundantly present on Islay, and form part of the rough grazing land. These are:

- North Atlantic Wet Heaths (4010)[1]; Humid, peaty or semi-peaty heaths, other than blanket bogs, of the Atlantic and sub-Atlantic domains, important for cross-leaved heath (*Erica tetralix*).
- Blanket Bog (7130); Extensive bog communities or landscapes on flat or sloping ground with poor surface drainage, in oceanic climates with heavy rainfall, characteristic of western and northern Britain and Ireland. Bogs locally dominated by *Sphagnum* mosses. Important species like round-leaved sundew (*Drosera rotundifolia*), oblong-leaved sundew (*Drosera intermedia*), black bog-rush (*Schoenus nigricans*) and white beak-sedge (*Rhynchospora alba*) are found here.
- European Dry Heaths; (4030); European dry heaths typically occur on freely-draining, acidic to circumneutral soils with generally low nutrient content. Ericaceous dwarf-shrubs dominate the vegetation. The most common is heather *Calluna vulgaris*, which often occurs in combination with gorse *Ulex* spp., bilberry *Vaccinium* spp. or bell heather *Erica cinerea*, though other dwarf-shrubs are important locally. Nearly all dry heath is semi-natural, being derived from woodland through a long history of grazing and burning. Most dry heaths are managed as extensive grazing land for livestock or, in upland areas, as grouse moors.

'The Rhinns of Islay' are of particular importance: for example at Kilchoman (Machir Bay) fossilised dune systems with a 'machair' morphology occur. Machair is a distinctive sand dune formation formed by a particular combination of physical factors, including climate and landform. The vegetation is typical for calcareous or neutral sandy grassland. These grazed coastal dunes are of natural importance and are found nowhere else in the world but in the north and west of Scotland and western Ireland. The woodlands on the Rhinns are of significance as some of Britain's most westerly woods. The *Salix aurita* scrub woodland is an unusual woodland community and is rare in the District. Several uncommon higher plant species including the Irish lady's tresses (*Spiranthes romanzoffiana*) the meadow thistle (*Cirsium dissectum*) and the great fen-sedge (*Cladium mariscus*) are associated with the fens around Loch Corr. Species like buckbean *(Menyanthes trifoliata)*, marsh arrowgrass *(Triglochin palustris),* pale butterwort *(Pinguicula lusitanica),* bog asphodel *(Narthecium ossifragum),* marsh cinquefoil *(Potentilla palustris)* and fairy flax *(Linum catharticum)* can be found in fields with semi-natural vegetation, maintained through grazing.

2.5 Summary

Thanks to its climate, geographical conditions and human interference, Islay still contains a large variety of habitats and species. Each of these habitats is influenced more or less by farming and some important habitats, which form important biotopes for floristic and faunistic species, depend for their survival on extensive farming practices. Traditionally crofting was the common agricultural farm system practised on the island. In the last hundred years however a shift from arable cropping towards a larger dominance of livestock farming has occurred, although on

[1] Numbers between brackets indicate the NATURA 2000 code used in the EU-habitat Directive Annex I list.

most farms some form of mixed livestock farming with arable cropping still exists. Thanks to its remoteness and the natural constraints, farming is generally still extensive. Farms are usually large in size but extensive with respect to stocking density and input use per unit of land. A large part of farm usually exists of semi-natural vegetation which makes up the rough grazing land. At present, most farmers rely heavily for their income on subsidies and other off-farm activities.

The high nature value of Islay is reflected in the relatively rough terrain farmers operate and the many nature conservation designations. Several habitats present on Islay are listed in the Annex I list of the EU Habitat Directive and provide a home for several important and rare birds and vegetation types. This is also a reason why Islay can make use of a large number of regulations and measures, aimed either at supporting production or compensate for environmental constraints in their farming practices.

This chapter meant to give relevant information on the study area in order to place this study in its specific context. In addition to the basic information for Islay given here, the next chapter gives a more detailed look into the theoretical background of the study.

3 Theoretical background

3.1 Introduction

In this chapter theoretical aspects of the ecological processes that are involved in the relationship between extensive livestock farming and birds and vegetation diversity are discussed together with a detailed description of all the relevant policy for Islay's farmers.

In the next, firstly some general aspects are given of the high nature value of extensive livestock systems. In the third section the effects of farming practices on birds is discussed, especially in relation to intensification. As grazing forms a key factor in most extensive livestock systems, important ecological principles of grazing are then explained in the third section. Finally, the agricultural and nature conservation policy, which are influencing the extensive livestock systems on Islay are described.

3.2 Extensive livestock systems; characteristics and high nature value aspects

According to the definition given by Beaufoy, Baldock and Clark (1994) low intensity farming systems are distinct from intensive farming systems especially in that they are low in their use of external inputs, especially fertilisers and agrochemicals. Extensive farming is a similar term but is applied particularly to those farming systems, which on top of a limited use of external inputs, are characterised by the exploitation of land on a large scale (Beaufoy, Baldock and Clark, 1994).

Except for some remaining crofts, this applies to most farmers on Islay, as the typical farm comprises a large, generally extensively managed rough grazing area besides the 'inbye' and the rotational arable cropping fields. Considering farms on Islay, it is important to realise that generally the management practises associated with the rough grazing can be regarded as low intensive. Yet, management practises exerted on the permanent grassland and the rotational arable cropping may be rather intensive, with well-drained fields, moderate stocking densities and N inputs of up to 200 kg per hectare. However, in a land use study on Islay, Bignal & McCracken (1996) concluded that though the botanical value of the fields used as permanent grasslands was limited, the existing mosaic of more and less intensive agricultural land uses was crucial for supporting such a large number of Annex I bird species and that "any simplification of the range of land-types could result in a disproportionate reduction in the numbers or productivity of these species".

Inherent characteristics of extensive livestock systems which benefit biodiversity are summarised below (Beaufoy et al., 1994). The area used for agriculture usually lacks fundamental alterations to the land, such as drainage. One of the results of that is the utilisation of a high proportion of semi-natural vegetation, which is a common factor to all extensive livestock systems as opposed to the high proportion of improved land found in modern agricultural systems in the EU. The climate, topography and the sometimes poor soil conditions of the area limit the possibilities of using the land for agriculture. In this way, it can be regarded more in the sense of a 'no choice' option than as a conscious consideration of the farmers to farm in a more natural way. What is important however, is the outcome that extensive livestock systems provide a greater range of ecological niches. The natural constraints also limit the proportion of land available for utilisation, meaning that semi-natural vegetation is generally forming a mosaic with more natural habitats and features. This can facilitate the dispersal of higher plants, mammals and birds, creating more stable populations. In addition, climatic constraints urge that the timing of management is synchronised with the annual natural growth cycle of the vegetation to avoid detrimental effects to a wide range of plant species involved. For example, due to the wet weather usually encountered in the west of Scotland, the number of cuts for hay- or silage making is limited to the drier months in summer whereas farmers living in a drier climate can start earlier and extend their activities as well. The relatively small nutritional value of semi-natural vegetation generally places a subsequent limit to the number of animals that can graze the area. This implies low grazing pressures or a grazing pressure that is only high for a very short period after which the animals have to be moved to another area. This leads to a greater heterogeneity of vegetation structure of which a number of invertebrates and birds benefit. In addition, areas with semi-natural vegetation are characterised by low levels of nutrient inputs and it has been shown that this has created conditions which are essential for the survival of a wide range of plant species intolerant of high nitrate and phosphate levels in the soil (Beaufoy et al., 1994).

The high nature value of extensive livestock systems is above all determined by their creation and maintenance of endangered, rare habitats, included nowadays in the EU Habitat Directive Annex I. Ostermann (1998) indicated that 29 habitats out of 198 (15%) listed in the Annex I list are considered to have their origin in rural land use practises like grazing, hay-making, crops and forestry. In other situations the habitats created by these extensive livestock systems are not endangered at a European scale, but certain management practices are beneficial for threatened species living within these habitats.

In order to compete with other farmers living in areas capable of more intensive production, farmers in the more remote parts of Europe see no other option but to change their way of farming. Socio-economical factors like the age of the farmer and the absence of a successor may impede the continuation of the farm with a subsequent risk of habitats being lost by natural succession. Younger farmers and/or farmers living in less isolated rural communities, who do not want to give up farming, gradually shift to more intensive farming ways, resulting in habitat and/or species loss as well. This is graphically presented in Figure 3.2 after Ostermann (1998). It is important to realise that very often abandonment and intensification go together rather than one of both; the intensification of farming systems often comprises both the abandonment of certain 'traditional' farming practises as a shift towards more intensive and specialised farming systems. Another aspect which should be mentioned is that, on abandoned fields which used to be managed intensively, biodiversity is likely to increase, though the increase in plant diversity is very slow and of minor importance (Kruess & Tscharntke, 2002; Marriott et al., 2002) compared to the diversity of other organisms like, for example, insect diversity (Kruess & Tscharntke, 2002).

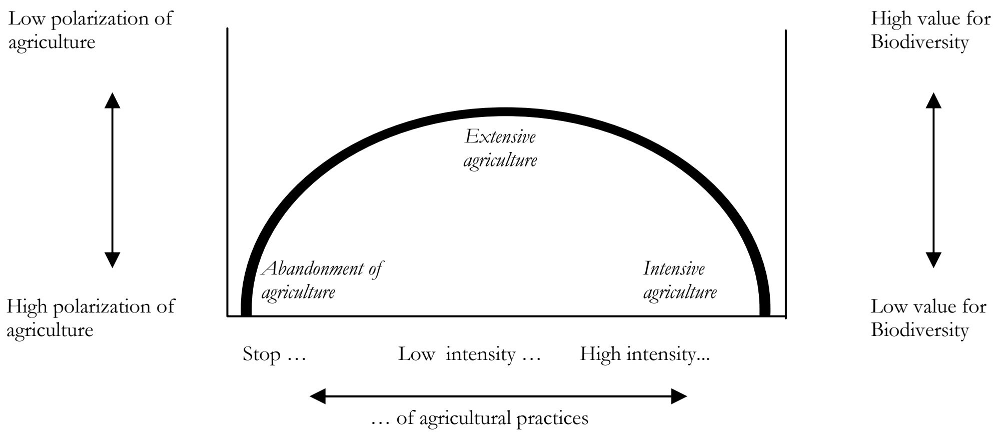

Figure 3.2 Relationship between biodiversity values in the agricultural landscape, the intensity of the agricultural management practises and the polarization of agriculture (after Ostermann, 1998)

Polarization of certain agricultural management practices and sometimes even the farming system as a whole forms a serious threat for biodiversity in semi-natural areas maintained by extensive livestock farming. During the 20th century, the decline in semi-natural habitats as a consequence of polarisation has been over 90% in most parts of Europe (European Environment Agency, 1998). One third (65) of all habitats listed in the Annex I list are considered to be threatened by an intensification of pastoral activities (pasture, grasscutting and haymaking, animal husbandry and harvesting crops). Abandonment of these activities might bring the subsistence of 28 habitats in danger (Ostermann, 1998). One example are the lowland hay meadows, where hay-making is almost entirely replaced by silage making.

To illustrate the situation set out above, in Box 3.1 two examples are given in which polarisation affected biodiversity within extensive livestock systems.

Box 3.1 Two examples of polarisation of extensive livestock systems and their effects on biodiversity.

Monts du Forez in the Massif Central in France. Schaminée and Meertens (1992) showed that alteration of farming practices had profound effects on the vegetation communities. They found above all, that modernisation of the traditional farming methods was responsible. One example was the strong modification of the hay fields due to changes in land use. The increase in modern agricultural techniques caused a noticeable increase in nitrophilous species. Associated with the modernisation was the abandonment of certain meadows and heathlands which also contributed to the changes in vegetation communities. Besides these changes, some parts previously grazed were abandoned while at other grazing fields important changes in the traditional grazing practices took place. The result was that along the whole range of different vegetation communities originally occurring, there was a succession towards other vegetation communities. Under influence of intensive grazing, a rapid succession from heathland towards Nardion grasslands occurred, resulting in a decrease of the botanical value of the vegetation.

Burren Uplands in Northern Ireland. The following is quoted from the Interactive Interpretative Centre of the Burren (Internet): “From an agricultural perspective, the Burren uplands are primarily associated with the practice of 'winterage', wherein animals are moved to the hill pastures in wintertime. Up until quite recently, hardy native breeds of beef cattle were used to graze upland grasslands between the months of October and April, requiring scarcely any dietary supplement prior to their removal to finishing grass elsewhere. The ecological significance of this tradition is immense: wintering animals removed all the litter and grasses that would otherwise inhibit herb growth and limit plant species diversity, without damaging these plants during their flowering season. Enormous changes have been wrought on the agricultural sector of the Burren, as elsewhere, in recent years, particularly since Ireland's accession to the EEC and the increasing exposure to the international marketplace and to advances in the field of agricultural science. Some of the more significant changes would come under the heading of 'intensification' - involving extensive reclamation, increased use of chemical fertilisers and slurry, the construction of slatted housing units, the massive increase in silage production, and increases in the amount of stock held. Other changes would be categorised under 'specialisation': traditionally the Burren would have supported small, labour-intensive mixed farming systems. A worrying implication of these changes in the Burren has been the increasing 'marginalisation' of upland grasslands, often manifesting itself in the form of hazel-scrub encroachment. Agriculture has become increasingly concentrated in lowland areas that are more amenable to modern farming systems, while less adaptable and accessible upland areas are becoming increasingly neglected, as their feeding capacity is displaced by that of imported fodder, their sheltering capacity increasingly devalued by the construction of slatted houses”.

3.3 Importance of extensive livestock farming for birds

The value of extensive livestock farming for birds has become more and more visible after the ongoing intensification of agriculture in Europe. The decline in farmland-birds and the intensification of agriculture show a remarkable correlation (Heath et al., 2000). Mike Evans, researcher on threatened birds of Birdlife International, expressed it even stronger in a news report on Reuters News Service (2000): "Intensive agriculture is the single most important thing that affects species and which also has wide ranging effects on bird habitats." Extensive farming, on the other hand, provides many conditions and opportunities for farmland-birds. Important characteristics of extensive farming are: a lack of fundamental alteration to the land, a high proportion of semi-natural vegetation, the willingness to adapt the management to natural constraints, low stocking rates and a low external input.

An example of a fundamental alteration to the land is drainage, which is often followed by conversion from wetland or wet grassland to arable or dry grassland. Drainage has a negative effect on breeding wader populations, mainly by causing by the loss of suitable breeding- and foraging-habitat (Green 1991). In extensive farming systems, relatively small parts of the land have been drained and often only superficially, as is the case with the permanent grasslands on Islay. The high proportion of undrained rough grazing makes it possible for wader birds to breed and forage within these systems, making Scotland a place of international significance for breeding waders.

The rough grazing accounts for a high proportion of semi-natural vegetation. This is usually an open type of vegetation that provides not only a suitable habitat for waders in the wetter areas but also provides a rich hunting and breeding area for raptors and owls (Tucker & Evans, 1997 and RSPB, 1993, 1995).

Islay knows many 'natural constraints', caused by its geography and climate. Most external input has to come from the mainland and be transported to the island by ferry, which makes it more expensive than on the mainland. Partly because of this the external inputs are relatively low, with the exception of draff feed that is bought from the whisky distilleries on Islay. An unusual constraint is formed by the many wintering geese, which makes autumn sowing of crops more difficult. Much of what is sown in autumn would be eaten by the geese in winter. Spring sowing of crops and cereals is beneficial for species that feed on winter-stubbles, examples are skylark, chough and whooper swan (McCracken & Foster, 1991 and Tucker & Evans, 1997).

Stocking density is closely related to grazing pressure, which is an important controlling factor for the vegetation, and therefore also for the birds that use it as a habitat. Low stocking densities create a diverse habitat, with suitable ecological niches for many species. Many bird species are dependent on this variation. Section 3.4 describes this process in closer detail. Another factor is that low stocking rates in the breeding season reduce the chance of egg- and chick trampling for ground breeding birds (Vickery et al., 2001). A low livestock stocking rate in winter leaves more food available for geese.

The low artificial fertilizer and agrochemical input in extensive livestock systems results in a diverse invertebrate fauna, in contrast to high input farming systems as demonstrated by Van Wingerden et al. (1992), who found that grasshopper density and diversity decreased with increasing fertilisation levels. Another study by Siepel (1990) shows a shift from larger to smaller sized invertebrate species with increasing fertilisation levels, which may be a major cause of the decrease of insectivorous vertebrates in his highly fertilised samples. Herbicide and insecticide use result in a lower weed-seed and prey-insect availabilities (Campbell et al, 1997 and Tucker & Heath, 1994), not only affecting seed- and insect-eating birds, but indirectly also raptors by the decline in insectivorous prey-species. An important factor for choughs is the use of 'Ivermectin', an anti-parasite drug for cattle (McCracken & Foster, 1992). This drug severely limits the number of invertebrates in cow's dung, not only intestinal parasites but also invertebrates that are attracted to dung after defecation are killed. These invertebrates are an important food-source for chough, especially in winter.

Another very important aspect of extensive farming is the mosaic of different arable, grass and semi-natural habitats they provide, in contrast to the large-scale, monoculture habitats of intensive farming. A varied habitat-mosaic generally offers the greatest biodiversity benefit (Angelstamm, 1992). In the case of farmland birds because it offers a combination of breeding- foraging- and roosting-habitats, to which these species have slowly become adapted over time. Söderström and Pärt (2000) found that landscape composition could be an important factor if birds use different habitats for foraging and breeding. A Nature Conservancy Council research project on Islay (Bignal et al., 1988) came to the conclusion that EU Birds Directive Annex I species use different land-types in different times of the year. So whereas they may not be associated with agriculture in summer, they may be found on inbye fields in winter (e.g.: golden plover). It is therefore important, especially when studying birds, because of their high mobility and large range, to put the high nature value of a particular habitat in a landscape perspective.

The above text shows the importance of extensive livestock farming for birds mostly in contrast to the extreme of intensive farming. The other extreme, abandonment, is a major problem in some, especially the poorer, agricultural areas in the EU. Abandonment of extensive livestock farming would have many drastic effects. When the mechanisms that create farmland-habitats are lost, these habitats will also be lost. The rotational arable cropping and permanent grasslands will soon be overgrown with by fast growing weed-species, and later on by shrubs (Dunford & Feehan, 2001; Fiala & Gaisler, 1999; Grayson, 2000). Without the grazing pressure of domesticated ruminants on the rough grazing its vegetation will radically change. The loss of farmland habitats will severely affect the populations of bird species that depend upon these.

3.4 Ecological principles of grazing within extensive livestock farming; the impact on vegetation

Though certainly all extensive management practices affect biodiversity on farmland in one way or another, grazing is the fundamental mechanism through which extensive livestock farming influences biodiversity (Roy Harris, 1998). Looking carefully at the concept of grazing it should be realised that a whole range of animals use the vegetation for food. The effect of grazing on vegetation is dependent on the type and behaviour of the organism(s) involved.

Grazing on Islay can be regarded as a complex ecological situation as different breeds of cattle, red deer, sheep, rabbits and different goose species in winter make use of the vegetation, each one having a specific grazing behaviour. Apart from the different effects and interactions which are present between domesticated animals used as livestock, "natural" grazing animals are acting simultaneously on the vegetation as well. For instance, Clarke et al. (1995) found that red deer were distributed more evenly over the heather whereas sheep tended to be concentrated near to grass patches. This can have important implications for vegetation dynamics (Palmer and Hester, 2000). The presence of a certain grazer may be beneficial for other grazers. Bignal et al. (1988) showed that wintering geese profit from pastures that were grazed short in the late summer by either sheep or cattle.

Large herbivores, like cattle and red deer, have different feeding strategies compared to smaller herbivores such as sheep and rabbits. Compared with sheep, cattle are relatively unselective as grazers, due to their larger mouth parts and their lower metabolic requirements relative to their body weight (Gordon and Iason, 1989). This means they can survive on poorer quality forage than sheep. Thus, sheep tend to select a greater proportion of the preferred plant species and plant parts in their diet than cattle and this can affect the floristic diversity of vegetation communities. However, this does not mean that large herbivores are not selective at all. In grasslands for example, a mixed grazing regime of cattle and sheep can be beneficial in that agricultural weeds like broad-leaved dock and creeping thistles, which are avoided by cattle, are eaten by sheep (Harris and Jones, 1998). Especially in the case a rough grazing has been abandoned for a certain period a mixed grazing regime of cattle and sheep can be used as restoration management (pers. comment, A.T. Kuiters). Trampling by cattle generally has more impact on the vegetation than sheep trampling because cattle have a much greater weight and tend to gather in favourite areas. Especially when the ground is wet, trampling by cattle can alter it in a pool of mud which is very detrimental to the vegetation, (Bignal, pers. comment, 2002; Harris and Jones, 1998). The disturbed ground is prone to be colonised by agricultural weeds.

Considering the last 50 years, there has been a steady increase in the sheep numbers with a correspondent decline in cattle numbers, leading to heavily-grazed grassland and moorland (Internet: Scottish Natural Heritage; Argyll West and Islands). Only recently this tendency seems to be on its reverse, presumably as a consequence of support measures such as the Beef Cattle top ups and Extensification Premium Scheme (see Annex 1 for glossary of terms), implemented within the LFA policies to keep cattle. Another important change concerning grazing on Islay is the decrease of outwintering cattle (Wright et al., 2002; Internet: RSPB, chough research). Considering the different grazing behaviour of sheep and cattle one can imagine that this change certainly must have been an important factor in the development of the vegetation; taking in mind the selective grazing behaviour of sheep, too high stocking levels of sheep can lead to a decrease in species diversity and habitat structure (Mitchell & Hartley, 2001; Internet: English Nature).

When considering the ecological impact of grazing on the vegetation, it needs to be clear that the function, structure and biodiversity of the vegetation is influenced by a range of abiotic conditions. In response to the plant "menu", grazing animals tend to make a choice from among the plant communities, the species within these communities and even up to the plant organs. This is illustrated in Fig. 3.2 after Gordon, 2000. Both abiotic and biotic conditions, like grazing, play an important role in the development of vegetation communities and it is important not to consider these influences apart from each other as they can be strongly interacting (Milne and Hartley, 2001). For example, with grazing animals present, nutrient deposition generally is higher which may accelerate the response of a habitat such as heather moorland (Alonso et al., 2001). This makes it difficult to discriminate which factor is most responsible. In spite of this, for Scotland, grazing has been found the major controlling factor over vegetation change (Alonso et al., 2001; Stevenson and Thompson, 1993).

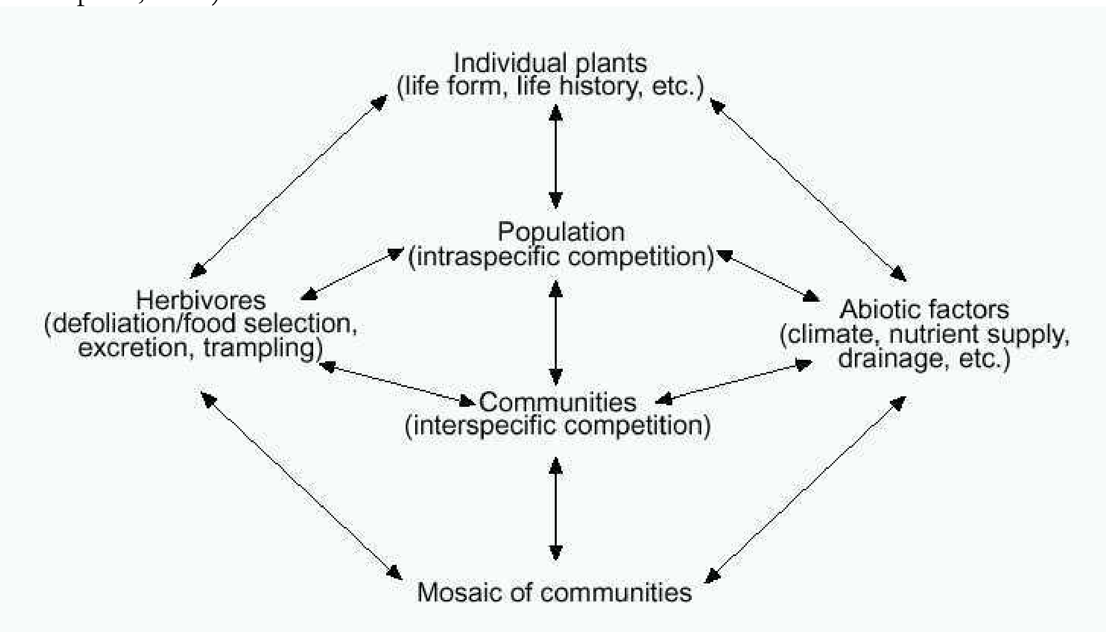

Figure 3.2 A schematic representation of the characteristics of vegetation and their relationships with abiotic factors and grazing (after Gordon, 2000)

In the absence of grazing, vegetation composition and structure are determined mainly by the present combination of a-biotic conditions. Those species that are most efficient in acquiring resources, particularly the most limiting one(s), will be present in a larger abundance than other species. For example, Berendse and Elberse (1990) found that in low-productive heathlands, bell-heather (*Erica tetralix*) is a stronger competitor than purple moorgrass (*Molinia caerula*) but under nutrient-rich conditions, the mutual competition relation reversed. This is explained by the large nutrient losses of *Molinia caerula* (as aboveground parts die back in winter) as compared to the low nutrient losses of the ever-green dwarf shrub *Erica tetralix*. In nutrient-rich situations these bigger nutrient losses can be compensated by the faster growth and larger nutrient uptake which *Molinia caerula* can realise under these circumstances. Under nutrient poor conditions *Molinia caerula* is not able to compensate for these losses and therefore loses the competition with *Erica tetralix*, which grows slower but handles its nutrients more efficiently.

Grazing animals can determine the relative abundance of species in a habitat, by preferring certain plants and ignoring others, thus influencing the competitive abilities of plant species relative to each other. The preference for certain species depends on ever changing relationships between quality (digestibility), quantity and accessibility, relative to other species present (Harris and Jones, 1998). It has been shown that in heather moor land, sheep grazed on *Molinia caerula*, *Trichosporum cespitosum*, grasses and sedges in summer and on *Calluna vulgaris* and *Eriophorum vaginatum* in winter (Grant et al., 1976; Grant et al.,1985). This choice is determined mainly by the palatability and the nutritional value of the plants relative to each other. Hence, the impact of grazing on heather moorland is unlikely to be the same over wide areas as variations in vegetation composition and structure will cause grazers to be attracted to some areas more than others (Grant & Milne, 1981). Another effect of grazing is that it has a significant impact on the microclimate of the soil and sod. Changes in these conditions affect seed germination and the establishment of species of grass, herbs and woody plants (Kuiters, 2002).

Thus, in addition to a-biotic conditions, grazing behaviour can have important effects on vegetation composition, vegetation structure and species richness. For example, Welch (1984) and Welch and Scott (1995) showed that different intensities of heather grazing had different outcomes in botanical composition in the long-term. Light grazing favoured ericoids and lichens and heavy grazing favoured graminoids and forbs. Important to notice is that the increase in species number with low livestock density was largely due to bryophytes and lichens, the latter being sensitive to trampling. Species richness was higher on base-rich sites than on acid sites and it was affected much more by soil type than by either a decrease or an increase in Calluna abundance (Welch, 1985; Welch and Scott, 1995). Generally, with high grazing pressure, species which are highly tolerant to grazing and trampling (such as short and rosette species) or intolerant of shading are favoured and expel non-tolerant species by competition resulting in relatively species-poor vegetation. With intermediate grazing intensities, a mosaic of microhabitats and plant life forms can be found which enhances species richness. Again, interaction with nutrients available in the soil and moisture content of the soil form important factors which must be taken into account. The effects of grazing by livestock on plant species richness are often found to be very diverse and above all are rather complex than straightforward (van Wingerden et al., 1997). Kuiters (2002) even pronounced it clearer: "conclusions regarding the effects of grazing tend to be assumptions rather than the sum of substantial factual evidence".

In the case of a large unfenced area with natural variation in habitats and the quality of the vegetation, a vegetation pattern will develop according to the grazing behaviour of the animals present. This may result in a strong grazing gradient with some parts being ignored almost completely. To have more control on the development of the vegetation, fencing can be an effective measure. This can be part of targeted nature conservation management because the timing and intensity of the grazing pressure can be controlled. However, when fenced areas remain ungrazed too long, the heather may become so dominant that a species-poor vegetation is left. Moreover, it will get into a degenerate phase in which the shoots of the plant are no longer attractive for sheep (Fielding and Haworth, 1999).

Burning of heather is an important factor associated with grazing on heather and moorlands. The actual aim of the 'muirburn' is to rejuvenate the heather, and to increase the nutrient content of the new shoots so the grazing animals will benefit. The response of heather to fire is highly variable and is dependent on the habitat that is burned (wet bog or dry heath), the phase the heather is in (pioneer, building, mature, degenerate), and the temperature and duration of the fire (Fielding and Haworth, 1999). Only when applied very carefully, burning can form a useful tool in heather management.

Since heather in itself is no climax vegetation-type, eventually it would be replaced by a wooded vegetation community, starting with species as eared-willow (*Salix aurita*) and birch (*Betula pendula*), followed later on by other trees. The principal force that drives this succession is the change in soil conditions caused by the earlier species. Grazing can fulfil a very important task in preventing such climax species to appear or otherwise to keep certain species under control. In this way grazing contributes to a greater variety of herbs, sedges and grasses. A number of studies have shown that grazing prevents scrub encroachment (Diemont, 1996; Dunford and Feehan, 2001; Miles, 1981) and in fact this is one of the most important beneficial aspects of grazing. However, a recent study reported that the combination of a high grazing pressure with increased atmospheric nitrogen deposition is the driving factor behind the shift from heather moorland towards heather grassland mosaic (Alonso et al., 2001). This indicates that a careful management is necessary regarding the stocking density on the rough grazing fields.

In most of the vegetation types found on Islay, grazing within pastoral systems has a more or less important function in maintaining them (Bignal, 1988). Grazing animals are found in a range of habitats. Generally, near the farm the more fertile ground is found and here the so-called inbye fields are formed. Most of these pastures are improved (i.e. fertilised and/or drained) or used as arable land. Though the inbye fields do contribute to the overall high nature value by adding to the mosaic of habitats on the island generally their botanical values are limited. Therefore, here, only the high nature value of the rough grazing (heather/moorland) is considered.

The rough grazing area encompasses different types of semi-natural habitats where the maximum nutrient uptake by the animals is restricted. These include: coastal habitat, machair and hill pastures, but the majority of these so-called rough grazing fields consists of heathland, moorland and blanket bogs. These habitats are all characterised by a (partly) different range of plant species naturally occurring within them. Differences in species richness and botanical composition are determined in the first place by a-biotic conditions. As plants respond differently to a certain grazing behaviour, the effects of grazing are different on these different habitats as well. Coastal dune systems for example, naturally contain nutrient-richer soils than heather moorland which occurs on less fertile, more acidic soils. Generally vegetation communities of richer grounds are more tolerant to higher livestock densities.

The effect of grazing on 'gamma diversity', the species diversity of a landscape composed of several plant communities, biotopes and or life communities, has not been studied very well. Preferential use of certain vegetation types, walking paths to salt blocks and water-pools and gathering at places for shelter, dunging and resting (day-night shift) can add to the natural variation in habitats. Thereby it can contribute to a diverse mosaic of habitats leading to a higher diversity at the landscape level.

In order to understand the importance of grazing for a habitat as a whole, it is necessary to look at the principle of the food pyramid principle. Firstly, grazing by the 'primary consumers' can have a major influence on almost all aspects of the 'primary producers' (i.e. the vegetation) such as structure, growth form, species richness etc. The grazing of the domesticated animals like sheep and cattle thus can affect the abundance of other 'primary consumers', the 'secondary consumers' of these organisms and all other organisms in the higher trophic levels that use the vegetation for other activities like sheltering and nesting. In Box 3.2 this is illustrated on the basis of the marsh fritillary butterfly (*Euphydryas aurinia*) on Islay.

Box 3.2 The benefit of grazing for the marsh fritillary butterfly

An example of typical high nature value on Islay is the case of the blanket bog Glac na Criche (part of the Rhinns of Islay). It is different from other blanket bogs in that it has a much more complex topography, giving rise to watershed, valleyside and valley mires. It contains three Annex I habitats, namely Vegetated Sea Cliffs of the Atlantic and Baltic coasts, European Dry Heaths and Blanket Bogs.
The site is considered to be of significant importance for the marsh fritillary butterfly (*Euphydryas aurinia scotica)*. Records for the species are patchy across the overall Rhinns area and the site is made up of a complex of areas which are known to hold some core parts of the overall Rhinns meta-population (Internet; Joint Nature Conservation Committee).
The marsh fritillary butterfly *Euphydryas aurinia* is found in a range of habitats in which its larval food plant, devil's-bit scabious, *Succisa pratensis*, occurs. Although populations may occur occasionally on wet heath, bog margins and woodland clearings, most colonies are found in damp acidic or dry calcareous grasslands. Grazing is crucial to the success of a marsh fritillary butterfly colony, with cattle or horses removing the coarser vegetation and creating the most suitable sward. Sheep selectively graze devil's-bit scabious (*Succisa pratensis*) and are therefore detrimental to marsh fritillary butterfly populations, except at very low stocking rates. The aim of the grazing regime is to produce an uneven patchwork of short and long vegetation by the end of the grazing period (Internet, Butterfly Conservation). Two factors related to grazing, that endanger the subsistence of meta-populations are, in the first place, the change in grazing stock and practice by farmers and conservation bodies, and, in the second place, the scrub invasion through abandonment of grazing (Internet; Wildlifetrust).
The secret of the marsh fritillary's success on Islay lies in the traditional grazing practices of island farmers, a light, non-intensive approach that allows the survival of species-rich swards. Highland cattle, grazing in a free-ranging manner have proven to be key habitat-managers in creating the essential dynamic patchwork (Bignal & Pienkowski, 1999).

3.5 Policy

3.5.1 Common Agricultural Policy

Context

The CAP has been driven by a strategic need for food security in Europe, which lead to a deliberate economic signal to increase domestic food production and reduce dependence on imports. Its main mechanism was market management to remove surpluses which in theory would be fed back onto the market during periods of shortage and protection for the domestic market through import taxes and export subsidies (Defra, 2001). Production responded surpluses became chronic which led to friction with other suppliers to the world market who were not so reliant on subsidy. In some areas the intensification of agricultural production led to environmental damage. As a result various reforms have been introduced to the CAP.

An important component of the Agenda 2000 reforms to the Common Agricultural Policy, agreed in 1999, was the Rural Development Regulation, designated by the European Commission as the 'second pillar' to the CAP. The 'first pillar' consist of all market price support measures and direct payment to farmers. The proposals for the Mid Term Review comprised significant expansion and reinforcement of this second pillar. The priorities of the Scottish Rural Development Plan are to assist the future viability and sustainability of Scottish farming and to encourage farming practices which contribute to the economic, social and environmental sustainability of rural areas. Some 65 percent of the budget is directed at LFA support, 24 percent to agri-environment schemes and 11 percent to forestry measures mostly on farmland (Ward & Thompson, 2002).

In June 2003 the Council of Agriculture Ministers of the European Union reached agreement on a package of proposals for further reform of the CAP. These proposals include a decoupling of direct payments from production, a compulsory cross compliance, a compulsory modulation from the 1st pillar to the 2nd pillar and a strengthened rural development policy.

The decoupling of direct payments from production from 1 January 2005 will be the most important change of the Mid Term Review of the CAP. A single payment scheme, based on a reference period of 2000 – 2002 will replace the livestock premia to promote a more market oriented, sustainable agriculture. There will be no obligation to produce anything, though there will be new, binding cross compliance rules to avoid land abandonment. Compulsory cross-compliance will apply to statutory EU standards in the field of environment, food safety and animal health and welfare.

Market support
Until now income support for farmers on Islay has come largely from several livestock premia. These premia have been introduced in 1992 and were meant to compensate farmers for the cuts in intervention prices. Most farmers qualify for income support under the Sheep Annual Premium Scheme, the Suckler Cow Premium Scheme, the Beef Special Premium Scheme and the Extensification Payment Scheme. The latter under the condition that stocking density is below the maximum of 1,8 LU/ha. The payment is doubled when below the limit of 1,4 LU/ha. All premia are paid based on the number of animals a farmer has. The rates of payment and detailed rules are determined by the EU. Suckler Cow Premium and Sheep Annual Premium claims are limited to the number of animals for which the

farmer has quota. Individual quota for cattle and sheep have been introduced in the CAP in 1993 to control production.

Rural development

In 1975 the European Union introduced the Less Favoured Area designation, to give additional financial support to farmers in disadvantaged areas, of which Islay is an example. Until 2001 farmers in LFAs have received additional income support through the Hill Livestock Compensatory Allowance Scheme (HLCA). This scheme was replaced in 2001 by the Less Favoured Areas Support Scheme, following the Agenda 2000 reforms of the CAP.

The schemes are designed to support and maintain agriculture in disadvantaged areas which, because of their location, climate and topography, are vulnerable to economic decline and depopulation. Within the HLCA Scheme the Less Favoured Areas were split up in two zones: the "disadvantaged areas" and the "severely disadvantaged" areas, which included Islay. This differentiation allowed for different levels of payments, which were headage payments at that time. The headage payments-based HLCA was seen as inconsistent with environmental incentives because it encouraged farmers to increase the numbers of animals per hectare with subsequent losses in biodiversity and wildlife.

The change from HLCA to LFASS in 2001 introduced area-based payments. To qualify for the LFASS one has to comply with the Good Farming Practice Guidelines. This includes not removing hedges, dry stone walls or other boundary features without prior approval, avoiding under- and overgrazing and the notification of "Possibly Damaging Operations" on Sites of Special Scientific Interests (SSSIs). This is an important aspect for farmers on Islay, because about 25% of the island is designated as a SSSI. To give farmers time to adjust to the new area-based payments, safety net arrangements were introduced on a degressive basis which last for three years from and including the 2001 scheme.

Since its introduction the LFASS has been amended twice. The current LFASS 2003 will be effective for at least three years to provide some constancy. It is based on four factors. Firstly the grazing category, which is calculated from stocking density based on a reference period, this determines the amount of eligible hectares of the total forage area for which to receive support. The lower the stocking density, the lower the proportion of eligible hectares is. Secondly the number of eligible hectares are corrected for possible excess of minimum (0,12 LU/ha) or maximum (2,0 LU/ha) stocking densities to avoid overcompensation. Then the proportion of cattle in total livestock units determines the eligibility for a bonus factor. Ten percent cattle or more gives a 35% bonus and fifty percent or more gives a 70% bonus. Finally the location is important. A difference is made between 'very fragile', 'fragile' and 'standard' areas. Very fragile areas are paid most per hectare. Islay has been classified as a 'very fragile' area.

Agri-environment measures have been introduced in the CAP in 1992 (Regulation 2078/92), although early forms of agri-environmental schemes already existed in the

1980s. Under Agenda 2000 agri-environment measures were integrated in the Rural Development Regulation (1257/1999). These measures create the opportunity for farmers to voluntarily make agreements on management practices beyond the baseline of 'good farming practices'.

In Scotland agri-environment measures were introduced under the Environmentally Sensitive Areas Scheme between 1987 and 1994. Ten different ESAs were designated during that time of which Islay is one. Inside these ESAs farmers can enter the ESA Scheme. Since 1997 farmers outside ESAs have had the possibility to enter the Countryside Premium Scheme (see Annex 1 for glossary of terms). Under the ESA scheme, incentives are provided to farmers in these areas to manage their land in ways which conserve wildlife, landscape and historic features. The ESA scheme is voluntary and farmers and agricultural land managers with land within one of the 10 designated ESA boundaries in Scotland are able to enter into 10 year management agreements. Since every single ESA has its own typical characteristics, the land management practices which farmers in the scheme must follow are tailored to suit the needs of each particular ESA. In order to enter an ESA scheme in Scotland, farmers must enter into a conservation plan that commits them to carrying out certain positive conservation activities, the so-called 'tier 2' activities, appropriate to their farm (Roberts et al., 2002; Internet: Scottish Executive; Nature Conservation Designations And Land Values). The payments come in two forms: annual payments for adhering to certain management prescriptions and capital payments for capital works such as fencing for stock control, dyking or bracken control. The farmers are entitled to a payment for carrying out these activities plus a Tier 1 payment that compensates them for adhering to a basic management prescription for the area.

In January 2001, the Rural Stewardship Scheme was launched which replaced the ESA scheme and the Countryside Premium Scheme. No new entrants to the ESA scheme were allowed and contracts are not expected to be renewed. Reasons for this major change in the agri-environment measures were a growing unease about the performance of the ESA scheme (for further detail see: Centre for Rural Economics Research & CJC Consulting, 2002). The new scheme was planned to deliver clearly defined environmental gain, particularly in contributing more to achieving BAP objectives. The RSS scheme is based on a scoring system with the highest scoring applications being selected. The scoring takes into account the number of activities proposed and the contribution to national and local BAP's (Centre for Rural Economics Research & CJC Consulting, 2002).

New measures for the 2nd Pillar as proposed by the European Commission do not include additional agri-environmental measures. In addition, until 2007 there will be no mandatory modulation for the Member States. Therefore in the short term no big changes regarding agri-environmental measures can be expected. It is difficult to say what will happen afterwards, because the amount of money allocated by the European Commission to Scotland for rural development depends on a number of criteria and thus is not known yet. Moreover, it is up to the Rural Development Committee in Scotland how to spend the funds and no plans are made in this early stage of the reforms.

3.5.2 Nature Conservation

For a number of farmers, nature conservation measures provide additional subsidies in the case they co-operate in special management schemes or action plans aimed at the conservation and protection of designated sites or rare, threatened species. Conservation policy relies on the designation of certain areas that are important for their high nature value.

In 1979 the European Community adopted the Council Directive on the Conservation of Wild Birds (79/409/EEC). This Directive is usually referred to as the Birds Directive. Article 1 applies to the conservation of birds and also to their eggs, nests and habitats. Article 4 requires Member States to take special measures to conserve the habitat of certain listed threatened species through the designation of Special Protection Areas.

In 1992 the European Community adopted Council Directive 92/43/EEC on the conservation of natural habitats and wild fauna and flora, known as the Habitats Directive. Under this directive, action must be taken to protect species and habitats through the designation of Special Areas of Conservation. Together, Special Protection Areas and Special Areas of Conservation form the Natura 2000 network. This European-wide network of sites is designed to promote the conservation of habitats, wild animals and plants, both on land and at sea. When farmland is designated under Natura 2000 as Special Protection Area or Special Area of Conservation, management agreements for specific organisms like the marsh fritillary butterfly on Islay, may be applied. In Scotland these management agreements are paid by Scottish Natural Heritage (SNH).

RAMSAR sites are designated by the Government under the RAMSAR convention of 1971 on Wetlands of International Importance. The UK government's policy is to apply the same considerations to the protection of RAMSAR sites as if they were classified as SPAs (Scottish Office, 2001).

Throughout the UK, the backbone of the system of protected areas for nature conservation is the SSSI series (Scottish Office, 2001). Sites of Special Scientific Interest are designated on the grounds that they are the most important areas for the conservation of habitats, species and geological features. In Scotland there are over 1.450 SSSIs covering 990.000 hectares or 11.6% of the total land area (SNH, 2000). Areas can be designated as a SSSI by Scottish Natural Heritage (SNH) under the Wildlife and Countryside Act of 1981. There is a large number of SSSIs though not all have been designated as SACs and SPAs. If a farm is situated within a SSSI, the landholder is provided, in addition to a statement of the scientific interest of the site, with a list of "potentially damaging operations" (PDOs) thought likely to harm the interest. These might include drainage work, felling, variation of grazing, spraying of pesticides, and are specific to individual sites, though drawn from a standard list. Having examined the individual case, SNH may either give consent to it or enter into an individually negotiated management agreement with the owner or occupier to compensate him for not carrying out an activity. If a user goes ahead regardless, he is liable to a fine of up to £1,000 and may be ordered to restore the 'damage'. Management agreements can also be used at any time to provide payment for positive maintenance or enhancement of the scientific interest.

Additional to agri-environment schemes incorporated within the ESA scheme or management agreements based on the designation of a certain area, a couple of other environmentally-aimed agreements are present which, in some cases, can form a considerable source of income or compensation payment. For example the Local Goose Management Scheme, paid by SNH, is rather important as over 40.000 geese overwinter on Islay. The compensation payments are based on the area of grass, both re-seeded and permanent, on each farm. In 1999/2000 the expenditure for the Islay Voluntary Goose Management Scheme, consisting of 118 agreements, for SNH was £418,194 (SNH, Fact and Figures 1999/2000). One year later, the total annual sum involved even reached £503,000 on 111 agreements for the whole of Islay (SNH, Fact and Figures 2000/2001).

In addition to the Goose Management Schemes, the Royal Society for the Protection of Birds owns land for which it also provides voluntary management schemes for birds. The most important one on Islay is the corncrake management scheme, in which late mowing, after the 1st of august, is the main restriction for farmers. Chough Management Agreements on Islay are based on a joint agreement with RSPB & SNH. Whereas SNH bird-management schemes are concentrated in SSSI designated area, the RSPB schemes cover areas outside these designated sites, which are nevertheless important for bird populations, in this case the corncrake.

After the Convention on Biological Diversity of Rio 1992 three types of Action Plans have been developed in the UK by the Biodiversity Steering Group which set priorities for nationally important and locally important habitats and wildlife - Species Action Plans, Habitat Action Plans and Local Biodiversity Action Plans (Internet: UK Biodiversity). These action plans include both species and habitat management schemes. The mixture of site-based and wider policies is essential to meet the conservation requirements of most species. Bird populations within protected areas are frequently influenced by the consequences of land use in surrounding areas, and thus, protected sites are not closed units (Janzen 1983; Schafer 1990). This highlights the need for taking a species-based approach to the provision of conservation needs, reviewing provision of both sites and complementary wider countryside needs.

3.6 Conclusions

The relationship between extensive livestock farming and high nature value has been reviewed in this chapter. It is argued that extensive livestock farming and high nature value landscapes as well as the biodiversity they provide, form a coherent system of high conservation value. Policy influences this system in two ways, through the Common Agricultural Policy *and* the Environmental Policy, both with different goals and instruments.

The influence of extensive livestock farming on high nature value has been described by reviewing its effects on two components of biodiversity, namely birds and vegetation. Important characteristics of extensive livestock farming are: lack of fundamental alteration to the land, utilisation of a high proportion of semi-natural vegetation, the willingness to adapt the management to natural constraints, low stocking rates and low external input. Those conditions favour farmland-birds, as they provide the necessary habitat conditions. Moreover, extensive livestock farming provides an important condition at the scale of the Islay landscape. Referring to stocking numbers and input levels of nitrogen, management practices on the rough grazing can be considered as extensive, while the in bye fields are being farmed more intensively. This mosaic of natural habitats and the different arable, grassland and semi-natural habitats forms an essential condition for many farmland birds, as most of them depend on more than one habitat during at least part of the year. Such may be a combination of different agricultural habitats or a combination of agricultural and natural habitats. Most, if not all of the characteristics described above are absent from modern intensive agricultural systems, but also from rural areas where farming has been abandoned. This polarization, the development of extensive farming systems to either intensive systems or abandonment forms the main threat to biodiversity in such extensive agricultural areas.

Vegetation composition is determined by a number of biotic factors, such as grazing animals, and a-biotic factors, such as soil type and climate. Situations of over- or undergrazing excluded, the effect of grazing depends on a number of aspects. First of all the type of livestock is important. Sheep differ from cattle in grazing behaviour, the latter being less selective in what they eat. Apart from livestock, wild animals, on Islay mostly red deer and feral goats, feed on the rough grazing and consequently also influence the vegetation. Some species may also facilitate grazing for other species as goes for cattle grazing which facilitates goose grazing.

All these grazing animals with their different grazing behaviour influence the vegetation. This influence is not similar at all places: especially in large unfenced areas gradients in grazing pressure will originate. Along these gradients different stages of succession of the vegetation can be seen, from grazing resistant grassy vegetation communities on heavily grazed parts to high heather vegetation communities on hardly grazed parts. An important feature of grazing is that succession to climax vegetations is impeded and that it prevents scrub encroachment. In this way grazing contributes to a greater variety of herbs, sedges and grasses. It is still important to realize however, that biotic and a-biotic factors are strongly interacting and can not be considered separately.

The most important policies influencing extensive livestock farming are the CAP and Environmental Policy. Under the CAP farmers have long been stimulated to intensify. This stimulation has decreased after the recent reforms of the CAP. Although extensive livestock farming on Islay has remained quite extensive according to the characteristics described above it seems unlikely that agriculture on Islay will intensify. At this time direct income support from the CAP comes from several livestock premia and is limited to the quota a farmer has. Farmers can also obtain subsidies through the Rural Development Regulation. Important in this aspect are the Less Favoured Areas Support Scheme and the Rural Stewardship Scheme, formerly known as the Environmentally Sensitive Areas Scheme.

Several aspects of environmental policy are important for extensive livestock farming on Islay. Environmental policy usually restricts farmers in their management, while offering a form of compensation for income loss because of restrictions. The backbone of the Scottish network of designated sites is formed by Sites of Special Scientific Interest by Scottish Natural Heritage. Many SSSI-sites on Islay have also been designated as a Special Protection Area or Special Area of Conservation under respectively the Birds Directive and Habitats Directive. Such protection and conservation areas form the Natura2000 network. Besides those designations there are also RAMSAR designated areas for wetlands of international importance. A special place is taken by the Local Goose Management Scheme. Moreover, the Royal Society for the Protection of Birds offers a number of management schemes for birds.

All the policies above have different effects on extensive livestock farming, some more obviously than others, but altogether forming a very complex system of instruments. An attempt will be made to identify the most important effects for birds and vegetation in the next chapters.

4 Methodology

4.1 General set-up

The way this study has been set up, is described in the figure below. The study consists of literature research, expert knowledge, a series of interviews and a field study. The field study was done to investigate the effect of grazing on vegetation. The effects of farming on birds were investigated through a literature study, expert knowledge and a series of interviews with farmers concerning their farming practices. Next, on the basis of the elaboration of those data, predictions have been made on the effects of policy measures on high nature value, in this case birds and vegetation. In order to keep a good overview of the research, each step will be described separately below. Figure 4.1 shows a flowchart of the general setup of this study. The characters indicate the different steps described below.

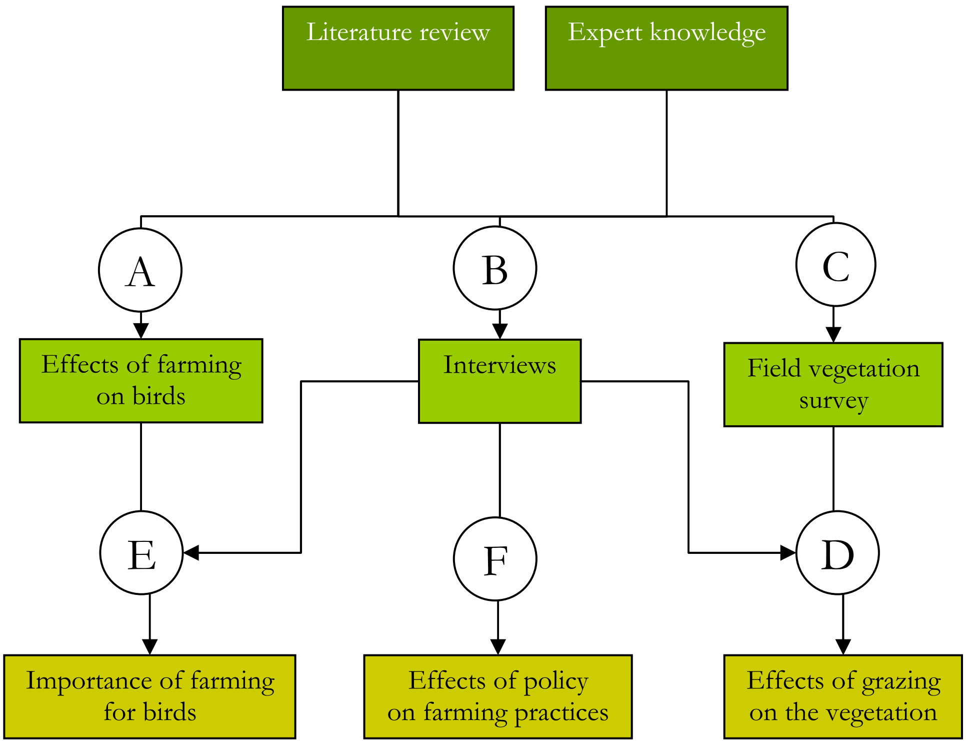

Figure 4.1 Flowchart of the general setup.

4.2 Step by step

A. Birds table

One of the goals in this study is to identify the links between farming practices and high nature value. Literature has been reviewed as to assess the impact, positive as well as negative, of farming practices on bird species. Because farming only affects the bird species that actually come in contact with farming in some way, a selection of bird species has been made, based on the Annex I and Annex II lists from the EU Birds Directive. Out of the total of 181 species on Annex I of the EU Birds Directive, 28 species are present on Islay. Eleven of these were considered to be influenced by agriculture "because of their dependence on agricultural habitats such as meadows, arable land and rough pasture in at least part of their lifecycle" (Tucker and Evans, 1997). In order to give a more complete picture, four Annex II species, which are also under pressure in the UK, were added to this list (see table 4.1).

Table 4.1 Important bird species on Islay influenced by agriculture.

Annex I species	Annex II species
Whooper swan	Black grouse
Greenland white-fronted goose	Curlew
Barnacle goose	Redshank
Hen harrier	Skylark
Golden eagle	
Merlin	
Peregrine	
Corncrake	
Golden plover	
Short-eared owl	
Chough	

Only the effects of common agricultural practices on Islay have been reviewed. Some of these have been split up on the basis of their intensity or timing. These common agricultural practices were determined with the help of two experts; one a farmer on Islay and member of the EFNCP, the other an agricultural advisor. The practices are listed below in table 4.2.

Table 4.2 Most common and important farming practices affecting high nature value.

Permanent grassland	Rotational arable cropping	Rough grazing	Other factors
High stocking density summer	High artificial fertilizer input	High stocking density	Vegetation mosaic
High stocking density winter	Low artificial fertilizer input	Low stocking density	Habitat mosaic
Low stocking density summer	Drainage	Drainage	Abandonment
Low stocking density winter	Hay production	Presence of carcasses	Afforestation
High artificial fertilizer input	Silage production	Habitat fragmentation	
Low artificial fertilizer input	Reseeding	Mixed livestock	
Drainage	Early cutting		
Ivermectin use	Late cutting		

The effects of these practices on the selected birds are discussed in chapter 5, for a table with the complete results see Annex 2a,b,c and d. The table describes whether the influence of a farming practice is positive, negative or does not affect the particular bird-species. In this table the farming practices are divided into four different categories, depending on the area of the farm affected by the specific practice. The permanent grassland, rotational arable cropping, rough grazing and 'other factors' categories are separated in the table. Information from different books and articles was used to find out about the effect of a particular practice on a bird-species[2]. For some species more information was available than for others. When there was no information available, neither in literature nor from experts, nothing was filled in. The most important results are discussed in chapter 5.

B. Interviews

The interviews consisted of a questionnaire about farming practices. The questions focussed on the farming practices mentioned in table 4.2. The goal was getting an overview of farming practices on Islay and predicting effects of farming on birds (step E) and to evaluate the effects of policy on farming practices (step F). To get a more complete picture of the farming system as a whole, some other categories of questions have been added. Questions cover the following general topics: *general aspects, cattle, sheep, permanent grassland, rotational arable cropping, rough grazing, extra input on the farm, environment* and *personal*. For each category one question refers to the most significant changes in the last ten years. The total number of questions was eighty (for complete questionnaire see Annex 3a).

Fourteen farmers were interviewed out of an estimated total of hundred and twenty farmers on the island. Two samples of seven farms each were taken from two 'different' areas on the island. Seven farms on the 'Rhinns', the western half of Islay which is a SSSI area, and seven farms on the rest of the island. To introduce the study the chairman of the local National Farmers Union was asked to announce it on a meeting. Next, the farmers were approached individually by the local farmer/EFNCP member, who made an appointment for the interview. All approached farmers were willing to co-operate. The farmers were interviewed at their farm. This usually took anywhere between forty-five and ninety minutes.

C. Vegetation

From the range of different farming practices we have selected grazing to study the effects of. A range of different habitats on Islay are being grazed. Due to its diverse and complex geomorphology, differences in vegetation occur. As the response of plant species is very specific and dependent on the timing and intensity of grazing and the type of grazer involved, it is difficult to predict the effects of stocking densities on the species richness, species composition and structure of vegetation. However in general, the natural carrying capacity of nutrient-rich soils is higher and thus better able to support higher stocking densities, without adverse effects on species richness, and composition, and structure of the vegetation. On Islay, grazing mostly takes place on moor-land and heath, thus, under poor-nutrient conditions. Therefore, a rather light grazing regime would be sufficient to prevent encroachment of scrubs and woodland, and to maintain relatively species-rich vegetation as well. With the help of a local farmer, three sites have been selected for vegetation study.

[2] Literature used for the table is listed in Annex 2e

Next, the selection of quadrates will be described along with their characteristics, followed by the sampling technique. Finally, the way in which the collected data have been analysed, will be described.

Selection of sites and techniques used
In order to present examples of the impact of grazing on different characteristics of the vegetation, areas were chosen where grazing intensities had been constant for at least the last 5 years. The selection of sites has been performed in such a way that most actual grazing pressures are represented. Sites have been selected at three locations in the north-west part of Islay (see Figure 4.2 and Annex 4a), where the soils belong to the Kilchoman Phyllite soiltype; grey and pyrite – covered by thin calcareous silt layers (British Geological Survey, 1:50,000).

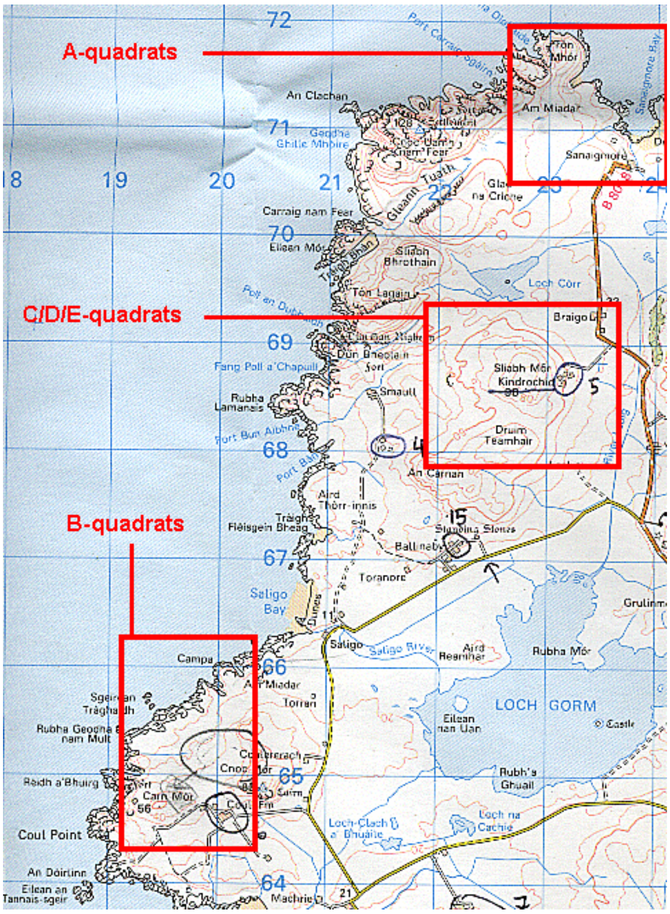

Figure 4.2 Position of the vegetation plots at the north-west side of Islay (for detailed map see Annex 3a)

Table 4.3 Characteristics of the sampled quadrates.

	A-plots (6)	B-plots (6)	C-plots (3)	D-plots (2)	E-plots (2)
Vegetation	Heather moorland	Grassland mosaic	Patches of old heather and Molinia	Grazedside of fence → grassland	Ungrazed side of fence → heather
Stocking density	0.17 LU/ha	0.67 LU/ha (8 yrs ago LU/ha was 2.5)	0 (or end of grazing gradient)	unknown	unknown
Grazing animals present	Highlander & sheep	5 cows & 130 sheep	None	Horses and sheep	Sheep
Apparent grazing pressure (grazed shoots, height of vegetation)	Low	Intermediate	None	High	Low/end of grazing gradient
Remarks	A1 = with 15 ° inclination A4 – A6 run along gradual slope (A6 = lowest)	B3 = rather different from other plots;without grass- but wet heather species are present; B4 – B6 run along gradual slope (B4 = lowest)	C1 = dry with Calluna, C2 and C3 are wet with *Molinia caerulea*	D1 = dry, on top of hill D2 = wet, in *Sphagnum/Scir pus cespitosa.* bog	E1 = rather dry, regene-ration of *Salix aurita;* E2 = rather wet, *Calluna/Scirpus cespito sa* bog

Table 4.3 summarises the characteristics of the different plots, which are described more extensively here. In site A, Highlander cows and Blackface sheep were used for grazing while the livestock density was rather low, but within the area there was certainly a differentiation as the sheep tended to be concentrated on the grassy parts near the cliffs and near the barn/sheds (see some photos in Annex 4b). From the barns to the moor-land, where the quadrates were situated, the apparent grazing pressure on the vegetation declined, though grazing certainly still occurred. Thus, a grazing gradient was very obvious, as the parts with more sandy soils were apparently attracting more sheep than the wetter, peat areas. In addition, the sandy soils were probably richer in nutrients – as a consequence of sand drift from the sea-shore - as compared to the peat areas.

In site B, grazing intensity has been high until 1994 with 80 cows, for the last 8 years there was a grazing regime of 5 cows and 130 sheep from April – October. The vegetation consists of grassland with at some parts remains of heather. In the winter there was no stock on the land. Unlike the situation in Site A, there were no high rock formations that provided shelter for the incoming sea wind (see photos in Annex 4b).

In site C there were no signs of grazing. Probably it formed the 'end of the grazing gradient' with the high-grazing-pressure-part near Site A. However, lately some fences may have been placed, so that the area was not accessible to cattle during recent years only. The vegetation was rather patchy with dense and long heather (*Calluna vulgaris*) growing on dryer, shallow parts and purple moorgrass (*Molinia* *caerulea*) on wetter parts. At some places eared willow (*Salix aurita*) was forming stiff shrubs. The vegetation was high, undisturbed and without grazed tips of the shoots. In this aspect it was evidently different from site A where the effects of grazing could not be overlooked.

Additionally, to keep factors like soil type as constant as possible, quadrates have been laid out on both sides of a fence, one side evidently being more grazed (site D) than the other (site E). By comparing the two quadrates of site D with their corresponding ones of site E we were able to discriminate between pure effects of grazing on vegetation and other factors.

Vegetation in site D was grassy and very short, apparently due to a rather high grazing pressure, by sheep and horses. In some places there were dense stands of Bracken (*Pteridium aquilinum*), in other, wetter places *Sphagnum* species prevailed. These vegetation characteristics discriminated Site D from Site B where such vegetation types did not occur.

In site E, vegetation consisted of long heather, like site C. However, here, some grazing trails of sheep were observed and vegetation was not as high as in site C. Differences between wetter and drier parts could be seen as well, but were not so clear as in site D. The most evident contrast with site D was the domination of shrubs, mainly *Calluna vulgaris* and at some parts *Salix aurita*.

In site A and B, two transects, each with three vegetation quadrates, have been laid out. The first quadrate was placed in a representative homogenous part of the vegetation whereas the second and the third then followed at regular distance (10 meter in between). Due to the patchy distribution of the vegetation in site C, quadrates were not placed in a transect as was done in site A and B, but in three different, homogenous, representative vegetation patches. In sites D and E, locations on both sides of the fence were chosen that were apparently equal concerning soil moisture conditions; D1/E1 were rather dry, whereas D2/E2 were very wet. The quadrates were placed at 5 meters distance from the fence, i.e. 10 meters from each other. The positions of the quadrates are summarised schematically in Figure 4.3

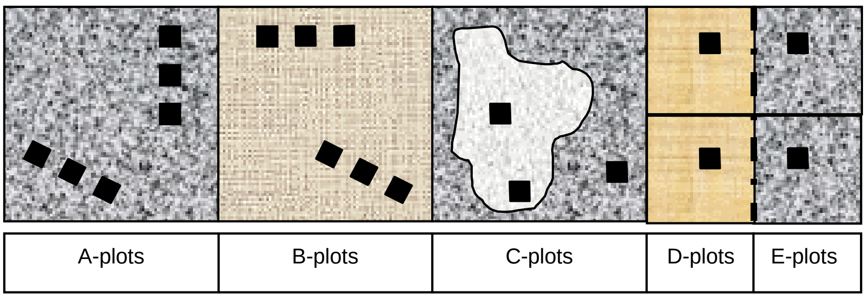

Figure 4.3 The way the plots were placed at the different sites (not on scale, dark pattern means heather dominated vegetation, other patterns are grass

Within the 3 x 3 meter quadrates the depth of the soil until bare rock was measured at four points and the numbers or cover values in percentages of vascular plants were recorded using the scale by Braun-Blanquet as modified by Barkman, Doing and Segal (see table 4.4). Mosses (Bryophytes) and lichens have not been recorded.

Table 4.4 Braun-Blanquet ordinal cover scale

Ordinal Value	Cover %	Abundance
1	< 5	1
2	< 5	2-5
3	< 5	6-50
4	< 5	> 50
5	5 – 12.5	Any
6	12.5 – 25	Any
7	25 – 50	Any
8	50 – 75	Any
9	75 – 100	Any

D. Vegetation data analysis

All records from the quadrates have been digitised by using the software package TURBOVEG (Hennekens and Schaminée, 2001). This program constructs a database that comprises species composition and cover percentage information of the 19 quadrates. The cover values that were used during input were defined as ordinal values (see table 4.4). The species data file (cnd-file) created by TURBOVEG has been used as input for data analysis by TWINSPAN, DENDRO and CANOCO. Moreover, TURBOVEG calculated the Ellenberg values for pH, N, salt and moisture for each quadrate and together with the measured values of the soil-depths, this formed the input to the environmental data file. An overview of the main characteristics of those programs is presented in Box 4.1, whereas in Annex 4c a schematic overview and a short description of the theoretical background for CANOCO are given. The results are presented in Chapter 5, section 5.3.

E. Farming practices on Islay and their effect on the birds

To predict and evaluate the effects of the farming practices on the selected bird species, the data on land management from the interviews (step B) have been combined with the tables created in step A. Application, timing and intensity of farming practices have been derived from the questionnaires. By coupling the data from the table to the data from the questionnaire, predictions could be made concerning the local effects on bird species. The results are presented in Chapter 5, section 5.2.

Box 4.1 Characteristics of programs used for vegetation data analysis.

TWINSPAN has been used to classify the quadrates based on similarity. Its output consists of a table that displays the entire species x quadrates matrix. The program is based on a divisive cluster method that separates the most distinctive sites – as to species composition - during each division step (Hill, 1979). In this way clusters of quadrates are identified which show similar vegetation composition and species abundance. With this table, vegetation community types can be identified and differences between areas with moderate and low grazing intensity or no stocking density as well.

DENDRO was also used to classify the quadrates, but in a different way from TWINSPAN. The method is based on hierarchic classification and it reflects the floristic similarity between the clusters of quadrates. The output is called a 'dendrogram' and the extent of dissimilarity is represented by the y-axis. The sequence of the quadrates along the x-axis is not of importance. Of importance is only which quadrates form a group and on which level (extent of dissimilarity) they are connected with other (groups of) quadrates. The way of forming clusters can vary; in this study the 'Average linkage' was used, which means that the similarity between two groups is represented by the average similarity between the quadrates of those groups.

CANOCO ordinates species according to the species compositions of the quadrates in a certain gradient (Ter Braak, 1987). In such a way, quadrates which are very similar are placed close together and quadrates that are rather different are situated further away from each other in a so-called ordination diagram. For CANOCO analysis the program CANOCO for Windows (CanoWin) was used to calculate the ordination. With the graphic programs (CanoDraw, CanoPost and Adobe Photoshop) the PCA-ordination diagram was obtained.

F. Effects of policy on farming practices

The effects of agricultural and nature conservation policy on farming practices have been evaluated by summarising the answers to questions concerning the main changes in farming practices on Islay of the last ten years. By evaluating these changes, predictions have been made on the way farmers may react to intended agricultural and nature conservation policy. The results are presented in Chapter 5, section 5.4.

5 Results

5.1 Introduction

The first section evaluates the importance of extensive livestock farming for high nature value. This is done by combining the results of the interviews on the one hand with information derived from the literature review about birds and the ecological principles of grazing at the other hand. In the next section, the results of the vegetation survey in the field will be presented. As the primary factor in determining species richness and species composition are the a-biotic conditions those will be regarded firstly. Then, the impact of grazing on the species richness and the species composition of the vegetation will be considered. The chapter ends with a description of the relationship between farming and current and future policy measures.

5.2 Effects of extensive livestock farming on birds

The following sections give a description of the effects of farming practices and their intensities (see annex 2a-2e), as derived from the interviews (see annex 3b-3c), on farmland birds on Islay. Farming practices are divided into four categories, according to their distribution over different fields on the farm (table 4.2).

These categories are:
- permanent grassland
- rotational arable cropping
- rough grazing
- other factors

It needs to be recognized that a particular farming practice does not have a similar effect on different nature values. Different bird species may be influenced differently by the same farming practice.

Permanent grassland (Annex 2a)
Usually, permanent grassland is present at every farm on Islay. The average size is 97 hectares, but it varies between 3 and 330 ha. An important factor on the permanent grassland is the stocking density. The seasonal timing plays an important role here, in the growing season vegetation and soil are less vulnerable to trampling damage than in winter, when the soil is wet and the vegetation cannot recover from damage. Estimated stocking densities in summer vary from 0.2 to 5 LU/ha. The weighed average is 0.81 LU/ha. This is relatively low, as compared to the maximum stocking density limit for the Extensification Payment Scheme, which is 1.4 LU/ha. Such low stocking rates in the breeding season have a low chance of egg and chick trampling for ground-breeding birds, like skylark, redshank and curlew. The low grazing pressure results in a sward consisting of high tussocks, good for skylarks to nest.

Moreover, such structures may contain higher abundance of invertebrate prey, for chough and skylark, as well as more abundant vertebrate prey for short-eared owls that hunt here, as compared to intensively grazed grassland. Finally, such extensively grazed grasslands may provide a larger grass leaf biomass, as compared to intensively grazed grassland, which is important for wintering barnacle- and Greenland white-fronted geese.

In winter the stocking density drops and varies between 0 and 0,9 LU/ha, the weighed average being 0,46 LU/ha. This drop may be caused by out-wintering on the rough grazing fields, in-wintering or away-wintering of livestock. This decrease of stocking densities in winter seems, at first sight, to be unfavourable to choughs, because of the invertebrates present in cattle dung being an important food source. However, this is partly compensated for by geese grazing here in winter. Choughs are doing well on goose-grazed fields, but livestock grazing instead of goose grazing in winter is also beneficial. Therefore, SNH has chough agreements with several farmers to maintain a minimum stocking density of cattle throughout the winter.

Fertiliser input is another important factor. The amount of nitrogen applied to the permanent grassland through artificial fertiliser - usually a 20N/10P/10K compound - varies between 0 and 200 kg/ha/yr. The weighed average is 60 kg N/ha/yr. Almost a third of the farmers however do not apply artificial fertilizer to their permanent grassland at all. Compared to the average input of artificial fertiliser on improved grasslands in the UK in 1999/2000 which was 100 kg N/ha/yr, this average gift is quite low at Islay (DEFRA, 2002). This relatively low fertilizer input does not have the severe effects of heavy fertiliser application on invertebrates. It allows a diverse invertebrate fauna, on which golden plover, chough, curlew, redshank and skylark may feed. Besides birds also mice and shrews feed on the invertebrate fauna. On their turn these species are preys for short eared owls. On the other hand, a higher fertilizer input would create plenty and nutritious food for geese in winter. Especially barnacle geese prefer such high productive fields.

The permanent grasslands on Islay have usually been drained well, but some wetter parts remain. Birds like whooper swans, curlew and redshank utilise the wetter areas for foraging and therefore would suffer from further drainage.

Changes in the last ten years have been relatively small, but the following notable changes have been mentioned by farmers: increased fencing because of management agreements, a general intensification and an increase in sheep numbers.

Rotational arable cropping (Annex 2b)
A field with rotational arable cropping was found at nearly all farms at Islay. The average area is 57 ha, and varies between 1 and 283 ha. The weighed average of nitrogen application through artificial fertiliser, usually a 20N/10P/10K compound, is 120 kg/ha/yr. This is – on the average – twice as high as compared to the permanent grassland. Nevertheless, this fertiliser is lower than the average input of nitrogen in the UK, which was 151 kg N/ha/yr in 1999/2000 (DEFRA, 2002). Barnacle geese and whooper swans may benefit from the nutritious sward this

fertiliser gift provides. But skylark will suffer from the change in vegetation structure, towards a more uniform and dense crop as a consequence of increasing fertiliser levels. The reduction in size of invertebrate prey (Siepel, 1990), caused by these high fertilisation levels, affects corncrake, chough, curlew, redshank and skylark negatively. Besides this, populations of insect-eating prey like mice and shrews will decline which in turn negatively affects the short-eared owl.

The rotational arable cropping has often been well drained to improve production. This means that species like corncrake, curlew, redshank, whooper swan and Greenland white-fronted goose, which prefer coarser vegetation, usually found on wetter parts, have trouble finding suitable habitats here.

Traditional hay production has often been replaced by silage production, but nevertheless about a third of all farmers still produce hay. Hay fields are important, in particular for corncrake and skylark, because they provide a suitable nesting habitat. The relevant difference is that haying is done once a year and rather late in the season, whereas the hay is drying at the field, while cutting is independent of weather, is done twice or three times a year, whereas the cut grass is removed directly. From the agricultural point of view growing silage gives higher yields, due to the possibility to cut several times per year. Almost half the farmers have their first cut in June, which is, for birds, too early. Another fifth has their first cut in July and the remaining third in August. Moreover, in total 20% of all farmers postpone cutting especially on vulnerable parts of their rotational grasslands until August.

Early silage cutting may be beneficial to choughs, because it creates a low, open sward. Corncrake and skylark however need higher vegetation for shelter. Early mowing however may be disastrous for corncrake, curlew, redshank and skylark, because their nests may be destroyed or their chicks killed. The chough and corncrake management schemes from SNH and RSPB play an important role in protecting the habitats of the latter species. So, instead of haying cutting for silage may affect invertebrate and bird life adversely.

Most farmers also grow cereals, barley and sometimes oats, usually for fodder, and sometimes cereals are grown mixed with the silage. Some farmers still use it to make their own straw. If other crops are grown it is usually rapeseed, also for fodder. The cereals are usually sown in spring, which can, at least partly, be explained by the many wintering geese that would damage autumn sown crops. Spring sowing is beneficial for whooper swans, Greenland white-fronted geese, choughs and skylarks, which feed on the stubbles that are left in winter. Besides these species also merlins, peregrines and short-eared owls profit indirectly because of the higher availability of seed-eating prey. The cereals also provide a forage habitat for the corncrake and a place to hide in.

Changes in rotational arable cropping have been quite small during the past ten years, a few farmers started growing barley, a few increased the area of rotational arable cropping and some have intensified.

Rough grazing fields (Annex 2c)
All farms at Islay have an area of rough grazing, with an average of 400 ha, and varying between 24 and 1440 ha. Both type of livestock as well as stocking density are important in determining vegetation composition and structure (being essential to animals), as described in section 3.4.

The weighed average stocking density in summer is 0.18 LU/ha, and varies between 0.07 and 1.00 LU/ha. In winter density is a little lower, namely 0.16 LU/ha varying between 0.04 and 0.75 LU/ha. These stocking densities are low and, especially in the case of mixed livestock, create a diverse vegetation structure with suitable ecological niches for many species, like Greenland white-fronted goose, hen harrier, golden eagle, golden plover, short-eared owl, black grouse and curlew. Choughs use the invertebrates from cattle dung as a source of food.

Almost three quarters of all farmers keep cattle as well as sheep on their rough grazing fields, but some either sheep or cattle. Mixed livestock helps creating a diverse vegetation structure because of the difference in grazing preferences of, in this case, cattle and sheep. In particular Greenland white-fronted geese, hen harriers and golden plovers may benefit from this.

The application of artificial fertiliser is very unusual on rough grazing fields. This is one of the conditions for the semi-natural vegetation to remain intact, which is important for species richness.

Drainage is does occur. About one third of the farmers have drained parts in their rough grazing fields. This is usually done to improve access for livestock to wetter areas, but at the same time it removes an important habitat for Greenland white-fronted goose, golden plover, black grouse, curlew and redshank. Hen harrier and merlin roost in wet places of the rough grazing, with high vegetation, and are therefore also affected by drainage.

The rough grazing is the most natural and usually the largest area of the farm. A result of the large and uncultivated area is the presence of livestock carcasses. Roughly three quarters of the farmers believe there are unfound livestock carcasses on their rough grazing. These form an important source of food for golden eagle, especially in winter when food is scarce. Choughs also feed on the invertebrates present in these carcasses.

Fencing is common and most farmers have their rough grazing field divided into 2, 3 or 4 compartments. Motivation for fencing is often a management agreement or to keep a better eye on the livestock. Almost half the farmers reported an increase in fenced areas in the last ten years. Very often this was the consequence of a management agreement rules by which additional fencing has been prescribed. Fencing on wrong places may lead to habitat fragmentation and reduction of suitable habitats for some species. Moreover, large gradients in grazing pressure resulting in extensive patterns of vegetation strongly differing in structure and composition may be destroyed. This may lead to lower diversity and consequently lower species richness.

Conclusive remarks
A habitat mosaic is obviously present on Islay. The natural variation is large and ranges from intertidal flats to rocky cliffs and moorland. This natural diversity is enhanced by the variation created by extensive livestock farming, as demonstrated by the diversification into permanent grassland, rotational arable cropping and rough grazing. Many bird species need more than one habitat, often a combination of natural and agricultural habitats. Such a mosaic is essential for whooper swan, Greenland white-fronted geese, barnacle geese, hen harrier, merlin, peregrine, golden plover, chough, black grouse, curlew and skylark. The benefits of extensive livestock farming for biodiversity may decrease with higher cattle density as well as (higher) fertiliser gifts on permanent grassland and rough grazing, by fragmentation of large rough grazing fields by increased fencing, and additionally by increasing the number of cuts on rotational grassland.

Other factors (Annex 2d)
Ivermectin is an anti-parasite drug for cattle. It kills invertebrates in the gastro-intestinal system and, after excretion, also in dung. Most farmers do not use Ivermectin anymore, either because of a management agreement or voluntarily, in order to protect the chough, which feeds on the invertebrates in cattle dung.

Abandonment may become an issue on Islay in the future. The average age of farmers is 52 years, so for most farmers their age does not yet form a problem. But only few farmers have a son or daughter working at the farm; many others do not have a successor. Abandonment of land would have very serious consequences for the rich bird wildlife. When the type of land use which has created the different types of fields with their difference in type and intensity of management the diversity in habitats is lost, which means that part of the habitats themselves are also lost. The rotational arable cropping and permanent grasslands will soon be overgrown with fast growing weed-species, bracken and shrub. Without the grazing of domesticated ruminants on the rough grazing its vegetation will change. The loss of farmland habitats will severely affect the populations of bird species that depend upon these. This is true for practically all species dealt with in this report.

Conclusive remarks
So, in conclusion, there are two major threats to the delicate relationship between extensive livestock farming and biodiversity, viz. intensification (more cattle, more cutting, more fertilisers, smaller rough grazing fields) *and* abandonment of farming. Both possible developments will lead to loss of farmland diversity, and consequently to loss of habitat diversity which implies loss of habitats, and consequently loss of species.

5.3 The relationship between vegetation, grazing and the environment

5.3.1 A-biotic conditions; their effect on vegetation and their relationship with grazing

The impact of a-biotic conditions on the vegetation and the relationship of the various a-biotic conditions with grazing are presented in this chapter, using results of a multivariate PCA-analysis. It is important to remember that the environmental soil data (pH, N, salt, moisture) have been determined indirectly from the plant species the vegetation consisted of by using the Ellenberg values of the species. In this way it is only meant to give an illustration in one look of the a-biotic conditions.

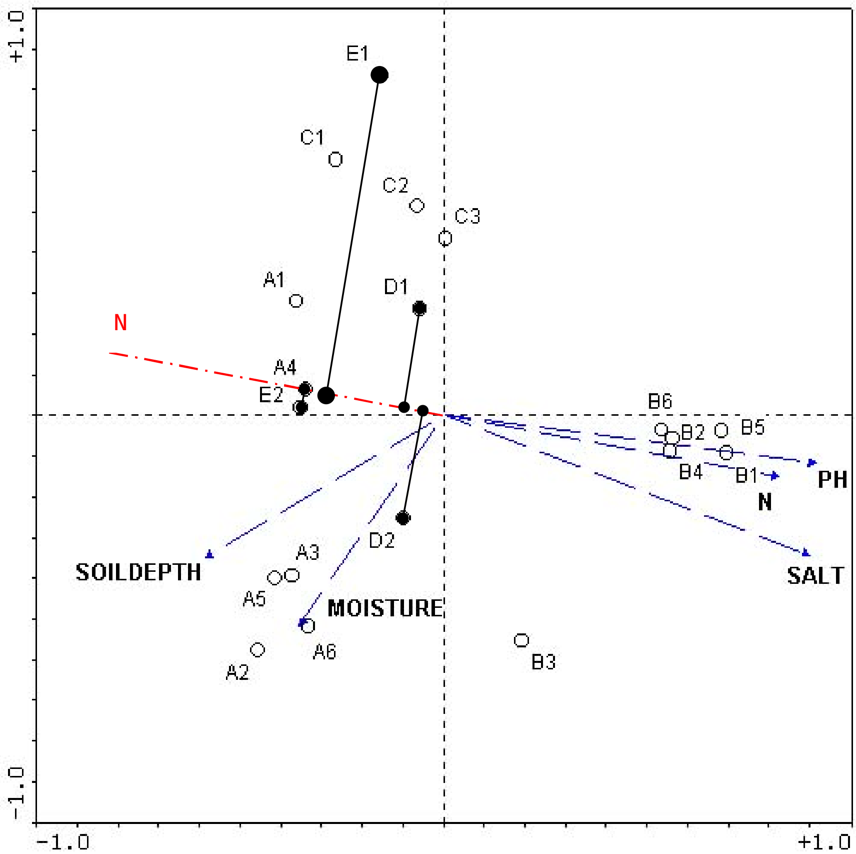

Figure 5.2 PCA-ordination diagram representing the vegetation compositions in the sampled quadrates (A1- E2). See for explanation of the quadrate figures: table 4.3 and top op table 5.1. The red line is the extended N-vector, the black lines are the perpendicular projections from the D- and E-quadrates on the N-vector.

The similarity in direction and position of the vectors for N, pH and Salt in the ordination diagram mean that they are highly correlated (see Figure 5.2). The different species composition of the B-quadrates is easily observed in the PCA-ordination diagram by the separate position of the B-quadrates. If the pH, N and Salt vectors are extended to the other site of the diagram and perpendicular lines are drawn from the quadrates to the arrows it can be seen that all the other quadrates apparently have a more acidic soil, with less nutrients than the B-quadrates and without the influence of salt spray.

The rough grazing A-quadrates were situated on relatively deep peat-layers (see table 5.1). The depth of the peat soil generally was more than 1 meter and this may explain the high Ellenberg values for moisture (see also table 5.1 further on). Here, most moorland species of natural value were found. The average Ellenberg values for N (2.3) and pH (3.4) of the B-quadrates are higher than the other quadrates (N = 1.2 – 1.8; pH = 1.2-2.4). Remarkable is the fact that the Ellenberg-value for N of quadrate D1 (2.5) was comparable with the extensive grassland B-quadrates but that D1 is still situated at the 'left side' of the PCA-ordination diagram. However, D1 is different from the B-quadrates in its lower Ellenberg value for pH. This may be an indication that within the range of quadrates included in this study, the pH of the soil is the most important factor in explaining the variation in species composition.

An effect of grazing may be nutrient enrichment of the soil, by dunging of the animals which is probably the case at the grazed site of the fence. In Figure 5.1 this is illustrated by extrapolating the position of the D- and E-quadrates with perpendicular lines on the N-vector; the soil at the grazed site of the fence (D-quadrates) is less acidic and nutrient-richer (Ellenberg value for N is 1,7-2,5) than the site of the fence with hardly no grazing or a very low grazing pressure (E-quadrates, Ellenberg value for N is 1,6-1,8). The altered soil conditions and the fact that *Calluna vulgaris* which is able to suppress other species, is absent from D are presumably the major factors leading to different species compositions on both sides of the fence.

Based on this study, it is very difficult to describe the relationship between a-biotic conditions and grazing patterns of cattle. This is mainly because stocking densities and locations for grazing are set by farmers. In the situation in which no compartments would have been present - thus allowing grazing animals to move over a large range of habitats and freely decide where to graze - it would be very interesting to see to which extent the grazing preference might be correlated with certain a-biotic conditions. However, the vegetation quadrates included in this study were located within fenced compartments. This implies that the outcome of the different aspects of vegetation within these quadrates is not entirely representing the natural preferences of the grazing animals. The compartment in which A-quadrates were situated is a very large rough grazing field (450 ha) which represents a long as well as strong gradient in grazing pressure, and several natural environmental factors. The field consisted of different vegetation types. Here however, while doing the vegetation sampling we did observe that sheep preferred to graze on the grassier coasts rather than on the heather moorland, where the plots were situated, though this may vary throughout the year.

5.3.2 Effects of grazing on the vegetation

Species richness

The species richness of higher plants showed considerable variation for the different groups of quadrates (table 5.1). Low species numbers (5-8) were found in the plots apparently without grazing or with a very light grazing pressure, such as the C1 and the E-quadrates. Intermediate species numbers (11-16) were found in the A-quadrates with a low livestock density and the *Molinia*-dominated C2/C3-quadrates with no apparent grazing pressure. Particularly in the B-quadrates and to a lesser degree in the D-quadrates, the highest species richness (16-27) was found. At these places there was a moderate livestock density.

From species numbers in the grazed (D-quadrates) and the hardly non-grazed site (E-quadrates) of the fence it can be concluded that grazing definitely affected the species richness. As can be seen in table 5.1, the species richness in the D-quadrates (18) was two times higher than in the E-quadrates (8). This is likely to be explained by the obvious differences in *Calluna vulgaris* cover and height; whereas at the hardly non-grazed site (E-quadrates) *Calluna vulgaris* covered 25-50% and vegetation height varied around 50 cm, at the grazed site (D-quadrates) *Calluna vulgaris* only covered about 5% and vegetation height was 10-15 cm.

Table 5.1 Characteristics of the sampled vegetation quadrates.

	A-plots	B-plots	C-1	C-2/C-3	D-1	D-2	E-1	E-2
Rough grazing fields	rough grazing, large (450 ha)	extensive gr. (formerly int. grazing), small (35 ha)	rough grazing large		Uphill, close to farm		Uphill	
Apparent grazing pressure	Low	Inter mediate	none	none	high	Inter-mediate	Very low	Low
total # species (mean)	13	22.8	5	13.5	20	16	8	8
# typical moorland species (1)	**7.5**	1.8	1	3.5	3	5	0	3
# sp. grasses / sedges / rushes	3	12	1	7	11	11	3	3
Mean Calluna %	33%	1%	88%	9%	9%	3%	38 %	38%
Mean Molinia %	9%	20%	3%	63%	38%	9%	63 %	3%
(Average) Ellenberg values								
Salt	0.05	0.35	0.0	0.05	0.2	0.2	0.0	0.0
pH	1.9	3.4	1.2	2.2	2.7	2.2	2.4	1.6
Nitrogen	1.6	2.3	1.2	1.6	2.5	1.7	1.8	1.6
Moist	8.0	7.5	6.7	7.5	6.3	8.0	7.4	8.0
(Average) depth of soil (cm)	107	37	15	63	27	24	56	36

(1) Melampyrum pratense, Eriophorum vaginatum, Eriophorum angustifolium, Myrica gale, Drosera rotundifolia, Empetrum nigrum, Pedicularis sylvatica, Scirpus cespitosus, Polygala serpyllifolia, Erica cinerea, Juncus squarrosus, Narthecium ossifragum and Dactylorhiza maculata ssp. ericetorum.

In the non-grazed quadrate (C1), where *Calluna vulgaris* was extremely dominant, only 5 species were found on 9 m^2. Generally, more species were found in plots where there was no domination of one or more species. In five quadrates, *Calluna vulgaris* or *Molinia caerula* were able to cover more than half of the area. Remarkable is the fact that four of these five quadrates were in the (hardly) not-grazed areas. This means that particularly in the absence of grazing these species are able to dominate. Especially for *Calluna vulgaris*, with a dense structure, the increase in plant mass, goes at the cost of less competitive species, and in quadrate C1 it simply left hardly any space or light for other species to be present.

In figure 5.3 for all quadrates the ordinal cover values (see table 4.4 & Annex 3d) of *Calluna vulgaris* were plotted against the total number of species present in that plot.

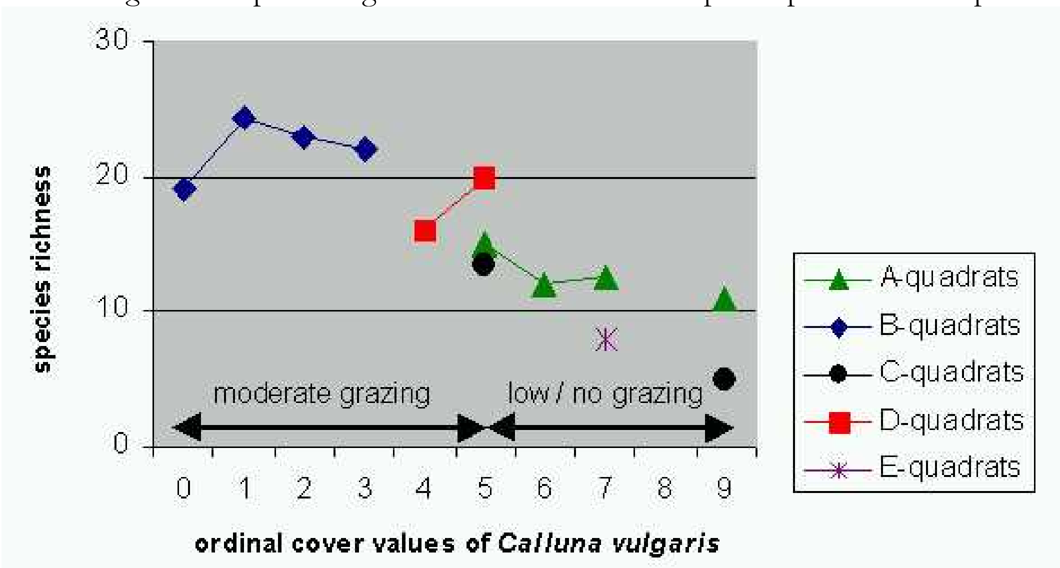

Figure 5.3 Relation of Calluna vulgaris cover with species richness (moderate grazing on fields containing B- and D-quadrates; low / no grazing on fields containing A- C- and E-quadrates).

A general decline in species richness is observed and the impact of grazing seems evident, provided that the soils on which the quadrates were located were identical. This assumption however does not appeared to be true, according to the PCA – ordination diagram. There were local differences in grazing history. Moreover, not all sites were grazed by the same types or breeds of grazing animals.

In general, the benefit of grazing to species richness seems to be the prevention of potentially dominant species becoming so dominant that for other species there is simply no light to germinate and/or no place to grow. *However, an important fact that may not be overlooked is that grazing and soil-conditions are interacting in their effect on species richness.* Grazing animals naturally prefer more nutritious places to graze. At such places soil types generally are less acidic. Without cattle grazing more species are able to grow on such base-rich soils, than on acidic soils. Moreover, the interaction may be unevenly distributed on a landscape scale. In the next paragraph, the differences between the sites in species composition with regard to the nature value of the species are considered.

Species composition

Grazing intensity appeared to influence species numbers. However the species composition of the most species rich site (B-quadrates) was almost entirely different from the species poorer moorland quadrates (see Dendrogram, Annex 3e). *Calluna vulgaris, Molinia caerula, Erica tetralix* and *Potentilla erecta* were the only species that were present at all sites. A range of moorland species was more critical and did not occur at sites that were either moderately grazed or not grazed at all. For the moderately grazed sites the Ellenberg values indicate that different a-biotic conditions are playing a role, resulting in a vegetation type other than moorland vegetation with a higher nutrient content leading to higher potential grazing pressures. For sites that were (hardly) not grazed, the dominance of either *Calluna vulgaris* or *Molinia caerula* seems to be significant. Sites with moderate grazing pressure generally were rich in grasses, sedges and rushes and ruderal species.

Regarding the species composition, the B-quadrates (except for B3) were most dissimilar from all the other plots (see Dendrogram, Annex 4f). They were distinguished because of a range of species not occurring in the other, heather moorland quadrates. In the field the most striking difference is the almost absence of *Calluna vulgaris* and typical moorland species in favour of grasses, sedges and rushes (see table 5.1). Characteristic for the B-plots are species such as: *Anthoxanthum odoratum, Nardus stricta*, *Carex panicea, Carex oederi ssp. oederi, and Cirsium palustre*. Moreover, a number of common, ruderal species, not of particular nature value, are present (e.g.: *Holcus lanatus, Plantago lanceolata, Ranunculus acris, Trifolium repens, Bellis perennis*). These species indicate coastal grassland with more nutrient-rich, less acidic soils. On places with little flushes and streams, some other typical species like *Ranunculus flammula*, *Hydrocotyle vulgaris* and *Anagallis tenella* occur.

In and around the A-quadrates typical moorland species such as *Myrica gale, Melampyrum pratense, Empetrum nigrum, Erica tetralix, Eriophorum angustifolium, Eriophorum vaginatum, Pedicularis sylvatica, Drosera rotundifolia, Narthecium ossifragum* and others were found (see table 5.1). They are of natural value, as they are characteristic plant species in the Annex I habitats (EC Habitat Directive): '*Northern Atlantic wet heaths with Erica tetralix*' and '*Blanket bogs*'. The mean number of typical moorland species is highest in those quadrats (table 5.1), which reflects the high species richness of the rough grazing field in which they are laying.

Although the species richness in C1 and the E-quadrates was lower than in the A-quadrates, their species range was still quite similar to the species-richer A-quadrates. The vegetation at the ungrazed site of the fence (E-quadrates) was more similar with the species rich heather moorland plots than to the vegetation of the grazed site of the fence (D-quadrates). Of the species present in the D–quadrates that were absent in the E-quadrates, 69% consisted of grasses, sedges and rushes.

In D1, where soil was drier than at D2, a number of ruderal species were found not occurring in other plots like *Rumex acetosa, Pteridium aquilinum, Galium saxatile* and *Cerastium fontanum.* Surprisingly, the grazed vegetation (D-quadrates) still showed more similarity with the heather moorland quadrates (A- C- and E-quadrates) than with the moderately grazed coastal grassland (B-quadrates) (see Dendrogram, Annex 3e). Yet, the grazing pressure was apparently even higher (vegetation was grazed much shorter) than on the B-quadrates. *This gives rise to the hypothesis that at Site B it is not just the grazing pressure, but above all, the different soil-conditions which cause the different species-composition.*

Conclusive remarks
Overall it can be concluded that grazing certainly influences species composition, but that the extent to which this happens is determined by the intensity of grazing, soil conditions and the interaction between these two factors. In this study, a high nature value biotope was found on deep peaty soils, where stocking densities were relative low. High stocking levels generally were associated with a vegetation rich in grasses and sedges. No grazing at all was found to affect vegetation composition as well; particularly on 'dry heaths' where *Calluna vulgaris* shrubs are not suppressed by grazing and the incoming coastal winds it becomes so dominant that less vigorous plants and bryophytes are likely to disappear.

5.4 Effects of agricultural policy on extensive livestock farming

5.4.1 Farmers' income

The largest effect on farmers, mentioned by many interviewed farmers, is the decreasing amount of money to be made by farming. Many farmers are earning income from other sources than farming, such as on-farm diversification (other sources of income at the farm), taking a second job or depending on their partner's income. On top of that their farming-income consist for an increasing percentage of subsidies, either from market support, rural development or nature conservation schemes.

Market support
The largest change has been the reduction of intervention prices by the EU. Instead farmers are compensated with direct support payments, in the case of Islay these are mostly livestock premia. Even though no quantitative data has been collected from farmers on this subject, the calculations in table 5.2 make clear that these premia now form an important part of a farmer's income. Until now income support payments were paid per head of livestock. This may have led to the higher number of cattle and sheep at present as compared to ten years ago, and consequently to a slight intensification of livestock farming on Islay.

Table 5.2 Example of direct income support for a regular farmer according to schemes in 2003

	Number of Eligible animals	Premium per head	Totals per premium
Suckler Cow Premium	75	200	15000
Beef Special Premium	30	150	4500
Sheep Annual Premium	620	21	13020
Extensification Payment	105	80	8400
total payment (euro)			40920

Rural development
The rural development has become particularly important for Islay farmers over the past decade, even though a measure like the LFASS (Less Favoured Areas Support Scheme) already exists for over 25 years. Since it has been changed three times in the

last three years it is hard to tell what the influence of the LFA scheme has been, except for causing uncertainty. Farmers have difficulties adapting to such quick changes. It becomes clear from the following calculation for a regular farmer that LFA support is important for his income. This farmer has 500 ha of forage area, 190 livestock units and 55% cattle in his total livestock units. This means he falls into grazing category B, which makes 1/3 out of his total hectares eligible (63). He will receive a beef-cattle top-up of 70% and the payment per hectare is 67 euros. Based on these numbers he will receive a total payment of approximately 19.000 Euros.

The introduction of the ESA (Environmentally Sensitive Area) scheme was mentioned by all farmers as a major change. Especially in agriculturally less favoured areas, entering an ESA scheme is considered to be important. In the first place in supporting the management that is essential for maintaining the variety and attraction of Scotland's countryside and secondly in relation to the key priorities of Natura 2000 and the Biodiversity Action Plans (Internet: Scottish Natural Heritage; Proposals for improvements to the operation of agri-environment schemes in Scotland). Moreover, there is a strong socio-economic aspect because the ESA-payments at least compensate for forgone income. Some of the interviewed farmers even mentioned their farm could not survive without this additional source of income.

Nature conservation

In addition to ESA schemes, environmental schemes have also become very common on Islay. Half of the interviewed farmers participated in one or more environmental schemes, not counting the goose scheme in which almost all farmers participate. These environmental schemes are either SNH or, less often, RSPB funded. They are usually considered as a way of compensating for lost income. The goose scheme is very important in this aspect. A clear negative effect of the schemes as to diversity has been the increase in fenced areas. Nothing can be concluded about the consequences though, because these depend on too many variables.

5.4.2 Additional notes on future policy

Less Favoured Area Support Scheme

In August 2002 the LFASS underwent a reform, which brought about a number of important changes in the former scheme. Those changes that will very probably turn out to be important for farmers on Islay are discussed below.

The recognition of the economically fragile position with regard to transport by assigning farmers on Islay with the highest basic payment is an important step. Under the LFASS 2002, payment rates for improved grassland were either £45.00 per hectare (Northern Upland) or £30.40 per hectare (Moorland) whereas payment rates for rough grazing were £9.60 per hectare (Moorland) or £12.50 per hectare (Northern Upland). However, under the present scheme one general payment rate of £44.50 per hectare holds for all types of land-use. It may be clear that this change in measure is in favour of farmers with a large ratio of rough grazing fields / in bye fields with the financial benefit being greatest with increasing sizes of the rough grazing fields. On Islay, the ratio of rough grazing / in bye fields varied between 0.17 and 6.58 whereas the size of the rough grazing of the interviewed farmers varied largely as well; between 24 and 1440 hectares. Small farmers and crofters, who have more arable or in bye area than rough grazing, will not be among the winners. However, since the overall stocking densities on the in bye fields on the average are about five times higher than stocking densities on the rough grazing the downside of having a large rough grazing compared to the in bye fields is that they are more likely to have overall low stocking densities, classifying them into categories with a lower hectare value. This is the factor by which the number of hectares must be multiplied to get the eventual number of hectares that is paid for. It was estimated that the majority of the farmers in the parishes of Kilchoman and Kilmeny were in Grazing Category B, which means a hectare value of 0.333, while the majority of the farmers in the south western parish, Kildalton and the Oa, were in Category A, meaning a hectare value of a only 0.167.

We compared the different LFA schemes in a simple model to assess the financial consequences for farmers on Islay. We took the Grazing Categories, the beef cattle bonus factor and the different payments of the former LFASS and the current one as fixed parameters and the size of the rough grazing and the in bye as variables. This comparison revealed that all farmers classified in Grazing Category A are very likely to loose overall from the current change. Only those farms, which were formerly classified as Northern Upland, where the ratio of the large grazing / in bye is 6 or larger and where 50 per cent or more of livestock consists of cattle will gain from the change to the current LFASS. For farms classified in Grazing B, the situation will be more beneficial since all farmers where the ratio of the large grazing / in bye fields is equal to or larger than three will be winners, except those farmers whose land used to be classified as Northern Upland and contain less than 10% of their livestock in cattle. In higher Grazing Categories, almost all farmers will be winners.

With regard to nature conservation it may be concluded that especially those farmers which have put a low stocking density on the land as they recognise the relatively poor land quality and attempt to avoid overgrazing, will be off worse.

Agri-Environmental Measures

Over the next years the ESA agreements for many farmers on Islay will expire and some interviewed farmers expressed their worries about the opportunities to continue into a new scheme. The severe limitation on funding means that many farmers who have submitted worthwhile applications to the scheme find themselves excluded because there are no funds available (Internet: Scottish Natural Heritage (b)). Restricted funding has created a very competitive scheme with current entry restricted to less than 1 percent of Scottish farms (Ward and Thompson, 2002). From a rural development perspective the Rural Stewardship Scheme is not successful since large farms and estates are highly competitive because of the diversity of habitats present. Small farmers and crofters on Islay are not likely to benefit from the change from ESA scheme to the new Rural Stewardship Scheme.

Especially large farms in designated areas (Ramsar, SSSI, SPA, and SAC) are likely to be among the ones who are able to enter in RSS schemes.

Reform of the Common Agricultural Policy

The implications of the structural change of the CAP after the Midterm Review for Islay farmers is not so easy to forecast. During the proposals of the Midterm Review most countries were against because of various reasons, but the most important uncertainty is that it is not exactly known what will be the consequence of removing the obligation to produce. Particularly among environmentalists a fear exists that decoupling without strict environmental cross compliance measures could mean a greater risk of abandonment in sectors where profitability depends on direct support (Internet: Birdlife International; WWF Europe). This comprises above all marginal, less-favoured areas like Islay where yields are lower whereas transport costs may be higher.

Since it is up to the Member States themselves how to implement the rural development measures, the benefits that these measures will deliver for farmers are harder to foresee than the apparent adverse effects of the reduction in direct payments.

Despite having 12 percent of the EU's agricultural land, the UK only receives 3.5 per cent of total EU funds concerned with rural development. Within the UK, Scotland receives the lowest allocation of Rural Development Regulation funding per farmer or per hectare farmed (Ward and Thompson, 2002). The compulsory modulation will affect Scotland more than other European countries since, taking the country as a whole, Scotland has a relatively small farmed area, with relatively low agricultural employment and relatively high prosperity and is therefore unlikely to be a net recipient of modulated funds (Internet; Scottish Crofting Foundation).

It is estimated that, nowadays, only 9% of the farmers in Scotland receive less than 5000 Euro per year, as compared to an EU average of over 60% (National Farmers Union Scotland 2002b). So 91 % is estimated to receive more than 5000 Euro. This is coherent with our own findings on direct income support of Islay farmers, based on livestock numbers, which were retrieved through the interviews.

But because of the fact that most farmers on Islay belong to the highest receivers of direct payments, it may be expected that they will be cut considerably for funding by future market reforms during the coming nine years (see table 5.3). This is even more than twice the amount cut for rural development, which implies that Islay farmers may suffer from costs for future wine, olive and tobacco reforms.

Table 5.3 Cutting of direct payments to farmers for modulation of 1st pillar funds after the CAP reform of June 2003 in EU

Budget year	2005	2006	2007	2008 to 2013
Percentage of cutting for farms with up to EUR 5000 direct payments a year	0%	0%	0%	0%
Percentage of cutting for farms receiving more than EUR 5000 direct payments a year	3%	4%	5%	5%

Jim Walker, president of the National Farmers Union of Scotland expressed it like this: “there is a real danger that we could see Scottish farmers being taxed and farmers in other countries potentially getting the benefit. With average net farm income in Scotland last year at around £6,000 Scottish farming cannot afford such a cut” (National Farmers Union Scotland, 2002b).

6 Conclusion and discussion

We will try to answer the proposed research questions in this chapter on the basis of our results.

1. How does extensive livestock farming contribute to the high nature value on Islay?

- *What are the effects of grazing on the vegetation?*

From the fieldwork, it may be concluded that grazing certainly has a large impact on the vegetation. The most important effect of grazing is that it impedes the succession of the vegetation, thereby creating semi-natural habitats. Heather is not a climax vegetation stage and would, in the absence of grazing, eventually become replaced by some kind of forest. This could be seen clearly at some places on the island where *Betula spp.* had replaced the heather vegetation. In this way, grazing animals can certainly be seen as an integrated functional part of these semi-natural ecosystems.

However, it is known that grazing alone may not prevent semi-natural habitats from being replaced by other vegetation types (Bartolomé et al., 2000). For example, heather moorland not influenced by coastal winds, needs a careful burning regime to prevent natural succession to scrub woodland (Fielding and Haworth, 1999). The speed with which this takes place is different for different regions, but for example for Exmoor it was estimated to take 100-200 years to develop a dominant scrub cover (Miller and Miles, 1984). In addition, other anthropogenic activities like turf stripping or sod cutting are considered to be necessary, particularly for heathlands coping with high atmospheric nutrient deposition, to prevent development to grassland (Bokdam and Gleichman, 2000; Gimingham, 1994).

If heather is not being grazed, it develops dense stands of dwarf shrubs which are very strong competitors. This was illustrated in plot C1, where *Calluna vulgaris* shrubs were very dominant with only 4 other plant species present in 4 m^2. Thus, a relation certainly exists between grazing and species richness. *The poverty in species in heather stands stresses the significance of extensive grazing to biodiversity, and, in addition, the threats of abandonment to biodiversity.*

Nevertheless, it was not possible to attribute the most important differences in species richness of the vegetation between sites with moderate grazing pressure and low grazing pressure entirely to grazing and its coherent effects. The reason for this are the complex interactions between the grazing behaviour and the a-biotic conditions present in different habitats. For example, every farmer tends to put animals on more fertile ground. In addition, grazing animals by nature prefer those areas where they can optimise their nutrient intake and calories (Bokdam, 2002). This means that they prefer areas where vegetation is of higher nutrient content to areas with vegetation of lower nutrient content. Thus, such areas do differ both in their soil and hydrological conditions as well as (and consequently) in grazing pressure. Therefore, it is not possible to disentangle possible effects of grazing from a-biotic conditions which determine the structure and the diversity of the vegetation.

From the foregoing it might have been concluded that uniform Heather stands in such moorland vegetation have no nature value. But this is not true. They have an important value as food source for many specialised insects, leaf, bud and flower feeders as well as pollen and nectar feeders. In addition, its specific vegetation structure offers exothermic animals such as lizards and bush crickets the possibility to regulate the body temperature by selecting the appropriate position along the vertical gradient, in according to body temperature, and weather conditions. So, uniform heather stands form an important part of such moor systems, but should not dominate the whole field.

Most species from the Annex 1 list of 'blanket bog' habitat (European habitat directive) were found on the rough grazing with a low stocking density and a mixed stock of Highland cattle and sheep. Generally, the areas with a higher stocking density were species richer, but the difference was made mainly by grasses and common, ruderal species. *This stresses the significance of extensive grazing to biodiversity, and, in addition, the threats of intensification to biodiversity.*

The plots on both sides of the fence, with the grazed one being richer in species, provide an example of the situation on a wider scale in the UK. The Countryside Survey 2000 conducted throughout the United Kingdom, revealed that between 1990 and 1998 within all of the following Broad Habitats, 'Acid Grassland', 'Dwarf Shrub Heath', 'Fen, Marsh and Swamp' and 'Bog' there has been an increase in species characteristic of more fertile situations while the abundance of species able to tolerate the low nutrient conditions normally associated with these habitats, decreased (Haines-Young et al., 2000). It is not understood to what extent grazing management and/or deposition of atmospheric nitrogen are the driving forces of these changes. Though the islands of Scotland can be considered as marginal agricultural areas, intensification of agricultural management practices has also occurred, though to a lesser degree.

On Islay, grazing occurs in various habitats, ranging from salt marshes to heather moorland but including also the in bye fields where the soils and the vegetation is altered and managed considerably by grazing and other farming management practices. A major fact to bear in mind when considering grazing in (the mosaic of) all of these semi-natural habitats, is that all components of these ecosystems, are dependent of vegetation for food, structure and microclimate as well. For instance, birds and smaller animals such as reptiles, grasshoppers, spiders and beetles all make use of the vegetation for particular activities and are likely to be influenced by changes in vegetation structure or composition (Hopkins, 1991; Kuiters, 2002), and consequently by grazing. Changes in vegetations structure, not yet reflected evidently in the vegetation composition, may have a considerable impact on invertebrates and consequently on higher trophic levels, such as bird species.

Local variation in grazing pressure is linked to variation in vegetation quality. Different vegetation types have a different carrying capacity, which means that they can stand a particular grazing pressure without deterioration. Therefore, the 'ideal' number of animals to put on the rough grazing is variable as well. To avoid habitat loss as a result of either overgrazing or scrub encroachment due to under-grazing, fencing may be applied to separate areas with different carrying capacities. Low intensity sheep farming on the southern Orkney Islands, in combination with development of "rich wildlife habitats across the whole range of vegetation communities" leaded to the conclusion that achievement of this wildlife goal was most easy if different habitats are fenced separately (Harris and Jones, 1998). In this light, the recent trend to divide the rough grazing in compartments is very important, but it will work out well only if it is executed in the right way. If large rough grazing fields are split up in smaller fenced compartments, it is crucial to assess the 'carrying capacity' of the different habitat types present on Islay. Stocking densities and the timing of grazing should be controlled in order to minimise the risk of overgrazing, and consequently loosing biodiversity. Recommended stocking densities may be assessed through the application of a grazing model such as the MLURI Hill Grazing Management Model (MLURI, 1993; Armstrong et al., 1997a, b) used in Orkney and Shetland (Simpson et al., 1998).

At the other hand, fencing prevents the development of a large grazing gradient, such as the one in the large rough grazing field in which the A-quadrates were situated. Interaction of a gradient in grazing and other, natural gradients may provide more diversity in vegetation structure and a-biotic conditions - and consequently in species richness – as compared to smaller fenced compartments. The pre-condition is that grazing is extensive, i.e. that grazing pressure is low, under the carrying capacity. Otherwise, parts of the field may be overgrazed. If farmers aim at more intensive grazing by utilising the natural carrying capacity, grazing in fenced compartments differing in (rather uniform) specific vegetation with maximal cattle densities according to the specific carrying capacity may provide a mosaic which – altogether - may be considered as an artificial gradient. The chances, however, for unique combinations of particular grazing pressures and particular a-biotic conditions, and consequent unique nature values may be smaller in such fenced compartments as compared to the former large rough grazing field.

- *What is the importance of extensive livestock farming for birds?*

The most important aspect for birds is the presence of extensive livestock farming itself. Without this the habitat requirements of most species would not be met. Extensive livestock farming provides a mosaic of different agricultural field types embedded in a rich mosaic of natural habitats. The reviewed bird-species are all more or less dependent on one or more of the agricultural habitats and sometimes also on natural habitats. Where a species such as the corncrake is heavily dependent on agriculture and requires very specialised management, other species like the golden eagle might not be so dependent on agriculture but would have more difficulties surviving without.

Farming practices play an important role. Farming practices which affect many bird species within these habitats are: grazing pressure, fertilisation, drainage, hay production, and timing of hay/silage cutting. As can be concluded from the interviews, many of these farming practices have remained quite extensive, but others have become more intensive. In section 3.3 it has been stated that extensive livestock farming provides many conditions and opportunities for farmland-birds. The results of the literature review and the interviews, described in section 5.2 and Annex 2 show clearly that the reviewed bird-species indeed have specific habitat needs that extensive livestock systems on Islay fulfil. The farming practices listed in table 6.1 are thought to have contributed most to Islay's richness in bird species.

Table 6.1 Most important farming practices for birds on Islay

Farming practice	Benefiting bird species
Low stocking densities on the permanent grasslands and the rough grazing	Greenland white fronted goose, barnacle goose, chough, skylark, hen harrier, merlin, peregrine, golden eagle, golden plover, short eared owl, black grouse, curlew
Spring sowing of cereals	Whooper swan, Greenland white-fronted goose, merlin, peregrine, corncrake, short-eared owl, chough, skylark
Low input of artificial fertilizer on the permanent grassland and the rough grazing	Golden Plover, short-eared owl, chough, curlew, redshank, skylark
Late cutting of hay and/or silage by a considerable number of farmers on their rotational arable cropping	Corncrake, curlew, redshank, skylark
Livestock carcasses on rough grazing	Golden eagle, chough
Very restricted use of Ivermectin	Chough

The situation on Islay may be considered as positive for the reviewed bird species. There is still room for improvement however. The interviews revealed several aspects to be improved, as shown in table 6.2. First of all the artificial fertilizer input on the rotational arable cropping is too high for several bird-species. Another danger is formed by the drainage of wetter parts, especially of the rotational arable cropping and the rough grazing fields.

Table 6.2 Most damaging farming practices for birds on Islay

Farming practice	Suffering bird species
Drainage of the rotational arable cropping fields and the rough grazing fields	Whooper swan, Greenland white-fronted goose, hen harrier, merlin, corncrake, golden plover, short-eared owl, black grouse, curlew, redshank
High artificial fertilizer input on the rotational arable cropping	Corncrake, short-eared owl, chough, curlew, redshank, skylark

Tables 6.1 en 6.2 summarize important results. As stated before field data of farmland birds on Islay were not available and the time for such field study too limited. The data from the interviews have been combined with data on birds from the literature review and therefore the results should be considered as indicative. The conclusions on the relationships between farming practices and birds remain theoretical, and not empirical. As such, *they stress the significance of extensive livestock holding to biodiversity, and, in addition, the threats of intensification to biodiversity.*

2. What are the effects of policy on extensive livestock farming on Islay?

Past and current policy

As indicated in sections 3.5, 5.5 and 5.6 the influence of policy on agriculture on Islay is quite complicated. It is hard to say which policy leads to a particular effect. A few things have become clear however.

First of all farming on Islay has become more intensive in the past *ten* years. However, during the last *three* years, a slight decrease in the total number of sheep and cattle (4 %, and % respectively) could be observed in the Argyll and Bute county (which includes Islay), while in the whole of Scotland the reduction in livestock numbers, particularly in sheep, was larger (12 % for sheep and 5 % for cattle) (Scottish Executive: Scottish Agricultural Census – Summary sheets by geographic area 2000, 2001, 2002). It thus appears that the current combination of agricultural policy measures has been effective in impeding the steady increase in livestock numbers. The change from headage-based HLCA scheme to the area based payments within the LFA support scheme in 2000 may have played an important role.

Secondly, the introduction of agri-environment schemes was considered as very important, mostly in a positive way. Environmental and nature conservation policy has also had quite a large impact, by subsidies as well as the restrictions, and the latter were not always considered as positive. Nowadays a smaller part of a farmer's income comes from farming, and of this farming income a larger part consists of subsidies. Farmers have become more and more dependent on subsidies and other income.

Future policy

Future agricultural policy may not work out in favour of most farmers on Islay. The structural change of the LFASS as from the start of 2003 is generally seen as a step back towards the HLCA and has therefore been heavily criticised by the Scottish Crofting Foundation and The Highland Council. Above all, the intention to minimise the percentage of winners and losers, without the creation of a new rural development scheme is seen as inconsistent with various articles implemented within the Rural Development Regulation (Internet: The Highland Council & Scottish Crofting Foundation). Based on a simple model it was expected that particularly low extensive farmers, with overall stocking densities lower than 0.2 LU/ha will loose considerably. Farmers with higher stocking densities generally will be better off. The presence of a reference period (2000-2002) to establish a Grazing Category for each farm, may deliver environmental benefit, by taking away the motive to increase stocking numbers. At the same time it may also work out negative for the environment, since as a consequence of the past agricultural policy, farmers on poor ground may have put too high stocking densities on their ground leading to overgrazing. For those farmers on Islay who changed from dairy to livestock farming, after the closure of the creamery, this reference period is a problem since they had to build up suckler cow quota in this period and are not placed in the right grazing category. From the perspective of sustainable agriculture, rural development and nature conservation it is *irrational that Grazing Categories are based on actual grazing level instead of giving a reflection of the carrying capacity for grazing of the land.*

The replacement of the ESA scheme by the RSS, which is highly competitive, will especially harm farmers with a small area of land as well as farmers whose agricultural land is of a relatively low habitat quality but who were able to enter into an ESA scheme before. Though from a nature conservation point of view it might be a cost-effective way of spending money, it does not make sense from a rural development perspective. With all the money spent on only 476 applications, it seems more like a measure to create nature reserves rather than a wider countryside conservation measure. For most organisms, the protection of selected sites alone is normally inadequate to conserve populations in the long term. The appropriate management of areas outside protected sites is also required. Apart from nature conservation point of view, the danger of the insufficient funding for agri-environment measures in Scotland is that farmers will lose their good will and become discouraged to enter future agri-environmental schemes. It has therefore been widely criticized by environmentalist organizations like Scottish Wildlife Trust, WWF Scotland and Scottish Natural Heritage.

Because of the CAP reforms, modulated money will not all be allocated within the UK, but will be partly redistributed within the EU. Of the interviewed farmers, the majority falls in the category of the highest receivers of direct payments and will therefore be cut considerably from the start of the modulation. Because of the relatively high percentage of high receivers, it seems likely that Scotland will receive less money from modulation after redistribution. These proposals may therefore lead to an even lower availability of funds for rural development measures.

Overall, future measures and proposed changes within the range of agricultural and rural development policy still seem to favour intensive farming over extensive farming. For intensive farmers will receive – on the basis of what they produce – more money per UAA than extensive farmers. Enhancement of production by extensive farmers will not lead to higher subsidies, as the determining factors for subsidy height, i.e. surface area as well as grazing category remain constant. Similarly, lower production will not lead to loss of subsidy money. Therefore, such financial advantage of intensive farmers probably will not stimulate intensification of extensive farms.

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Annex 1 Glossary of terms

Terms	Implementation and Background
Annex I / II / III / IV / V / VI	Annexes of Habitat and Birds Directive, listing natural habitat types and species of community interest whose conservation requires certain measures. Each Annex is defined by different criteria.
Biodiversity Action Plans (BAP)	The UK Government's response to the Convention on Biological Diversity (CBD) signed in 1992 in Rio de Janeiro. The UK Biodiversity Action Plan consists of 391 Species Action Plans, 45 Habitat Action Plans and 162 Local Biodiversity Action Plans with targeted actions for protection and conservation.
Beef Special Premium Scheme (BSPS)	The Beef Special Premium Scheme (BSPS) is funded by the European Union (EU) to give direct support to beef producers. The scheme operates on a calendar year basis, and premium can only be paid on male cattle.
Countryside Premium Scheme (CPS)	Scottish Statutory Instruments 1997 No. 330. Its objectives are to protect and enhance landscape, wildlife habitats and to conserve historic features. The scheme covers all land in Scotland outside Environmentally Sensitive Areas. Farmers are free to enter and to choose from different management options. They receive an annual payment for each hectare which is part of the scheme, as compensation for the potential income that they lose by continuing with traditional, less intensive farming methods.
Environmentally Sensitive Area (ESA)	ESAs were introduced under Section 18 of the 1986 Agriculture Act. An ESA is a type of designation for an agricultural area which needs special protection because of its landscape, wildlife or historical value. Farmers enter a voluntary scheme and agree to participate in a 10 year management agreement. They receive an annual payment for each hectare which is part of the scheme, as compensation for the potential income that they lose by continuing with traditional, less intensive farming methods

Terms	Implementation and Background
EU Birds Directive	This Directive was proposed under Council Directive, 79/409/EEC and eventually implemented in April 1981. It imposes strict legal obligations on European Union Member States to maintain populations of naturally occurring wild birds at levels corresponding to ecological requirements. Member States must take special measures to conserve the habitat of certain listed threatened species through the designation of Special Protection Areas (SPA).
EU Habitats Directive	Official name: the Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora (92/43/EEC). The fundamental purpose of this directive is to establish a network of protected areas (Natura 2000) throughout the Community designed to conserve fauna, flora and natural habitats of EU importance. Criteria for selection include priority habitats and species, as identified in the Annexes.
Extensification Payment Scheme (EPS)	The EPS was introduced in January 2000 as part of the 'Agenda 2000' reform of the CAP. It is a headage payment made to producers who receive Suckler Cow Premium and/or Beef Special Premium, and who meet specific stocking density levels. The Extensification Payment encourages farmers to reduce the number of stock per hectare of land.
Less Favoured Area (LFA) & LFA Support Scheme	The definition of such areas and the criteria for their establishment and demarcation were originally set out in EC Directive 75/268 which was subsequently integrated into Regulation 950/97. LFA's are those regions where natural features (e.g. altitude and latitude) place constraints on agricultural production. The LFA policy was adopted to protect and maintain the countryside and rural environment; to combat large scale depopulation of farming and rural areas, leading to land abandonment and to offset the impact of permanent natural handicap on production costs. In Scotland payments were first headage based but changed later to area payments.
Natura 2000	European Union network of sites designated by Member States under the EU Birds Directive and under the EU Habitats Directive. The main instrument through which the EU nature conservation policy is implemented.

Terms	Implementation and Background
Ramsar Site	Convention of Wetlands of International Importance, especially as Waterfowl Habitat. All of these sites are already SSSI's and although no additional legislative protection is derived from being known as Ramsar Sites there may be less likelihood of consent being given for Potentially Damaging Operations.
Rural Stewardship Scheme (RSS)	The legislative bases are Council Regulation (EC) 1257/1999, Commission Regulations (EC) 445/2002, 963/2003 and The Rural Stewardship Scheme (Scotland) Regulations 2001, as amended on 30th June 2003. It replaces both the ESA-scheme and the Countryside Premium Scheme. The RSS is meant to contribute to rural policy objectives. Especially there should be benefit to biodiversity and the environment. Entry is voluntary but competitive and agreements last five years but may be extended for a further five years. In exchange for receiving payments, successful applicants to the scheme are expected to manage specified areas of land and undertake capital works in accordance with the requirements of the chosen option.
Sheep Annual Premium Scheme (SAPS)	The SAPS is fully funded by the EU and is payable to producers of eligible sheep, limited to the number of sheep for which quota is held. An eligible animal is a live female sheep, which will be at least 12 months old, or will have given birth to a lamb by the end of the retention period.
Special Area of Conservation (SAC)	Special Areas of Conservation were proposed under the Habitats Directive and receive the same level of protection as SPA's for birds. Together the two series are known as Natura 2000. Each EU member state must compile a list of all sites containing the 168 habitat types and 632 species that are thought to require conservation.

Terms	Implementation and Background
Site of Special Scientific Interest (SSSI)	National Parks and Access to the Countryside Act 1949. Sites of Special Scientific Interest (SSSI) are statutorily notified under the Wildlife & Countryside Act 1981 (part II) and are the main nature conservation site protection measure in Britain. The purpose of the SSSI system is to safeguard for present and future generations a series of sites, which are individually of high natural heritage importance, and form a series which in total represents the diversity and geographic range of habitats, species, geological and geomorphological features in England, Scotland and Wales. Landowners must notify the national agency if they wish to undertake a Potentially Damaging Operation
Special Protection Area (SPA)	European Commission Directive on the Conservation of Wild Birds (79/409/EEC). Classified SPAs and candidate SACs together form the European wide network of sites known as Natura 2000. All EU countries are committed to taking requisite measures to protect suitable habitat for all wild birds. There is a list indicating conservation priority. In particular SPA's are expected to protect areas of international importance for rare or vulnerable species (e.g. merlin and golden eagle).
Suckler Cow Premium Scheme (SCPS)	The SCPS is fully funded by the EU and is aimed at specialist beef producers. To qualify for premium producers must keep the animals (or eligible replacements) for a six month retention period.

Annex 2 a: Effect of farming practices on birds; permanent grassland

					permanent grassland						
				Europ. threat status	**a**	**b**	**c**	**d**	**e**	**f**	**g**
nr.	**species**	**common name**	**birds directive**	**s = secure l = localized v = vulnerable r = rare d = declining**	high stocking density summer	high stocking density winter	low stocking density summer (no under-grazing)	low stocking density winter (no under-grazing)	high artificial fertilizer input	low artificial fertilizer input	drainage
1	*Cygnus cygnus*	whooper swan	I	s	x	x	x	x	x	x	-1
2	*Anser albifrons flavirostris*	greenland white fronted goose	I	s	1	-1	1	x	1	1	x
3	*Branta leucopsis*	barnacle goose	I	l	1	-1	1	x	1	1	x
4	*Circus cyaneus*	hen harrier	I	v	x	x	x	x	x	x	x
5	*Aquila chrysaetos*	golden eagle	I	r	x	x	x	x	x	x	x
6	*Falco columbarius*	merlin	I	s	x	x	x	x	x	x	x
7	*Falco peregrinus*	peregrine	I	r	x	x	x	x	x	x	x
8	*Crex crex*	corncrake	I	v	x	x	x	x	x	x	x
9	*Pluvialis apricaria*	golden plover	I	s	x	1	x	-1	-1	x	x
10	*Asio flammeus*	short-eared owl	I	v	-1	-1	x	x	-1	x	x
11	*Pyrrhocorax pyrrhocorax*	chough	I	v	-1	1	1	-1	-1	x	x
12	*Tetrao tetrix*	black grouse	II	v	x	x	x	x	x	x	x
13	*Numenius arquata*	curlew	II	d	-1	x	x	x	-1	x	-1
14	*Tringa totanus*	redshank	II	d	-1	x	x	x	-1	x	-1
15	*Alauda arvensis*	skylark	II	v	-1	x	1	x	-1	x	x
a	trampling of nests (13,14,15), facilitating for geese (2,3), reduced invertebrate fauna by removing vegetation (a.o. tipulidae larvae (11)), reduced prey availability (rodents(10))										
b	disturbance (2,3,9), competition (2,3), destruction of soil/vegetation (2,3), open vegetation (access to prey (9,11))										
c	facilitating for geese (2,3), keeping sward low (o.a.tipulidae larvae - 11), maintaining tussocks for nesting (15)										
d	vegetation too high (9,11)										
e	nutritious food (2,3), less invertebrate prey (9,11,13,14,15), too small invertebrate prey(14), altering vegetation composition leading to loss of habitat (15)										
f	nutritious food (2,3)										
g	changes in soil-invertebrates by lower water table (1,13,14)										

Annex 2 b: Effect of farming practices on birds; rotational arable cropping

					rotational arable cropping								
				Europ. threat status	**a**	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**I**
nr.	**species**	**common name**	**birds directive**	**s = secure l = localized v = vulnerable r = rare d = declining**	high artificial fertilizer input	low artificial fertilizer input	drainage	hay making	silage production	reseeding	early cutting	late cutting	spring sown cereal/ rapeseed
1	*Cygnus cygnus*	whooper swan	I	s	1	1	-1	1	1	x	x	x	1
2	*Anser albifrons flavirostris*	greenland white fronted goose	I	s	x	1	-1	1	1	x	x	x	1
3	*Branta leucopsis*	barnacle goose	I	l	1	1	x	1	1	1	x	x	x
4	*Circus cyaneus*	hen harrier	I	v	x	x	x	x	x	x	x	x	x
5	*Aquila chrysaetos*	golden eagle	I	r	x	x	x	x	x	x	x	x	x
6	*Falco columbarius*	merlin	I	s	x	x	x	x	x	x	x	x	1
7	*Falco peregrinus*	peregrine	I	r	x	x	x	x	x	x	x	x	1
8	*Crex crex*	corncrake	I	v	-1	x	-1	1	x	-1	-1	1	1
9	*Pluvialis apricaria*	golden plover	I	s	x	x	x	x	x	x	x	x	x
10	*Asio flammeus*	short-eared owl	I	v	-1	x	x	x	x	x	x	x	1
11	*Pyrrhocorax pyrrhocorax*	chough	I	v	-1	x	x	x	x	x	1	-1	1
12	*Tetrao tetrix*	black grouse	II	v	x	x	x	x	x	x	x	x	x
13	*Numenius arquata*	curlew	II	d	-1	x	-1	x	-1	-1	-1	1	x
14	*Tringa totanus*	redshank	II	d	-1	x	-1	x	x	-1	-1	1	x
15	*Alauda arvensis*	skylark	II	v	-1	x	x	1	-1	-1	-1	1	1

a	nutrituous food (1,3) too dense vegetation (8,11,15), less invertebrate prey (8,11,13,14,15), altering vegetation composition leading to loss of habitat (15)
b	nutrituous food (1,2,3)
c	loss of habitat (1,2,8,13,14)
d	nutrituous food(1,2,3), suitable nesting habitat (8,15)
e	nutrituous food(1,2,3), unsuitable nesting habitat (13,15)
f	nutrituous food (3), removing habitat (8,13,14,15)
g	loss of habitat (8,15), creating feeding habitat (11) high risk of killing young birds and destroying nests (8,13,14,15)
h	reduced risk of killing fledglings (8,13,14,15), shelter (8,13,14,15) too high vegetation (11)
I	providing habitat (8)providing seed for food (1,2,8,11,15), more seed-eating prey birds (6,7), more small rodents (10)

Annex 2 c: Effect of farming practices on birds; rough hill pastures

					rough grazing					
				Europ. threat status	a	b	c	d	e	f
nr.	species	common name	birds directive	s = secure l = localized v = vulnerable r = rare d = declining	high stocking density	low stocking density	drainage	presence of carcasses	habitat fragmentation	mixed livestock
1	*Cygnus cygnus*	whooper swan	I	s	x	x	x	x	x	x
2	*Anser albifrons flavirostris*	greenland white fronted goose	I	s	-1	1	-1	x	-1	x
3	*Branta leucopsis*	barnacle goose	I	l	x	x	x	x	x	x
4	*Circus cyaneus*	hen harrier	I	v	-1	1	-1	x	-1	1
5	*Aquila chrysaetos*	golden eagle	I	r	-1	1	x	1	-1	x
6	*Falco columbarius*	merlin	I	s	-1	x	-1	x	-1	x
7	*Falco peregrinus*	peregrine	I	r	-1	x	x	x	-1	x
8	*Crex crex*	corncrake	I	v	x	x	x	x	x	x
9	*Pluvialis apricaria*	golden plover	I	s	-1	1	-1	x	-1	1
10	*Asio flammeus*	short-eared owl	I	v	-1	1	-1	x	-1	1
11	*Pyrrhocorax pyrrhocorax*	chough	I	v	1	x	x	1	x	x
12	*Tetrao tetrix*	black grouse	II	v	-1	1	-1	x	-1	x
13	*Numenius arquata*	curlew	II	d	-1	1	-1	x	-1	x
14	*Tringa totanus*	redshank	II	d	-1	x	-1	x	x	x
15	*Alauda arvensis*	skylark	II	v	-1	x	x	x	-1	x

a	trampling of nests (4,6,9,10,12,13,14,15), overgrazing resulting in decline in prey/food availability (2,4,5,6,7,9,10,12,13,14,15), more dung (11)
b	creating habitat (2,4,5,9,10,12,13)
c	changes in soil-invertebrates by lower water table(9,13,14), loss of (roosting) habitat (2,4,6,12,13,14,15), less voles (10)
d	providing food (5,11)
e	surface of area drops belows critical threshold of organisms requirements (4,5,6,7,9,10,12,13,15)
f	more diverse vegetation structure --> more small rodents (4,10) and insects (9)

Annex 2 d: Effect of factors related to farming on birds

nr.	species	common name	birds directive	Europ. threat status s = secure l = localized v = vulnerable r = rare d = declining	other factors a vegetation mosaic	b habitat mosaic	c abandonment	d afforestation (usually of moorland)	e Ivermectin use	f loss of marginal features (hedgerows, stonewalls etc.)
1	*Cygnus cygnus*	whooper swan	I	s	x	1	-1	-1	x	1
2	*Anser albifrons flavirostris*	greenland white fronted goose	I	s	x	1	-1	-1	x	1
3	*Branta leucopsis*	barnacle goose	I	l	x	1	-1	x	x	1
4	*Circus cyaneus*	hen harrier	I	v	1	1	x	-1	x	-1
5	*Aquila chrysaetos*	golden eagle	I	r	x	x	x	-1	x	x
6	*Falco columbarius*	merlin	I	s	x	1	x	-1	x	-1
7	*Falco peregrinus*	peregrine	I	r	x	1	x	-1	x	-1
8	*Crex crex*	corncrake	I	v	x	x	-1	-1	x	-1
9	*Pluvialis apricaria*	golden plover	I	s	x	1	-1	-1	x	x
10	*Asio flammeus*	short-eared owl	I	v	1	x	-1	-1	x	-1
11	*Pyrrhocorax pyrrhocorax*	chough	I	v	x	1	-1	-1	-1	-1
12	*Tetrao tetrix*	black grouse	II	v	1	1	x	-1	x	x
13	*Numenius arquata*	curlew	II	d	x	1	-1	-1	x	x
14	*Tringa totanus*	redshank	II	d	1	x	-1	-1	x	x
15	*Alauda arvensis*	skylark	II	v	1	1	-1	-1	x	1

a	species dependent on mosaic of differing vegetation structure at some point in its annual cycle (4,10,12,14,15)
b	species dependent on more than one habitat, agricultural(4,6,7,12,13,15), or other (1,2,3,9,11)
c	plant succession leading to loss of habitat (1,2,3,8,9,10,11,13,14,15)
d	dramatic change in vegetation structure resulting in habitat loss (1,2,4,5,6,7,8,9,10,11,12,13,14,15)
e	Decline in dung/soil invertebrates (11)
f	fewer nest sites (8, 11), fewer places for shelter (8), more openness (1,2,3,15), less prey (4,6,10)

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Annex 3 a: The questionnaire

Questionnaire
General (farm divided into inbye, rotational arable cropping and rough grazing)
what is the total area of your farm?
what is the area of your inbye?
what is the area of rotational arable cropping?
what is the area of rough grazing?
do you use pesticides?
-if yes, what type(s)?
-if yes, on what parts of your farm? (inbye, cropping or rough grazing?)
what have been the most significant changes on your farm, regarding the questions above, in the last 10 years?
Cattle
how many suckler cows do you have?
-for how many do you receive Suckler Cow Premium?
what breed(s) is your cattle?
what have been the most significant changes on your farm, regarding the questions above, in the last 10 years?
Sheep
what's the total number of sheep you have?
-how many ewes and hoggs do you have?
-for how many do you receive Sheep Annual Premium?
what breed(s) are your sheep?
what have been the most significant changes on your farm, regarding the questions above, in the last 10 years?
Inbye
what types of livestock do you keep on your inbye?
can you estimate the average stocking density in summer?
can you estimate the average stocking density in winter?
what type of artificial fertilizer do you use on your inbye?
-how much do you use per hectare per year?
how much of your in bye has been drained?
what have been the most significant changes on your farm, regarding the questions above, in the last 10 years?
Rotational arable cropping
what type of artificial fertilizer do you use on your rotational arable cropping?
-how much do you use per hectare per year?
how much of your rotational arable cropping has been drained?
do you produce hay?
-if yes, how many hectares?
-if yes, how many tons per hectare?
do you produce silage?
-if yes, how many hectares?
-if yes, how many tons per hectare?
-if yes, is it wrapped or pitted?
do you grow cereals?
-if yes, how many hectares?
-if yes, do you produce straw?
do you produce other crops?
-if yes, which ones?
-if yes, how many hectares of each?
when do you mow your hay and/or silage?
what have been the most significant changes on your farm, regarding the questions above, in the last 10 years?

Rough grazing
what types of livestock do you keep on your rough grazing?
what's the average stocking density in summer?
what's the average stocking density in winter?
do you use artificial fertilizer on your rough grazing?
-if yes, what proportion of your rough grazing receives fertilizer?
-if yes, how much per hectare per year?
have parts of your rough grazing been drained
do you burn parts of your grazing?
do you think livestock carcasses ever remain undiscovered on your rough grazing?
how many compartments is your rough grazing divided into?
what have been the most significant changes on your farm, regarding the questions above, in the last 10 years?
Extra input on farm
how much hay/silage do you buy in (tons)?
-what is it fed to?
how much straw do you buy in (tons)?
-is it used for feeding or for bedding?
what types of concentrate (including draff) do you feed?
-how many tons?
-to what?
what have been the most significant changes on your farm, regarding the questions above, in the last 10 years?
Environment
do you have an SNH goose agreement?
has part of your farm been designated as SSSI?
what is the area of rough grazing in SSSI, SAC or SPA?
-what's the designated site's interest?
what is the area of inbye-ground in SSSI, SAC or SPA?
-what is the designated site's interest?
do you have an SNH management agreement?
are you in the Agri-Environment Scheme (either ESA or RSS)?
do you have an RSPB management scheme?
what have been the most significant changes on your farm, regarding the questions above, in the last 10 years?
Personal
what is your age?
do you have a son or daughter working at the farm?
how many fulltime and parttime jobs are there on your farm?
do you rely entirely on farming for your income?
-if not, from what other sources do you have income?
do you regard yourself as a fulltime or parttime farmer?
roughly what proportion of your gross **family** income is derived from farming?
roughly what proportion of your gross **farm** income is made up from subsidies?
what have been the most significant changes on your farm, regarding the questions above, in the last 10 years?

Annex 3 b: Questionnaire, qualitative results

Questionnaire (farmer code)	
general (all areas in hectares)	
-type(s) of pesticides used?	mostly herbicides, some ivermectin
-pesticides used on what part of farm?	inbye, rotational arable cropping, rarely on rough grazing
most significant changes on your farm in the last 10 years?	very diverse answers, mostly given answer: stopped using Ivermectin
cattle	
what breed(s) is your cattle?	Limousin, Simmental, Aberdeen Angus, some Hereford and Highland
most significant changes on your farm in the last 10 years?	generally an intensification (more cows, more intensive breeds), some farmers changed from dairy to beef farming
sheep	
what breed(s) are your sheep?	Blackface, Cheviot, Texel, Swaledale, rarely Hebridean and Icelandic
most significant changes on your farm in the last 10 years?	generally an intensification (larger flocks, more intensive breeds)
inbye	
what types of livestock do you keep on your inbye?	most keep both, some either cattle or sheep
what type of artificial fertilizer used on inbye?	mostly used are a 20/10/10 compound and pure N
proportion of inbye that has been drained?	considerable parts have open drainage
most significant changes on your farm in the last 10 years?	fencing, intensification (mechanisation, drainage, reseeding)
rotational arable cropping	
type of artificial fertilizer used on rotational arable cropping?	mostly used is 20/10/10 compound
proportion of rotational arable cropping drained?	considerable parts have open drainage
-is the silage wrapped or pitted?	half pitted, half wrapped
-which other cereals are produced?	rapeseed
when do you mow your hay and/or silage?	roughly a third starts in august, the rest mostly in june/july, but many leave parts unmowed until august
most significant changes on your farm in the last 10 years?	introducing barley, intensification (reseeding)
rough grazing	
what types of livestock do you keep on your rough grazing?	most keep both, some either cattle or sheep
-proportion of rough grazing receiving artificial fertilizer?	one unique case of fertilizing a small part of the rough grazing
most significant changes on your farm in the last 10 years?	comparting the rough grazing
extra input on farm	
-to what is the bought-in hay/silage fed?	cattle, sheep, sick animals
-is bought in straw used for feeding or bedding?	mostly for bedding
what types of concentrate (including draff) do you feed?	draff, sugarbeet pulp, cow cobs, sheep rolls, calve feed
-fed to what?	fed mostly to young animals and ewes/cows, but also as winterfodder for all stock
most significant changes on your farm in the last 10 years?	increase in concentrates, but sometimes a decrease because of change from dairy to beef farming
environment	
-what are the designated sites interests? (rough grazing)	flora and fauna, in particular marsh fritillary butterlfy and chough
-what are the designated sites interests? (inbye)	flora and fauna, in particular geese and chough
most significant changes on your farm in the last 10 years?	unanimously: the introduction of the schemes, especially the ESA scheme
personal	
-if not, from what other sources do you have income?	2nd job, wife's job, on-farm diversification
most significant changes on your farm in the last 10 years?	heavy reliance on subsidies for income, getting a 2nd job

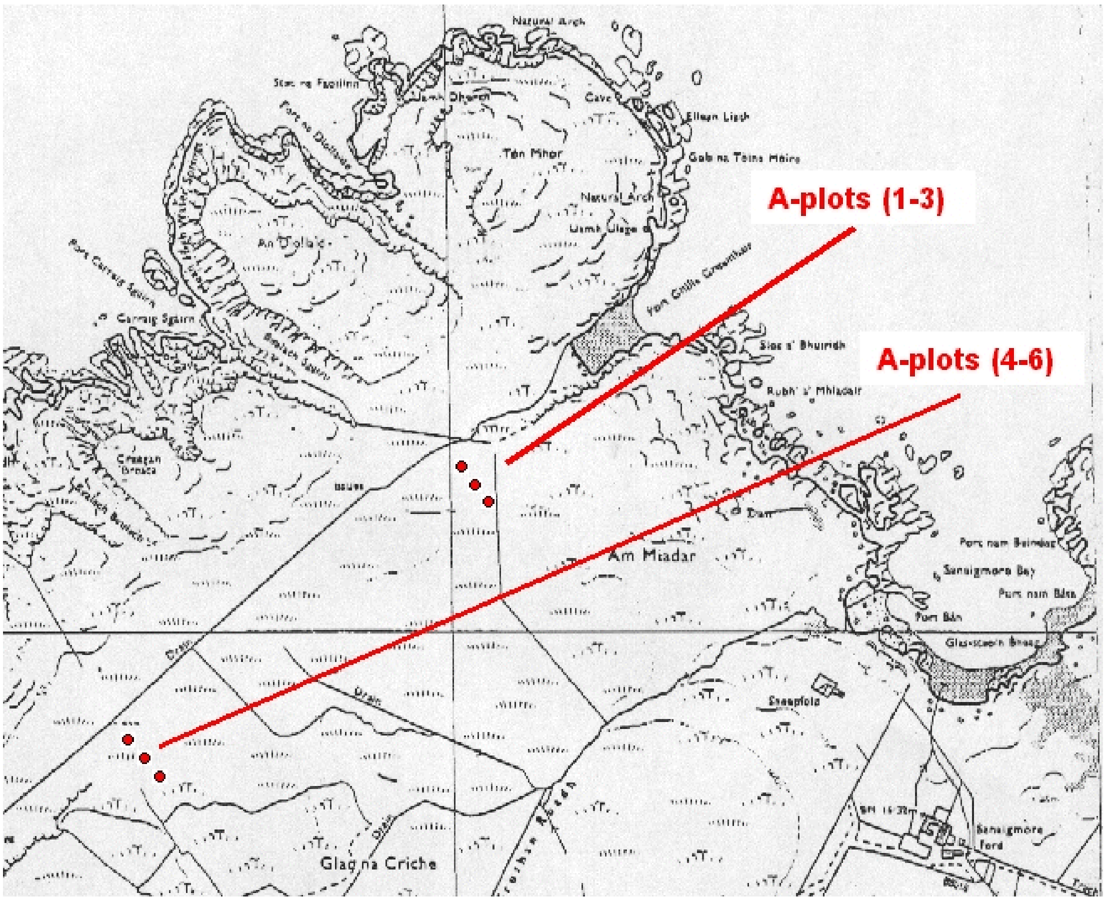
Annex 3 c: Questionnaire, quantitative results

Questionnaire (farmer code)	4	1	21	2	5	9	18	19	20	16	6	24	27	17	N	MEAN	STDEV
general (all areas in hectares; 0=no, 1=yes)																	
what is the total area of your farm?	322,00	1027,00	162,00	1900,00	622,00	74,00	267,00	1417,00	118,00	51,00	401,00	39,00	798,00	399,00	14	542,64	562,86
what is the area of your inbye?	60,00	330,00	133,00	177,00	58,00	0,00	48,00	121,00	14,00	20,00	73,00	3,00	168,00	62,00	14	90,50	89,94
what is the area of rotational arable cropping?	24,00	100,00	5,00	283,00	24,00	15,60	20,00	81,00	25,00	1,00	56,00	1,00	0,00	103,00	14	52,76	75,38
what is the area of rough grazing?	237,00	597,00	24,00	1440,00	560,00	57,90	199,00	1215,00	79,00	30,00	272,00	35,00	630,00	234,00	14	400,71	447,70
do you use pesticides?	0,00	1,00	0,00		1,00	0,00	1,00	1,00	1,00	0,00	0,00	0,00	1,00	1,00	13	0,54	0,52
cattle																	
how many suckler cows do you have?	40,00	270,00	90,00	130,00	29,00	10,00	50,00	70,00	80,00	15,00	5,00		85,00	115,00	13	76,08	70,53
-for how many do you receive SCP?	25,00	259,00	70,00	95,00	31,00	9,75	47,00	0,00	80,00	13,50	0,00		85,00	110,00	13	63,48	69,77
sheep																	
what's the total number of sheep you have?	370,00	550,00	310,00	1500,00	695,00	125,00	795,00	544,00	140,00	0,00	1150,00	40,00	1650,00	690,00	14	611,36	520,49
-how many ewes and hoggs do you have?	370,00	450,00	230,00	1200,00	596,00	105,00	795,00	456,00	140,00		933,00	40,00	1650,00	675,00	13	587,69	467,11
-for how many do you receive SAP?	350,00	440,00	310,00	1460,00	670,00	120,00	795,00	544,00	140,00		1110,00	40,00	1595,00	650,00	13	632,62	496,01
inbye																	
average stocking density in summer? (LU/ha)	0,90	0,80	1,00	0,60	0,20		1,20	0,60	5,00	0,49	0,86		0,90	0,60	12	1,10	1,26
average stocking density in winter? (LU/ha)	0,90	0,70	0,32		0,25		0,80	0,20	0,60	0,49	0,00		0,90	0,20	11	0,49	0,31
-amount of artificial fertilizer used? (kg N/ha/y)	0,00	125,00	0,00	0,00	0,00		50,00	0,00	31,00	10,00	50,00	0,00	44,00	200,00	13	39,23	60,29
rotational arable cropping																	
-amount of artificial fertilizer used? (kg N/ha/y)	75,00	250,00	200,00	70,00	38,00	38,00	86,00	125,00	125,00	0,00	77,00	0,00		200,00	13	98,77	78,35
do you produce hay?	1,00	0,00	0,00	1,00	1,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00		1,00	13	0,31	0,48
-if yes, how many hectares?	7,00			8,00	10,00									5,00	4	7,50	2,08
-if yes, how many tons per hectare?	5,00			7,50	8,00										3	6,83	1,61
do you produce silage?	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00		1,00	13	1,00	0,00
-if yes, how many hectares?	12,00	80,00	5,00	50,00	10,00	3,50	20,00	16,00	25,40	1,00	40,00	1,00		52,00	13	24,30	24,34
-if yes, how many tons per hectare?	18,00			25,00	10,00	17,00	24,00	15,00	23,00	10,00	20,00				9	18,00	5,61
do you grow cereals?	1,00	1,00	0,00	1,00	1,00	0,00	1,00	1,00	1,00	0,00	1,00	1,00		1,00	13	0,77	0,44
-if yes, how many hectares?	6,00	20,00		45,00	3,00			6,50	3,00		12,00				7	13,64	15,07
-if yes, do you produce straw?	1,00	0,00		1,00	0,00		0,00	1,00	0,00		1,00	0,00		0,00	10	0,40	0,52
do you produce other crops?	0,00	0,00	0,00	1,00	1,00	0,00	0,00	1,00	0,00	0,00	1,00	0,00		1,00	13	0,38	0,51
-if yes, how many hectares of each?				20,00	0,50			4,00			8,00				4	8,13	8,49
rough grazing																	
average stocking density in summer? (LU/ha)	0,13	0,15		0,16	0,16	0,48	0,35	0,07	1,00	0,49	0,33	0,30	0,21	0,25	13	0,31	0,24
average stocking density in winter? (LU/ha)	0,30	0,15	0,23	0,13	0,16	0,40	0,35	0,04	0,75	0,49	0,00	0,30	0,21	0,40	14	0,28	0,20
do you use artificial fertilizer on rough grazing?	0,00	0,00	0,00	0,00	0,00	1,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	14	0,07	0,27
-area of rough grazing receiving fertilizer?						4,00									1	4,00	
-amount of artificial fertilizer used? (kg N/ha/y)																	
have parts of your rough grazing been drained	0,00	0,00	0,00	0,00	0,00	0,00	1,00		1,00	1,00	0,00	1,00	0,00	0,00	13	0,31	0,48
do you burn parts of your grazing?		1,00	0,00	1,00	0,00	1,00	0,00	1,00	0,00	0,00	0,00	1,00	1,00	1,00	13	0,54	0,52
livestock carcasses ever remain undiscovered?	1,00	1,00	0,00	1,00	1,00	0,00	1,00	1,00	1,00	0,00	1,00	0,00	1,00	1,00	14	0,71	0,47
how many compartments in rough grazing?	7,00	3,00	1,00	6,00	1,00	4,00	7,00	2,00	2,00	2,00	2,00	3,00	4,00	3,00	14	3,36	2,02

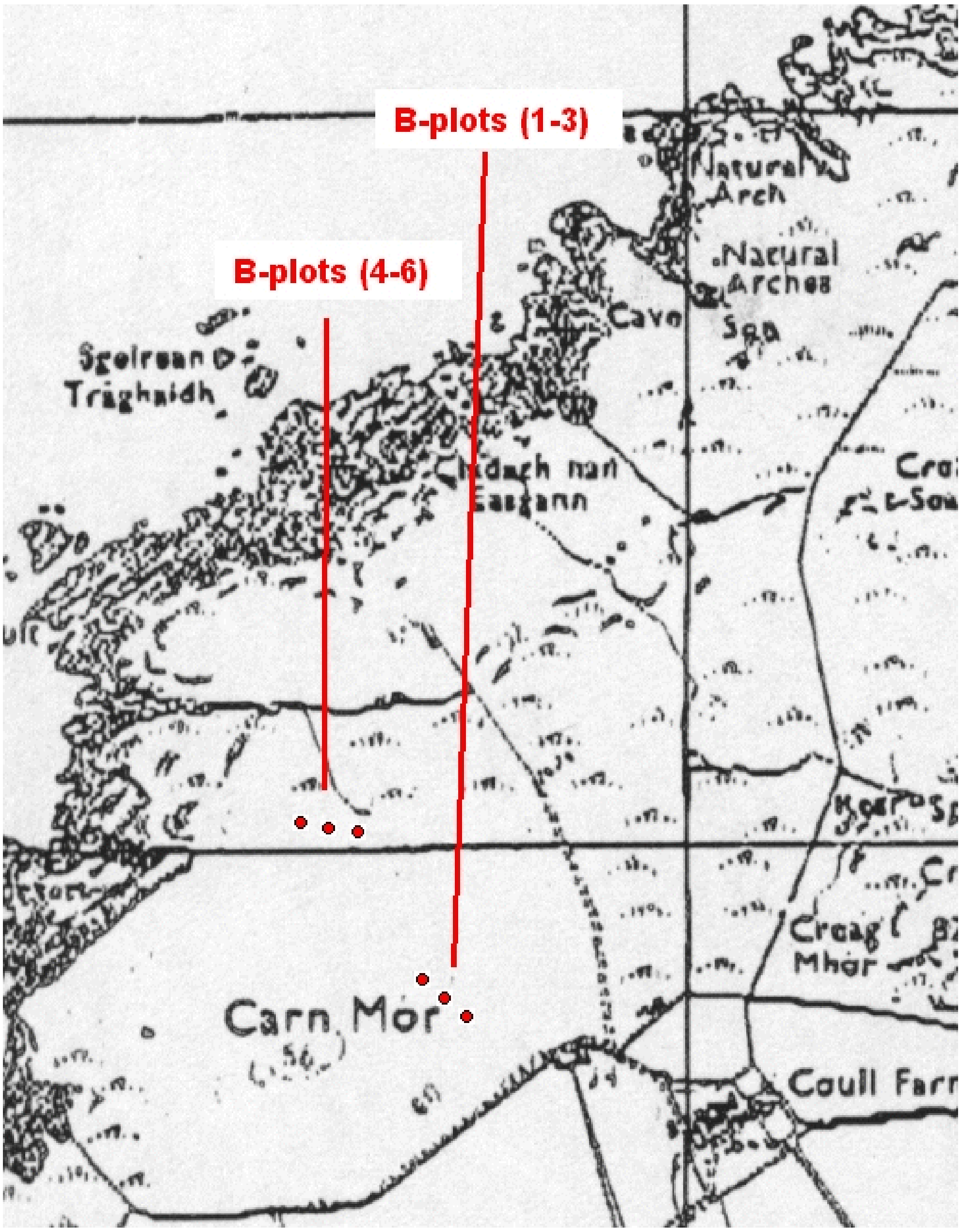
Questionnaire (farmer code)	4	1	21	2	5	9	18	19	20	16	6	24	27	17	N	MEAN	STDEV
extra input on farm																	
how much hay/silage do you buy in (tons)?	0,00	0,00	0,00	0,00	5,00	3,00	0,00	8,00	0,00	15,00	0,00	0,20	0,00	0,00	14	2,23	4,42
how much straw do you buy in (tons)?	0,00	0,00	3,00	0,00	2,00	2,00	3,00	10,00	5,00	1,00	0,00	0,00	2,50	0,00	14	2,04	2,78
environment																	
do you have an SNH goose agreement?	0,00	1,00	1,00	1,00	1,00	1,00	0,00	1,00	1,00	1,00	1,00	0,00	1,00	1,00	14	0,79	0,43
has part of your farm been designated as SSSI?	1,00	1,00	0,00	1,00	1,00	1,00	0,00	0,00	0,00	1,00	1,00	1,00	0,00	0,00	14	0,57	0,51
the area of rough grazing in SSSI, SAC or SPA?	237,00	597,00		1440,00	560,00	58,00				20,00	250,00	35,00	0,00		9	355,22	465,24
the area of inbye-ground in SSSI, SAC or SPA?					48,00						28,00	3,00			3	26,33	22,55
do you have an SNH management agreement?	0,00	1,00		1,00	0,00		0,00	1,00	0,00	1,00	1,00	0,00	1,00	1,00	12	0,58	0,51
are you in the Agri-Environment Scheme?		0,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	0,00	1,00	1,00	13	0,85	0,38
do you have an RSPB management scheme?	1,00	1,00	0,00	0,00	0,00	0,00	0,00	0,00	1,00	1,00	0,00	0,00	1,00	0,00	14	0,36	0,50
personal																	
what is your age?	32,00	49,00	46,00	56,00	51,00	47,00	32,00	49,00	52,00	60,00	82,00	78,00	49,00	43,00	14	51,86	14,21
a son or daughter working at the farm?	0,00	1,00	1,00	1,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	14	0,21	0,43
how many fulltime jobs are there on your farm?	1,00	3,00	2,00	2,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	14	1,29	0,61
how many parttime jobs are there on your farm?	0,00	0,00	0,00	2,00	2,00	1,00	0,00	0,00	1,00	0,00	2,00	0,00	1,00	1,00	14	0,71	0,83
do you rely entirely on farming for your income?	0,00	0,00	0,00	0,00	0,00	0,00	1,00	0,00	0,00	0,00		0,00	1,00	0,00	13	0,15	0,38
do you regard yourself as a fulltime farmer?	1,00	1,00	1,00	0,00	1,00	1,00	1,00	1,00	1,00	0,00	1,00	1,00	1,00	0,00	14	0,79	0,43
proportion of gross **family** income from farming?	0,50	0,60	0,40	0,85	0,50	0,60	0,90	0,70	0,50	0,45			1,00	0,50	12	0,63	0,19
proportion of gross **farm** income from subsidies?	0,50	0,75	0,50	0,50	0,73	0,40	0,50	0,70	0,60	0,60	0,60		0,50	0,45	13	0,56	0,11

Annex 4 a: Approximate position of the quadrats in the research-area

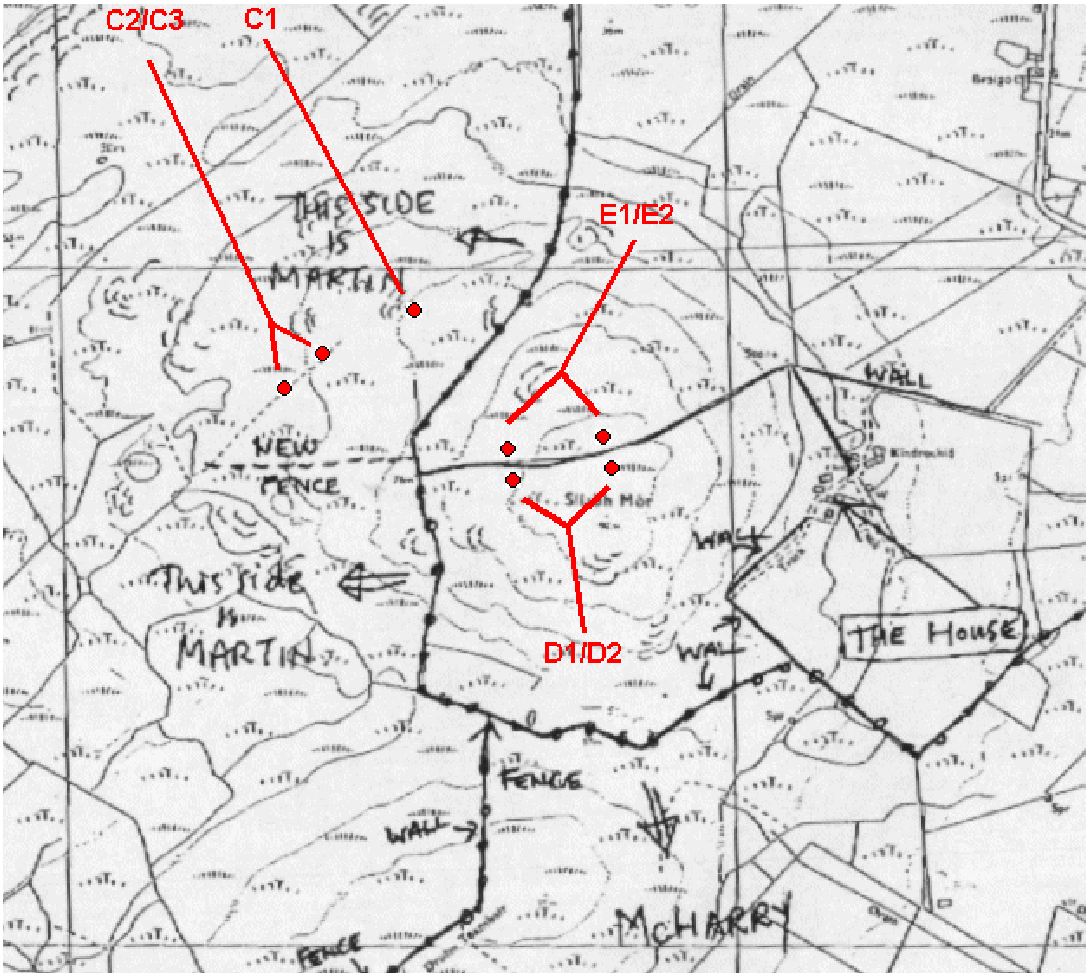
The grid-squares are 1 km^2



Position of the A-plots



Position of the B-plots



Position of the C, D and E-plots

Annex 4 b: Vegetation; photos of grazing animals and quadrats.

Highland cows, used by Eric Bignal, to graze the hill, including the area where the A-quadrats are situated.

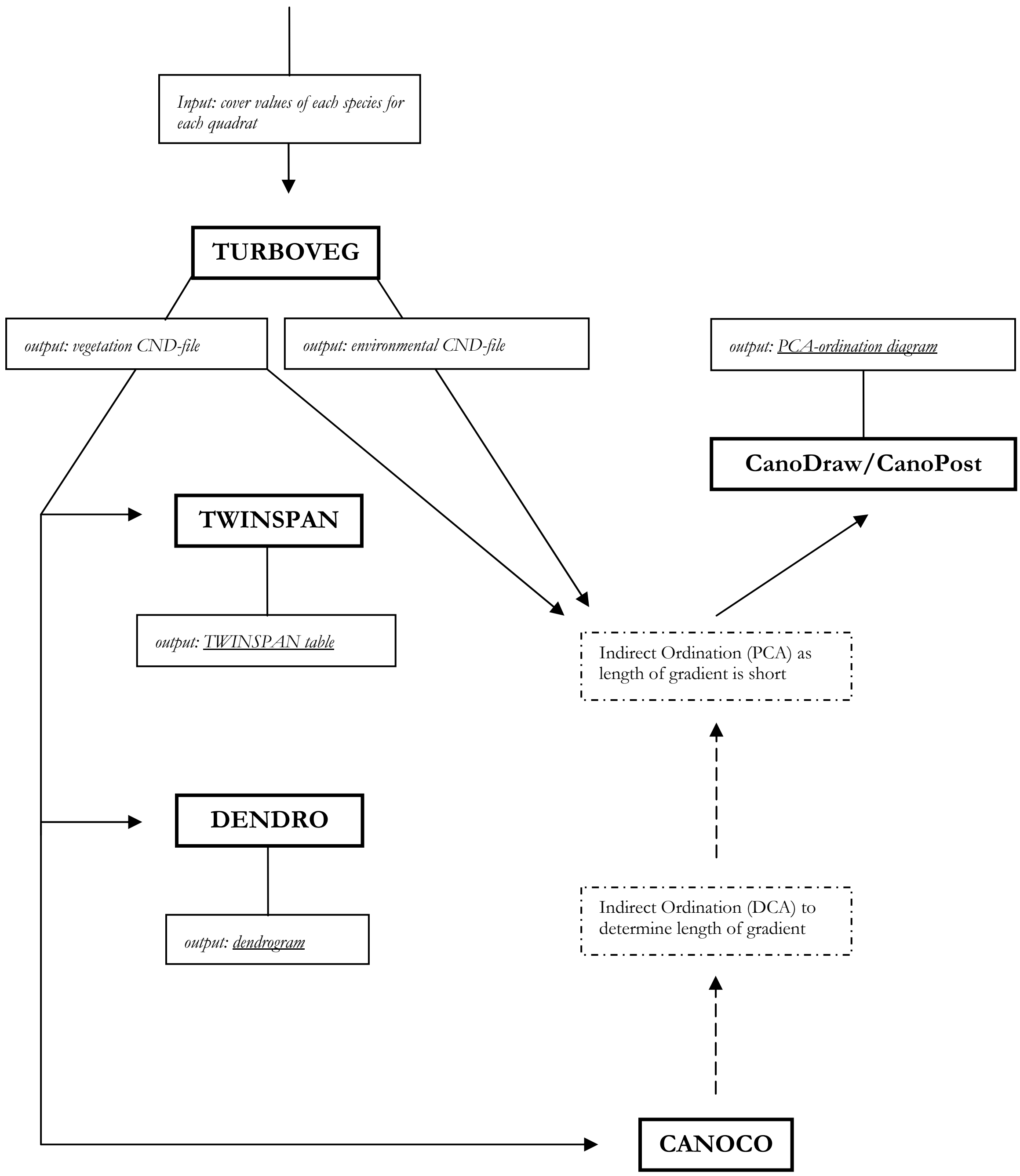
Blackface, one of the most common sheep breeds on Islay.

Vegetation quadrats A1 – A3, the white spikes are of cottongrass Eriophorum angustifolium.

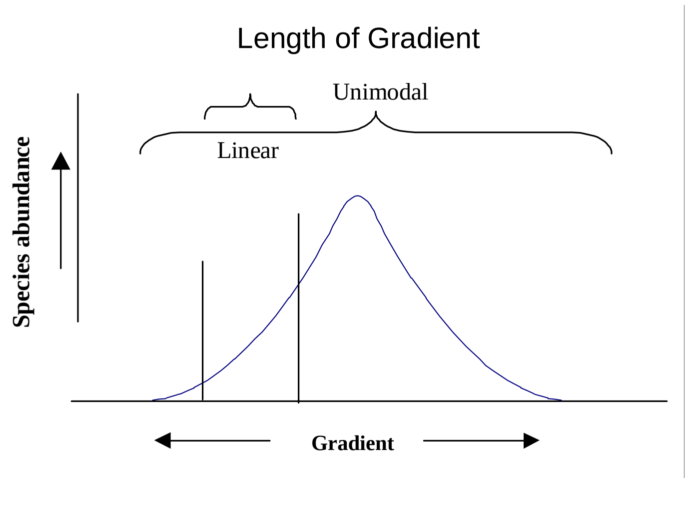
Sphagnum hummock, with butterwort (*Pinguicula vulgaris*) and sundew (*Drosera rotundifolia*) near quadrats A4-A6.

The rough pasture where quadrats B1-B6 are situated is influenced by strong incoming seawinds.

Annex 4 c: Schematic overview of used programs for analysis of the vegetation plots

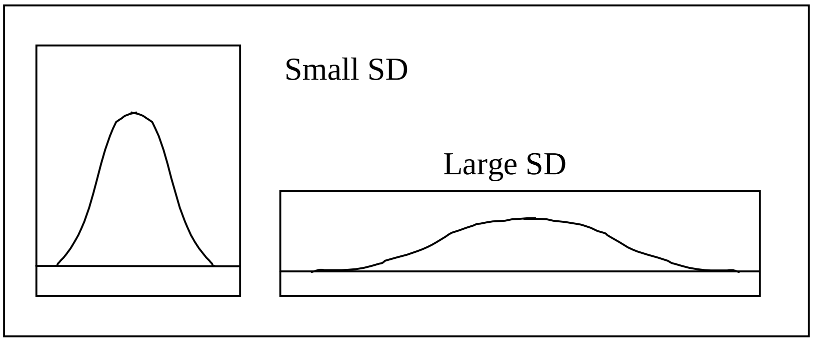


Annex 4 d: Background CANOCO



Theoretical bell-shaped response curve

CANOCO ordinates species according to the species compositions of the quadrats in a certain gradient. In such a way, quadrats which are very similar are placed close together and quadrats that are rather different are situated further away from each other in a so-called ordination diagram. Distinction can be made between direct and indirect gradient analysis. With direct gradient analysis, vegetation quadrats are ordinated along a gradually changing environmental gradient, of which the relation is known with the vegetation quadrats. With indirect gradient analysis first the most important differences in species composition are determined and ordinated and only after that the relation with environmental factors is calculated. In this study a direct gradient analysis can not be performed as the way in which the quadrats were associated with different environmental parameters was unknown in advance and the environmental variables used are indirectly measured i.e. the Ellenberg values afterwards. Which ordination method was best suitable for CANOCO analysis was determined in the following way. CANOCO assumes that generally the bell-shaped response curve (unimodal) will best describe the species response to a gradient. However, two exceptions have to be made where linear response curves are preferred. Figure 3 shows that if only a part of the gradient is measured (the part between vertical lines) the range of species scores is rather small. In this case a linear model will better describe the species response to the present gradient and is preferred during ordination analysis. The second exception is related to a large species standard deviation. If the average species SD is large, species abundance values are located relatively far away from the optimum. This results in a very flat bell-shaped curve that, at a certain point (with increasing SD), better fits to a linear model than to a unimodal model (see figure 4). Both exceptions are linked to a small length of gradient. As a rule of thumb it can be said that if the length of gradient is smaller than 3 S.D. units, a linear model gives the best fit in describing the species response and when the length of gradient exceeds 4 S.D. units, a unimodal model is more suitable for ordination analysis. A Detrended Correspondence



Two bell-shaped curves with different SD

Analysis (DCA) can be performed in case a unimodal model best describes the species response and to calculate the length of gradient. If a linear model gives the best fit, Principal Component Analysis (PCA) is suitable for indirect gradient analysis. In a PCA- ordination diagram the quadrats can be seen as vectors. The cosinus of the angle between the vectors of two quadrats reflects the correlation between those quadrats. Afterwards environmental factors can be added which are visible in the ordination diagram as arrows.

Annex 4 e: TWINSPAN-table of vegetation quadrats

```
A1-A6: 'lightly grazed' coastal heath
B1-B6: 'moderately grazed' coastal grassland
C1-C3: 'ungrazed' plots within patchy vegetation of Calluna/Molinia
D1/D2: 'moderately grazed' vegetation on top of hill; dry(D1)/wet(D2) soils
E1/E2: 'ungrazed' vegetation on top of hill at other site of fence

Number of species per relevé:             1   11111 11 12 2 12222
                                          158 41264 16860 2 93337

                                           ACE AAAAA CCEDD  B BBBBB
                                          112  34562 32121 3 64215

37 JUNCUS SQUARROSUS                      2-- ----- -2-3- - -1---  00000
35 DESCHAMPSIA FLEXUOSA                   1-- ----- -3323 - -----  000010
54 SALIX AURITA                           --- ----- --7-- - -----  000010
56 CAREX SP.                              --- ----- -1--- - -----  000010
46 ARCTOSTAPHYLOS UVA-URSI                --- ----- ----3 - -----  000011
47 CAREX PILULIFERA                       --- ----- ----1 - -----  000011
49 GALIUM SAXATILE                        --- ----- ----3 - -----  000011
50 LUZULA PILOSA                          --- ----- ----1 - -----  000011
51 POA   TRIVIALIS                        --- ----- ----2 - -----  000011
52 PTERIDIUM AQUILINUM                    --- ----- ----3 - -----  000011
53 RUMEX ACETOSA                          --- ----- ----1 - -----  000011
 4 CALLUNA VULGARIS                       997 57657 55745 3 -2111  000100
48 CERASTIUM FONTANUM                     --2 ----- ----1 - -----  000101
55 ERICA CINEREA                          -3- ----- ----- - -----  000101
38 MELAMPYRUM PRATENSE                    2-- 2--2- ----- - -----  000110
42 ERIOPHORUM VAGINATUM                   --- 5325- -3--- - -----  000110
39 MYRICA GALE                            3-- 53333 ----- - -----  000111
40 DROSERA ROTUNDIFOLIA                   --- 3---3 ----- - -----  000111
41 EMPETRUM NIGRUM                        --- 4-554 ----- - -----  000111
26 ERICA TETRALIX                         334 44445 5534- 3 -32-2  00100
28 PEDICULARIS SYLVATICA                  2-3 -3333 -1-33 3 --1--  001010
34 SCIRPUS CESPITOSUS subsp. GERMANICUS    2-6 -4547 ---74 7 -----  001010
36 ERIOPHORUM ANGUSTIFOLIUM               3-3 7-554 ---3- - 33---  001010
33 POLYGALA SERPYLLIFOLIA                 --- 32223 22-23 3 -----  001011
21 DACTYLORHIZA MACULATA subsp. ERICETORUM  --- -2-33 -1--- 3 ---2-  0011
12 MOLINIA CAERULA                        544 56553 88857 5 76575  01000
15 POTENTILLA ERECTA                      -23 43343 44335 4 45343  01001
19 COMPOSITAE SP./SUCCISA PRATENSIS       --- 33323 333-- 5 23333  0101
31 ELEOCHARIS MULTICAULIS                 --- 4---- ----- 3 -----  011
10 JUNCUS EFFUSUS                         --- ----- -4--3 - -2-22  1000
 5 CAREX NIGRA                            2-- ----3 ---33 2 -3-32  1001
32 NARTHECIUM OSSIFRAGUM                  --- 2---- 4---- 4 2----  101
30 CAREX ECHINATA                         --- ----- 44--- 2 44--3  11000
27 FESTUCA OVINA                          --- ---1- 23-3- 3 653-5  11001
 2 ANTHOXANTHUM ODORATUM                  --- ---3- 32234 4 56576  11010
22 LUZULA MULTIFLORA                      --- ----- ---23 3 -3231  110110
29 JUNCUS BULBOSUS                        --- ----- ---1- - --2-1  110111
 6 CAREX PANICEA                          --- ----- 2--4- 4 44655  111000
 1 ANAGALLIS TENELLA                      --- ----- ----- 3 32233  111001
 7 CAREX OEDERI subsp. OEDERI             --- ----- ----- 3 2-354  111001
 8 HOLCUS LANATUS                         --- ----- ----2 - 34343  111001
13 NARDUS STRICTA                         --- ----- ----- 3 46555  111001
14 PLANTAGO LANCEOLATA                    --- ----- ----- - -1-32  111001
16 RANUNCULUS ACRIS                       --- ----- ----- - -2223  111001
17 RANUNCULUS FLAMMULA                    --- ----- ----- - 32323  111001
18 DANTHONIA DECUMBENS                    --- ----- ----- 2 22-31  111001
20 TRIFOLIUM REPENS                       --- ----- ----- 2 23343  111001
23 CIRSIUM/CARDUUS SP.                    --- ----- ----- - 13123  111010
24 CAREX OEDERI subsp. OEDOCARPA          --- ----- ----- - 1-3--  11110
 9 HYDRCOTYLE VULGARIS                    --- ----- ----- - --332  111110
 3 BELLIS PERENNIS                        --- ----- ----- - 1-33-  111111
11 LOTUS CORNICULATUS                     --- ----- ----- - ---4-  111111
25 CAREX PULICARIS                        --- ----- ----- - --3--  111111
43 CAREX FLACCA                           --- ----- ----- - ----2  111011
44 PRUNELLA VULGARIS                      --- ----- ----- - ----2  111011
45 POA SP.                                --- ----- ----- - ----5  111011
                                          000 00000 00000 1 11111
                                           000 00000 11111 0 11111
                                          000 11111 00011   00110
                                          011 01111 00101   00011
                                            01  0011 01      01
                                                0101
```

Annex 4 f: Dendrogram of vegetation quadrats