ELSEVIER

Environmental Science & Policy 6 (2003) 105–113

Environmental Science & Policy

www.elsevier.com/locate/envsci

Soil erosion and land use policy in Iceland in relation to sheep grazing and government subsidies☆

O. Arnalds[a,*], B.H. Barkarson[b]

[a] *Agricultural Research Institute, 112 Reykjavik, Iceland*
[b] *Soil Conservation Service, Gunnarsholt, 851 Hella, Iceland*

Abstract

A recent national erosion assessment programme reveals that soil erosion is more active in Iceland than is witnessed in other European countries. Most of the communal grazing areas in the central highlands are not suitable for grazing by sheep because of poor condition. Agricultural subsidies are a substantial proportion of Iceland's national budget and the sheep farming is dependent on subsidies. Recently, a landmark agreement was made between sheep farmers and the government, where part of the production subsidies were tied to "*quality management*", including sustainable land use. This agreement calls for rapid assessment of all grazing land in Iceland. These challenges have been met by the use of classification of satellite imagery and innovative methods in obtaining farmland boundaries. The subsidy agreement may have more importance for attaining sustainable land use in Iceland than most government initiatives to date. Financial incentives, such as linking subsidies to land condition and improvements, encourage a reduction of grazing pressure on marginal highland areas, but do not lead to exclusion of such grazing practices. We believe that Icelandic rangelands should be divided into two categories: land intended for use (farmland), and land that should be protected from grazing by national law.

Keywords: Subsidies; Land degradation; Soil erosion; Iceland; Grazing; Sheep; Agricultural policy

1. Introduction

Icelandic agriculture is primarily based on sheep farming and dairy production, but poultry has recently gained in importance. A part of the sheep farming has relied on grazing of communal highland grazing areas. The current number of sheep is about 460,000 winterfed ewes. Many of the ecosystems that are being used for grazing by sheep can be considered "marginal areas" because of vulnerable vegetation and soils, harsh climate and periodic volcanic ash-fall events.

Land degradation and soil erosion are serious environmental problems in Iceland. A large proportion of Iceland's vegetation cover has been lost during the past 1150 years since man settled the island. Current soil erosion is more active in Iceland than witnessed in other European countries, especially on desert areas (Arnalds, 2000b; Arnalds et al., 2001a). A recent OECD "Environment Performance Review" (OECD, 2001) was very critical of land use policies in Iceland, and especially the poor state of the highlands.

There have been intense debates about the causes of the erosion problems, and especially the role of grazing. The land degradation and desertification problems in Iceland have traditionally been associated with land use and primarily grazing by sheep (e.g. Thorarinsson, 1961; Sigbjarnarson, 1969). The role of sheep grazing in the land degradation can, however, sometimes be questioned, especially in the highlands (Arnalds, 2000b; Olafsdottir et al., 2001). Both a cooling trend that began about 3000 BP, and increased melt water flooding from glaciers, may also play important roles in causing degradation, both alone and in combination with grazing by sheep. But we stress that deserts and erosion areas are not suitable for grazing, regardless of what has caused the current poor condition (RALA and SCS, 2001). Sheep grazing is especially damaging to severely degraded systems as it damages the resistance of the systems to degradation processes and prevents natural improvement of the land (Magnusson, 1997; RALA and SCS, 2001). A new national survey of erosion in Iceland (Arnalds et al., 2001a) concluded that much of the Icelandic highlands are not suitable for grazing because of limited plant growth (deserts) and severe erosion.

Recent changes in perspectives evolving from Agenda 21 and the concept of sustainable development have called for a critical review of Icelandic laws related to the environment.

☆ The views presented in this paper are those of the authors, and may not represent official policy of the Agricultural Research Institute or the Soil Conservation Service.

* Corresponding author.
E-mail address: ola@rala.is (O. Arnalds).

1462-9011/03/$ – see front matter
PII: S1462-9011(02)00115-6

A Ministry for the Environment was established in 1990 and new laws related to nature conservation have been made and amended. Laws concerning grazing, vegetation and soil conservation have, however, not been changed since 1965, excluding minor amendments.

Recently, a landmark agreement was made between Icelandic sheep farmers and the government, where part of production subsidies were tied to "*quality management*", including sustainable land use. This agreement has called for rapid assessment of all grazing land in Iceland, and the formulation of rules for sustainable land use.

In this paper we will describe and discuss these recent developments in policy making in relation to soil protection and grazing in Iceland and the land assessment programme.

2. Icelandic rangelands

2.1. Main characteristics

Iceland is an island of about 103,000 km^2, situated in the North Atlantic Ocean. About 280,000 people live in Iceland, mostly in towns with about 8% of the total population living in rural areas (Statistics Iceland, 2000).

The interior of the island consists mostly of highland areas rising from 400 m elevation to >1000 m. Mountain ranges also extend to the shoreline in many areas, but lowland areas are along the coastline and river plains. The highlands are mostly communal grazing areas.

The Icelandic climate, strongly influenced by the Gulf Stream, is described as cold temperate in the lowlands, and sub-arctic in the highlands. The island is humid in most areas. Precipitation generally varies between 600 and 1500 mm per year in lowland areas, but large tracts of Northeast Iceland receive less than 600 mm.

The vegetation varies from barren desert-like areas to lush birch woodlands. Plant production decreases rapidly with increased elevation. Desert areas (Fig. 1) are dominant surface types for most of the highland rangelands, representing >80% of the area within the interior. The vegetation of many of the commons has been mapped at the scale of 1:40,000 by the Agricultural Research Institute. Thorsteinsson et al. (1971) provided a description of the rangelands and major plant communities, but no recent comprehensive summary of the rangeland vegetation in Iceland is available. The calculated carrying capacity of Icelandic plant communities published by Thorsteinsson et al. (1971) was based on methods that are not used today by the Agricultural Research Institute and the Soil Conservation Service. The plant composition of vegetated highland rangelands reflects the sheep grazing, with species tolerant to grazing dominating most communities, such as small woody species (e.g. *Empetrum* spp., *Vaccinium* spp.), rushes (e.g. *Kobresia myosuroides*) and sedges (e.g. *Carex bigelowii*). Lichens and mosses are characteristic of degraded land, but also of areas where succession takes place on new surfaces such as lava fields, and of areas that are recovering from degradation (secondary succession). Lichens and mosses are also typical for locations with unfavorable climatic or hydrological conditions for higher plants. Grasses are common, especially where grazing intensity is relatively low, or climatic/hydrological conditions are favorable. Herbaceous plants and some *Salix* species are indicators of moderate grazing intensities.

2.2. Land degradation

A large percentage of Iceland's terrestrial ecosystems has been devastated since human settlement began, about 1100 years ago (Thorarinsson, 1961; Arnalds, 1987). The consequence has been the formation of landscapes that are almost totally barren—or deserts (Arnalds et al., 2001a,b).

Icelandic ecosystems evolved in the absence of large grazing animals. Fully vegetated ecosystems covered most of the country when man arrived and initiated livestock grazing and wood harvesting. Sources for reconstructing past ecosystem structures include pollen analyses, historical records, soil remnants, and relic vegetation (e.g. Einarsson, 1963; Thorarinsson, 1961, 1981; Arnalds, 1987; Hallsdottir, 1995; Kristinsson, 1995; Gisladottir, 1998; Aradottir and Arnalds, 2001). It is likely that large areas of moss heathland

Fig. 1. Examples of desert area in the highlands of Iceland (left) and vegetated area in the lowlands. There is a profound difference in ecosystem function between these two surface types, with limited plant production in the deserts. Vegetated areas sustain a variety of agricultural activities. Sheep are being driven into the desert highland in the figure to the left.

dominated by *Racomitrium* moss, and shrub heath, were destroyed in the highlands after the settlement (Magnusson, 1997). Grazing has altered species composition from more lush vegetation to less productive systems (Thorsteinsson, 1986). The degradation of Icelandic rangelands is most likely marked by events, such as severe cold spells and ash-fall events, which lead to reduced production and over-exploitation of vegetation. There are historical accounts of such ash-fall events and "summers that did not come". A cooling trend that began about 3000 years ago and sand encroachment from glacial margins and flood plains are also important factors in the degradation trend after the settlement (Arnalds et al., 2001a,b).

2.3. Commons and grazing patterns

Icelandic rangelands need to be separated into highland areas and lowland areas, when considering land degradation and sustainable grazing practices. The highland areas are much more sensitive to disturbance than the lowlands, and have less vegetation cover and vegetation yields.

Most of the highlands are communal grazing areas, where each local community (*hreppur*) has grazing rights. The size of the commons is quite variable, ranging from <100 to >5000 km^2 (Arnalds et al., 2001a). Their boundaries are often large rivers, glaciers, or high mountains, but fences are also used. Some boundaries are open, however, especially between the largest commons. The vegetation cover is also variable, from nearly fully vegetated commons (e.g. Northwest Iceland), to large commons with <2% vegetation cover within the active volcanic zone. The suitability of the commons for grazing is therefore very variable. The Icelandic Soil Conservation Service has tried continuously to facilitate the protection of the desert commons from grazing.

Grazing management practices on the commons, including length of grazing period and stocking density, are in the hands of district councils and vary between commons. The district councils have not offered incentives to achieve substantial changes to land use practices or to suggest protection from grazing. The grazing period for sheep on the commons generally ranges from late June to early September when the sheep are rounded up.

2.4. The national soil erosion inventory and implications

A national survey to map soil erosion in Iceland was initiated in 1991. The aim of the project was to establish an overview of the soil erosion problem in Iceland, and to provide guidance for further development of sustainable land use in Iceland. It was conducted by the Agricultural Research Institute and the Soil Conservation Service and was made at the scale of 1:100,000.

Soil erosion processes in Iceland are extremely varied, and many erosion processes can occur at the same site. The dominant soil types are Andosols (soils that form in volcanic parent materials) and they are very sensitive to erosion by wind and water when exposed. The survey was based on separating soil erosion into erosion forms that can be identified in the field. Each erosion form has also a scale for erosion severity, ranging from zero (no erosion) to five (very severe erosion). The work was carried out in the field, and mapped onto Landsat 5 images. The information was subsequently stored in a GIS database (Arnalds et al., 2001a; see also rala.is/desert).

The erosion survey provides an overview of erosion in Iceland and is linked to basic information about vegetation cover (six classes; LMI, 1993). Results were summarized for each county and local community in Iceland, and for

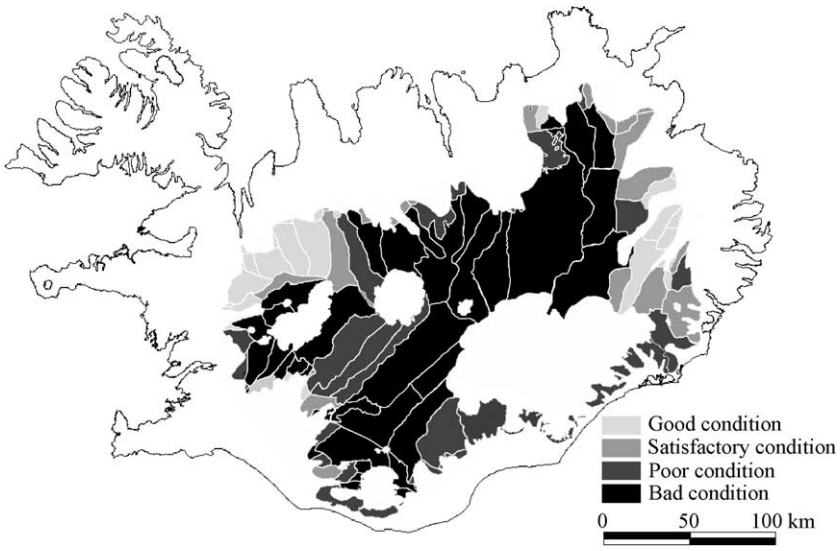

Fig. 2. Condition of commons in the Icelandic central highlands. A large proportion of the highlands is not suitable for grazing (classes C and D). Deserts and eroded areas are widespread within these commons, see Table 2.

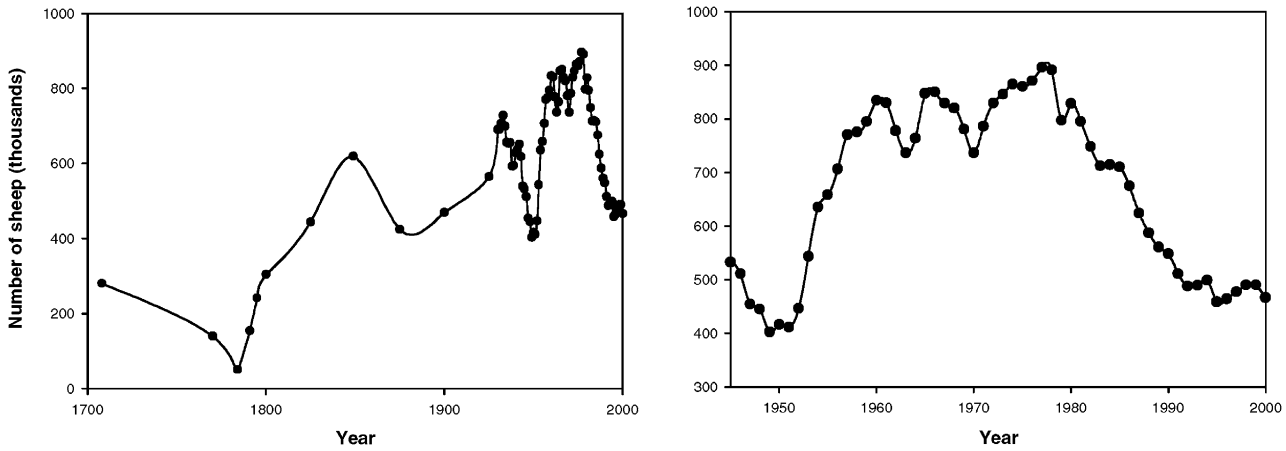

Fig. 3. Changes in sheep numbers in Iceland from about 1700 (left) and from 1945 to 2000 (right). The lows in both graphs occur because of the occurrence of animal diseases except for the trend after 1980. Sheep numbers have been declining since about 1978 because of government initiatives. Production still exceeds Icelandic market demand.

each common. The results showed well the poor condition of many of the highland commons, but also that some commons are well vegetated with minor erosion problems (Fig. 2).

The results shifted the discussion about erosion problems in Iceland from debates about causes and the role of sheep grazing in land degradation to discussions about solutions. A new proposal for soil conservation law and the new Government/sheep farmers' subsidy contract are partly influenced by the national erosion survey. Other factors, such as international development of law, increased environmental awareness, and participatory conservation approaches are also important drivers of these recent developments.

3. The Soil Conservation Service

The history of the Icelandic Soil Conservation Service is remarkable because organized soil conservation and land reclamation has been practiced in Iceland longer than in most other countries. The institute was first established in 1907 (as the Sand Reclamation Institute) to battle encroaching sand, long before the establishment of the US Soil Conservation Service. The institute has a broad agenda, which includes land reclamation, monitoring of rangeland condition, education and other activities. Approaches to soil conservation in Iceland have been undergoing changes, from federal intervention, agronomic approaches (seeding and fertilization) to advocating sustainable land use, land improvements and land literacy (Arnalds, 2000a). Two successful programs involving land users have recently been established, "*Farmers heal the land*" and "*Better farms*". About 40% of Icelandic sheep farmers are involved in these co-operative programs, which enhance sustainable land use and conservation ethics (Arnalds, 1999, 2000a). These programs mostly focus on the lowland areas, but not exclusively. Debates still remain about grazing of highland communal areas.

4. Sheep production in Iceland

4.1. Background

Currently there are about 27,000 dairy cows in Iceland, and 460,000 sheep on about 4600 farms, with 3400 registered owners of sheep and/or cattle (FAI, 2001). In addition, there are 60,000–80,000 horses, mostly used for breeding and recreational purposes. Dairy and beef production is by far the largest proportion of Icelandic agriculture (47% of production value), sheep farming is 23%, but poultry production is increasing, and is currently about 15% of Icelandic agricultural production value (FAI, 2001). Horticulture makes about 10% of the total agricultural production value and includes products grown in greenhouses heated by geothermal energy. Government support for dairy and sheep production is ranked as one of the highest among the OECD countries (OECD, 2002).

4.2. Sheep farming and subsidies[1]

The number of sheep in Iceland has been quite variable since the Middle Ages. From the 19th and into the 20th century the number rose gradually after a low of about 50,000 in 1784 (famine), with setbacks caused by animal sheep diseases and climatic cold spells (Fig. 3). The maximum number of sheep was in part controlled by the possibility to graze the sheep in winter, and haymaking in summer. With improved technology in haymaking during the 20th century, the number climbed to a maximum of 896,000 in 1977 (Fig. 3b,

[1] Subsidies include all direct government payments related to the sheep farming, including direct payments to farmers, export subsidies, government subsidies for wool, surplus storage and other items as grouped in recent government finances. In some cases, the subsidies are a little overestimated as a small part of the export subsidies (on average) was sometimes also used for dairy products until 1991.

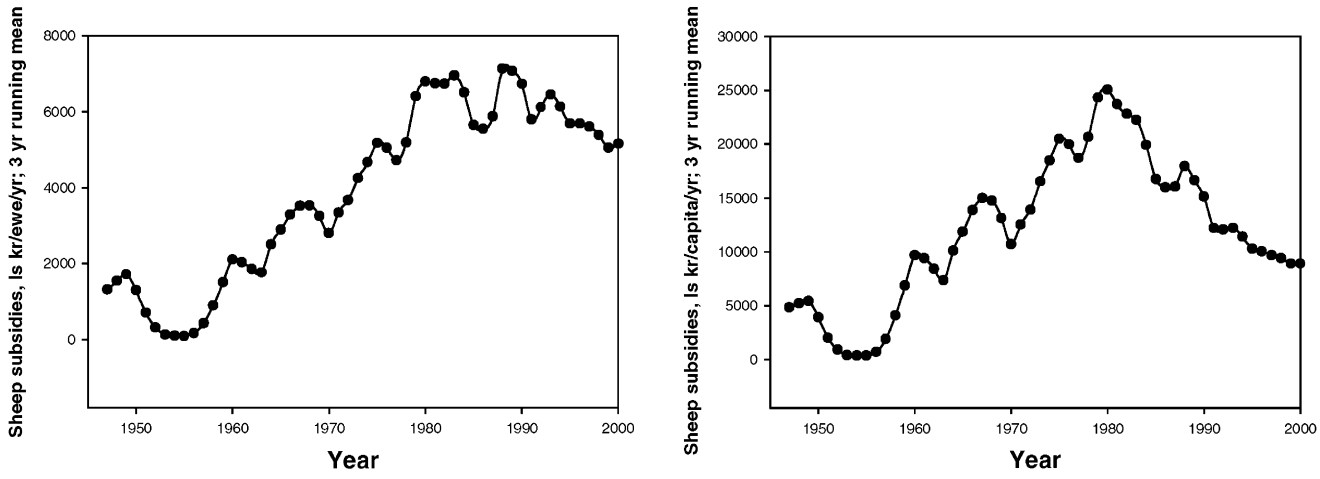

Fig. 4. Sheep subsidies in Iceland plotted per capita in Iceland and per head of sheep. The data is based on 3 years running mean (2000 currency). To obtain Euros, divide by 73 (2000 exchange rate).

Statistics Iceland, 1997). Today, most sheep are housed about 7 months over winter, relying on hay for winter.

The national consumption of lamb and mutton has been lower than the production levels in recent years, especially when sheep counts were highest. The domestic consumption of sheep products has been declining. The large number of sheep was supported by export subsidies. The average subsides for sheep production 1975–1977 was, 4127 million IS kr per year (2000 currency), or approximately 57 million € (assuming 73 kr/€, the average 2000 exchange rate), which is about 4% of national government expenditure for these years (numbers obtained from Icelandic Historical Statistics, Statistics Iceland, 1997). The subsidies are now largely provided as direct payments per head of sheep and, a total of 2339 million IS kr. in 2000 or about 32 million € (2000 exchange rate). This is a large reduction from the number quoted above for the 1970s. Data used for 1991–2000 were obtained from the Ministry of Finance yearly reports on government finances ('ríkisreikningur').

There are about 1950 sheep farms in Iceland (FAI, 2001). Most of them also have dairy cows. Increasing numbers of sheep farmers have other sources of income through off-farm employment. All recent contracts made between sheep farmers and the government have emphasized more economical production by reducing the number of sheep producers and increasing the farm size. Considerable resources have been used to buy farmers out of business. There was sharp decrease in the number of sheep after 1980, but this trend halted after about 1992. However, farms have become bigger; the average number of sheep per farm has increased by 13.4% since 1995, from 142 to 161 winterfed ewes (FAI, 2001; note that many of these farms also have dairy production). The subsidies are about half of the income of the sheep production industry.

Subsidies per head of sheep are shown in Fig. 4 (left) for the period 1945–2000. Values have increased from <2000 IS kr (27 €) in around 1960 (3 years running mean) to >5000 kr (>68 €) for the average of 1998–2000 (2000 currency and 73 kr/€ exchange rate in 2000). The subsidies calculated as IS kr/capita for each year (Fig. 4, right) show a rapid increase from about 1955–1980 (about 25,000 kr/capita; 2000 currency), but a near steady decrease since then, with about 9000 kr/capita in 2000 (123 €/capita, assuming 73 IS kr per €).

5. The new subsidy agreement

In the year 2000, a new subsidy agreement was signed between sheep farmers and the government for the next 7-year period. All farmers that have production quota entitlements are entitled to the subsidies. The payments are about 2400 million IS kr per year (average of total payments) or about 26 million € per year (at 90 kr/€, 2002 exchange rate), or about 60 € per winterfed ewe. This number is based on a total of 460,000 sheep in Iceland, but subsidies are actually provided for a lower number of ewes (350,000–400,000), the difference is sheep which are produced without subsidies (based on parliamentary documents with the contract, "Fylgiskjal II"). A part of the contract is based on *quality management*, with gradual increase in government support up to 22.5% more subsidies during the contract period to farmers that meet the quality criteria. The criteria for *quality management* include good animal treatment, controlled use of chemicals and medicine, and participation in a national breeding programme. The farmers' participation in the quality management part of the agreement is on a voluntary basis. This part of the contract will be implemented in 2004.

Sustainable land use is a part of the criteria for *quality management*. We perceive the reasons for using sustainable land use as criterion to be: (1) public pressure, partly brought on by the soil erosion mapping project; (2) GIS and RS technologies that have allowed for systematic evaluation of land on a large scale; (3) intentions of the sheep industry

to "make peace with the general public" for marketing purposes; and (4) future maintenance of subsidies within the EU policy framework as "green subsidies".

Two important tasks were needed to be undertaken before the implementation of the contract: (1) to generate a geographic database for all Icelandic farms (about 4600) with information about their grazing land; and (2) to develop guidelines for determination of sustainable grazing practices.

The contract will be revised in 2003. There is considerable resistance among sheep farmers against the *quality management* part of the agreement. There are three main reasons for the opposition:

- considerable book-keeping (red-tape) in relation to the sheep farming;
- grazing on some commons will not meet the quality criteria;
- the use of these commons is deeply rooted in rural traditions.

We therefore stress that the link that has been made between subsidies and land use, could possibly be reconsidered in the near future.

6. The Icelandic Farmland Database

6.1. Methods and applications

The project "*The Icelandic Farmland Database*", a joint project of several agricultural government agencies and the Farmers Association, was initiated in 2000. The aim of the project is to generate a new digital database with basic information for all Icelandic farmland. This task was to be completed within a relatively short time span because most of the information needs to be ready for use in 2003 in relation to the subsidy agreement. The project is based on three components: division of the surface into vegetation classes; mapping of all farm boundaries, and generation of database with information that can be linked to other available data on farm and rural statistics.

Landsat 7 images are used to separate Icelandic lowlands into 10 vegetation classes. The classes were defined based on two conditions: that the classes reflect grazing values (production and condition to some extent) and that these classes can be obtained by remote sensing techniques. The classification is made with the aid of >1000 control points for each Landsat image and extensive field verification to ensure >85% accuracy for the classification. Plans have been made to use higher resolution satellite imagery during the next phase of the project, including SPOT 5. The project demonstrates that large grazing areas with well defined growing period (cold temperate climate) can be evaluated for land use decisions by using simple classification of satellite images.

Farm boundaries are entered into the database from various sources, including data obtained by the Agricultural Research Institute in relation to vegetation mapping, and also from maps created by the local communities. More than half of the boundaries are obtained during open meetings held by the staff of the project, where farmers draw in the boundaries of their farms directly into the computer on top of the Landsat image (1:20,000). The cost of entering each farm into a GIS database by this method is a fraction of what conventional methods cost, such as visiting each farm and drawing the boundaries on top of an aerial photograph. The information is not as accurate, but errors are within margin for the intended use of the database. Information about most of the farms will be ready in the year 2003. Examples showing size of farms and proportion of each of the vegetation classes in two districts are presented in Table 1.

Table 1
Example of results from the Icelandic Farmland Database

	Hunathing vestra	Borgar-fjordur	Total/average	Condition[a]
Number of farms	158	378	536	
Total area (ha)	118294	306215	424509	
Mean farm size (ha)	749	1620	1363	
Wetland (%)	14.1	11.3	12.1	A
"Half-bog" (%)	6.3	1.5	2.8	A
Woodland (%)	0.1	3.8	2.7	A
Grassland (%)	5.3	1.8	2.8	B
Rich heath (%)	32.6	9.6	16.0	B
Poor heath (%)	27.0	34.6	32.5	C
Moss (%)	<1	13.8	10.0	C
Half vegetated (%)	6.3	13.3	11.3	C or D
Desert (%)	4.2	1.7	2.4	C or D
Cultivated (%)	2.8	3.3	3.2	A
Other (%)	1.3	2.9	2.4	

Vegetation classes and size of farms in two agricultural districts. The data represent >10% of Icelandic farms (preliminary results). The last column indicates automatic assigned condition class for evaluating each farm in relation to "quality management".

[a] A condition class assigned by the computer during automatic assessment of condition. If farms receive a poor overall rating, the condition is checked by professionals on location. A is best condition, B is fair, C is poor, and D is very poor condition (based on RALA and SCS, 2001). More information about the classification is provided at http://www.nytjaland.is.

The development of the database structure is at the initial stage. All the information will be public domain, and much of it will be made available through the Internet.

The *Icelandic Farmland Database* will have many useful applications in addition to its use for certifying sustainable grazing practices. The database serves as an official account of land resources of the farmland. Furthermore, carbon sequestration activities in relation to the Kyoto protocol can be registered into the database. Other attributes can be linked such as archaeological sites, place names, and other geo-referenced data. It will also be possible to use the database and data collected in relation to the *quality management* to compute various relationships between grazing land, grazing practices and production statistics.

6.2. Use of the database for certifying sustainable land use

The database gives a good indication of rangeland condition and vegetation production capacity on each farm. The criteria for the *quality management* are still being developed and may be subjected to revision. Some of the major characteristics according to the current methodology are outlined below. Three main rules are used and they are designed so they can be checked automatically in the *Farm Land Database*.

- A limit is set for how much cover (proportionally) of two vegetation groups, half vegetated and denuded land, is allowed on each farm, with an additional upper limit for a total area in hectares in each of those two vegetation groups.
- If proportional cover of poor condition classes (C and D; last column in Table 1), such as moss and poor heathland, reaches a certain limit the farm does not automatically meet the quality management criteria. The limit is still to be set.
- Each farm cannot graze commons where soil erosion and desertification are very active (data from the national soil erosion survey), or commons mainly characterized by deserts (e.g. desert areas >50–66% of the common, a limit yet to be set).

If these criteria are met, farms are granted a confirmation of sustainable land use. For farms not achieving these criteria, a further inspection must take place on location, taking into account soil erosion, vegetation condition and composition, and other factors affecting the land use. The additional information may lead to certification or else the farmer must enter a land improvement programme, such as *Better farms*. By doing so he is issued a temporary certification with an adjustment period of up to 10 years to improve the condition of the farmland. The Soil Conservation Service field agents will monitor progress.

The most sensitive issues in relation to the criteria concern the use of the highlands; especially areas characterized by desert, but with discontinuous vegetation patches. The development of criteria for the highlands involved discussions about the sustainability concept and questions were asked whether grazing of desert areas, although at very low stocking rates, can be considered sustainable if plant succession and recovery of those areas is negatively affected. For the commons, the limit is set to a certain level (proportion) of erosion areas and deserts. Farmers using commons characterized by eroded areas and/or deserts are not granted certification unless changes in grazing practices are made and the land is improved. In this case, an adjustment period of up to 10 years is granted, and those adjustments may well include no grazing on the common altogether for 10 years.

7. Discussion

7.1. The link between subsidies and sustainable land use

The link that now has been created between land use and subsidies for sheep farming can be regarded as a milestone towards sustainable land use in Iceland. It was brought about as a result of public pressure, partly triggered by the national soil erosion assessment programme, which demonstrated the poor condition of Icelandic rangelands in a systematic manner. More importantly, the contract was brought on by the farmers, determined to improve the image and quality of their products, with the aim to secure the foundation of sheep farming in Iceland.

These policy changes are in some way comparable to the EU *Agri-environmental Regulation* 2078/97 (see Buller et al., 2000). The Icelandic agreement is, however, more limited in scope. It deals only with one agricultural sector (sheep) and does not address set-aside policy, nature conservation, or public access. It differs also in that payments are made per head of sheep, while payments under *Regulation* 2078 are per area of land. The average *Regulation* 2078 payment is 117 ECU/ha per year (Buller, 2000). However, payments per hectare are considerably lower for farming practices comparable to the sheep grazing in Iceland.

Some ambitious decisions were made in 2000 in relation to what information would be available in 2003–2004, when the *quality management* part of the contract goes into effect. These challenges have been met by the use of classification of satellite imagery and innovative methods in gathering farmland boundaries. We believe that the contract can have more importance for attaining sustainable land use than most government initiatives to date, given that the *quality management* will not be abandoned.

It seems that linking government subsidies and land use practices is both justifiable and practical in Iceland for the following reasons:

- The consumer has a right to know if the products, which are heavily subsidized, are produced in a sustainable manner, hence, a high subsidy/capita for sheep products.

Table 2
Grazing statistics for the highland commons. The survey includes 25 commons, which represent the majority of all commons in the central highlands of Iceland

Condition of commons	No.[a]	Area (km^2)	Mean size (km^2)	Vegetated area (%)	Desert area (%)	Mean no of ewes[c]	Total no of ewes
Poor	17	14179	834	9	91	1946	31400
Good	8	3739	476	43	57	5174	37407
Total	25	17918	717[b]	16[b]	84[b]	2752[b]	68807

They are divided into two categories, poor condition (not suited for grazing) and good condition (suited or partly suited for grazing). Based on Barkarson, 2002.

[a] Number of commons surveyed total and in each category.

[b] Weighted mean.

[c] Average number of ewes (not including lambs) on each common.

- Society spends a substantial proportion of its income on maintaining these rural areas, but it is difficult to justify such support for non-sustainable production methods.
- The link between subsidies and sustainable land use is suited to modern environmental ideology, both global and local.
- The link gives a financial incentive for concentrating future development of sheep farming in areas with suitable land resources.

7.2. Subsidies and grazing of the Icelandic highlands

Does the subsidies agreement affect a large proportion of the sheep farmers? Recent research (Barkarson, 2002) involving the majority of the highland grazing areas shows that about 282 farms with about 70,000 ewes used the central highlands as grazing lands (Table 2). This is about 15% of winterfed ewes. Some of the commons used have good grazing lands, and only 7% of the total number of sheep is being grazed on commons in the central highlands in areas that are considered not suitable for grazing by the Agricultural Research Institute and the Soil Conservation Service (Barkarson, 2002). Although, this number does not include all the highland grazing, it does indicate that the highland grazing is not economically important on a national scale, although it may be important locally.

The farmers using commons not suited for grazing will not meet the criteria for *quality management* according to the subsidy agreement resulting in lower subsidies. The new subsidies agreement may therefore slowly turn a proportion of the sheep grazing off these unsuitable commons to other areas better suited for grazing by sheep.

7.3. Two land categories: farmland and protected land

Financial incentives, such as linking subsidies to land condition, encourage a reduction in grazing pressure on highland areas that are not suited for grazing, but do not lead to exclusion of such grazing practices. Educational emphasis and land-stewardship approaches (and "land-care approaches") do not end such practice either. It is the belief of the authors that land in Iceland needs to be divided into two categories with regard to grazing. These categories are,

- land intended for use (farmland), and
- land that primarily needs protection from grazing.

Most of the Icelandic lowlands are well suited for a variety of agriculture, including grazing by sheep. Some of the highlands are also suitable grazing areas, with good vegetation cover and minor erosion problems. The approach taken by the Soil Conservation Service towards the use of this land has proven to be appropriate, emphasizing land-stewardship.

The land that should be excluded from grazing by national level set-aside policy includes deserts, land highly susceptible to erosion, eroded areas, vegetation remnants and highland areas within the volcanic region (RALA and SCS, 2001). Less direct approach than national government decisions results in debates at a community level which is very damaging for environmental protection in general. We draw this conclusion based on lessons from the last century. Other types of approaches towards land that should not be used for grazing will also result in too complex rules that can be misleading. If an area is not suitable for a certain type of land use, it should be clearly stated. The Icelandic nation does not need the set-aside land for economic reasons, and in most cases, alternative grazing areas can be found.

We conclude that soil conservation law and subsidy policies should be closely connected, taking into account environmental issues and sustainability, economic issues (local and national), the right of the consumer to buy and pay (via subsidies) for products that are made without harming the environment.

References

Aradottir, A.L., Arnalds, O., 2001. Ecosystem degradation and restoration of birch woodlands in Iceland. In: Wielgolaski, F.E. (Ed.), Nordic Mountain Birch Ecosystems. Man and the Biosphere Series 27, Parthenon Publishing, New York, pp. 293–306.

Arnalds, A., 1987. Ecosystem disturbance in Iceland. Arctic Alpine Res. 19, 508–513.

Arnalds, A., 1999. Incentives for soil conservation in Iceland. In: Sanders, D., Huszar, P.C., Sombatpanit, S., Enters, T. (Eds.), Incentives

in Soil Conservation. Science Publishers, Enfield, New Hampshire, pp. 135–150.

Arnalds, A., 2000a. Evolution of rangeland conservation strategies. In: Arnalds, O., Archer, S. (Eds.), Rangeland Desertification. Advances in Vegetation Science. Kluwer Academic Publishers, Dordrecht, The Netherlands, pp. 153–163.

Arnalds, O., 2000b. The Icelandic "rofabard" soil erosion features. Earth Surf. Process. Landforms 25, 17–28.

Arnalds, O., Thorarinsdottir, E.Fl., Metusalemsson, S., Jonsson, A., Gretarsson, E., Arnason, A., 2001a. Soil erosion in Iceland. Soil Conservation Service and the Agricultural Research Institute, Reykjavik Iceland, 1997 (Translated from Icelandic Version).

Arnalds, O., Gisladottir, F.O., Sigurjonsson, H., 2001b. Sandy deserts of Iceland: an overview. J. Arid Environ. 47, 359–371.

Barkarson, B.H., 2002. Management of livestock grazing on central highland rangelands in Iceland. M.Sc. Thesis, University of Iceland, Reykjavik (English abstract).

Buller, H., 2000. Regulation 2078: patterns of implementation. In: Buller, H., Wilson, G.A., Höll, A. (Eds.), Agri-environmental Policy in the European Union. Ashgate Publishing, Aldershot, UK, pp. 219–253.

Buller, H., Wilson, G.A., Höll, A., 2000. Agri-environmental Policy in the European Union. Ashgate Publishing, Aldershot, UK.

Einarsson, Th., 1963. Pollen analytical studies on the vegetation and climate history of Iceland in late and post-glacial times. In: Löve, A., Löve, D. (Eds.), North Atlantic Biota and Their History. Pergamon Press, Oxford, pp. 355–365.

FAI, 2001. Icelandic agricultural statistics 2001, Hagtolur landbunadarins 2001. The Farmers Association of Iceland, Reykjavik, Iceland.

Gisladottir, G., 1998. Environmental characterisation and change in South-western Iceland. Dessertation No. 10, The Department of Physical Geography, Stockholm University Dissertation Series, Stockholm, Sweden.

Hallsdottir, M., 1995. On the pre-settlement history of Icelandic vegetation. Iceland. Agric. Sci. 9, 17–29.

Kristinsson, H., 1995. Post settlement history of Icelandic forests. Iceland. Agric. Sci. 9, 17–29.

LMI, 1993. Digital vegetation index map of Iceland. National Land Survey of Iceland, Akranes, Iceland.

Magnusson, S.H., 1997. Restoration of eroded areas in Iceland. In: Urbanska, K.M., Webb, N.R., Edwards, K.M. (Eds.), Restoration Ecology & Sustainable Development. Cambridge University Press, Cambridge, pp. 188–211.

OECD, 2001. Environmental Performance Reviews. Iceland, OECD, Paris.

OECD, 2002. Agricultural Policies in OECD Countries—Monitoring and Evaluation 2002. Country Chapters, OECD, Paris.

Olafsdottir, R., Schlyter, P., Haraldsson, H.V., 2001. Simulating Icelandic vegetation cover during the Holocene. Implications for long-term land degradation. Geografiska Annaler 83A, 203–215.

RALA, SCS, 2001. Certification of eco-friendly sheep production, draft report (Vidurkenning vistvaennar saudfjarframleidslu; drog ad greinargerd), Agricultural Research Institute, unpublished report, Reykjavik, Iceland.

Sigbjarnarson, G., 1969. The loessial soil formation and soil erosion on Haukadalsheidi. Natturufraedingurinn 39, 49–128 (In Icelandic with extended English summary).

Statistics Iceland, 1997. Icelandic Historical Statistics (Hagskinna). CD-Rom; Statistics Iceland, Reykjavik, Iceland.

Statistics Iceland, 2000. Statistical Yearbook of Iceland 2000. Statistics Iceland, Reykjavik, Iceland.

Thorarinsson, S., 1961. Wind erosion in Iceland. A tephrocronological study. Yearbook Iceland. Forest Society 1961, 17–54 (In Icelandic with extended English summary).

Thorarinsson, S., 1981. The application of tephrocronology in Iceland. In: Self, S., Sparks, R.S.J. (Eds.), Teprha Studies. Reidel, London, pp. 109–134.

Thorsteinsson, I., 1986. The effect of grazing on stability and development of northern rangelands: a case study of Iceland. In: Gudmundsson, O. (Ed.), Grazing Research at Northern Latitutes. Plenum Press, New York, pp. 37–43.

Thorsteinsson, I., Olafsson, G., Van Dyne, G.M., 1971. Range resources of Iceland. J. Range Manage. 24, 86–93.