

2.1 The Climate

Iceland, about 103,000 km² of volcanic island, is located far in the north, right under the Arctic Circle, between the 63° and 66.6° northerly latitudes, and 13–24° westerly longitudes (Fig. 2.1). In spite of the northerly global position, the climate is relatively mild. The reason is the oceanic climate and the powerful Gulf Stream, an ocean current that brings warm waters to the shores of Iceland. If it was not for this current, the climate of Iceland would be considerably colder than it is. However, a cold East Greenland Current influences the climate, but to the south the warm Irminger Current (part of the Gulf Stream) ensures relatively warm temperatures (Olafsson et al. 2007; Einarsson 1984). Low atmospheric pressure systems are frequent, sometimes referred to as the “Icelandic low” pressure system; this results in relatively high wind speeds, but Iceland is considered to be within the North Atlantic storm track (Olafsson et al. 2007). It is worth considering that continental areas at the same latitude as Iceland, in Siberia and Canada for example, experience much colder climates than Iceland, especially in winter. Mean monthly temperatures for Reykjavik on the one hand and several foreign cities are compared in Fig. 2.2.

The discussion in the subsequent chapters of this book often refers to geographic areas in Iceland, such as the North or Eastfjords. This division is presented in Fig. 2.3, but a larger version of the map was presented in the Introduction. It is based on the author’s perception of this division, which is quite general, but may vary on how these lines are drawn between people and the purpose for each such map.

Typical average values for temperature and precipitation at several locations in Iceland are presented in Table 2.1. As can be seen from this table, winters in Iceland are relatively mild with temperatures commonly near zero (see also Fig. 2.2). Low pressure systems that bring relatively mild air masses are common in winter, and often raise the temperature above zero and bring ample moisture to the southern shores with southerly winds. There is more stable or longer

lasting snow cover on the ground in the north and more so in the highlands. In the south, snow stays usually on the ground for a short time, for a day or a few days. Summers are, on the other hand, relatively cool compared to the neighboring countries (Fig. 2.2).

Table 2.1 presents averages based on the 1982–2012 (30 years) dataset, which results in significantly higher means than for the 1961–1990 averages, due to a warming trend. The averages for the last 5 years are still higher than the 1982–2012, an expression of global warming. The highest recorded temperature in Iceland is 30.5 °C (1939, Eastfjords), the lowest is –38 °C (1918, Northeast) (Olafsson et al. 2007).

There is noticeable difference in temperatures between the geographic areas of Iceland, but the elevation is the single most important factor affecting the mean temperatures (Fig. 2.4). As can be seen from this image, the mean annual temperatures are commonly 0–4 °C in the lowlands, but mostly 0 to –4 °C in the highlands. The highlands show Arctic character, where permafrost can be found in some locations under vegetation (see Chap. 10 on cryoturbation, also Thorhallsdottir 1997; Saemundsson et al. 2012).

A map of average temperatures in January and June is presented in Fig. 2.5. Winter temperatures are noticeably lower at the high elevations, especially in the north and northeast, but there are areas along the south coast where average temperatures are above freezing in January. Summer temperatures are also significantly higher in the southern and western lowlands (>10 °C), but are also favorable in the Eyjafjörður valleys (north) and inland valleys of the east. The warmest July areas are also those where barley production grows rapidly. It is interesting to note that the Arctic is sometimes defined as areas with average July temperature of <10 °C, but conventionally all of Iceland has been defined within the Arctic region (CAFF 2001, see Chap. 10).

Most parts of Iceland receive ample moisture for vegetation growth (Fig. 2.6) with >600 mm annual rainfall. Some areas in the south receive even more than 2,000 mm each year (record is >4,600 mm south of Vatnajökull glacier;

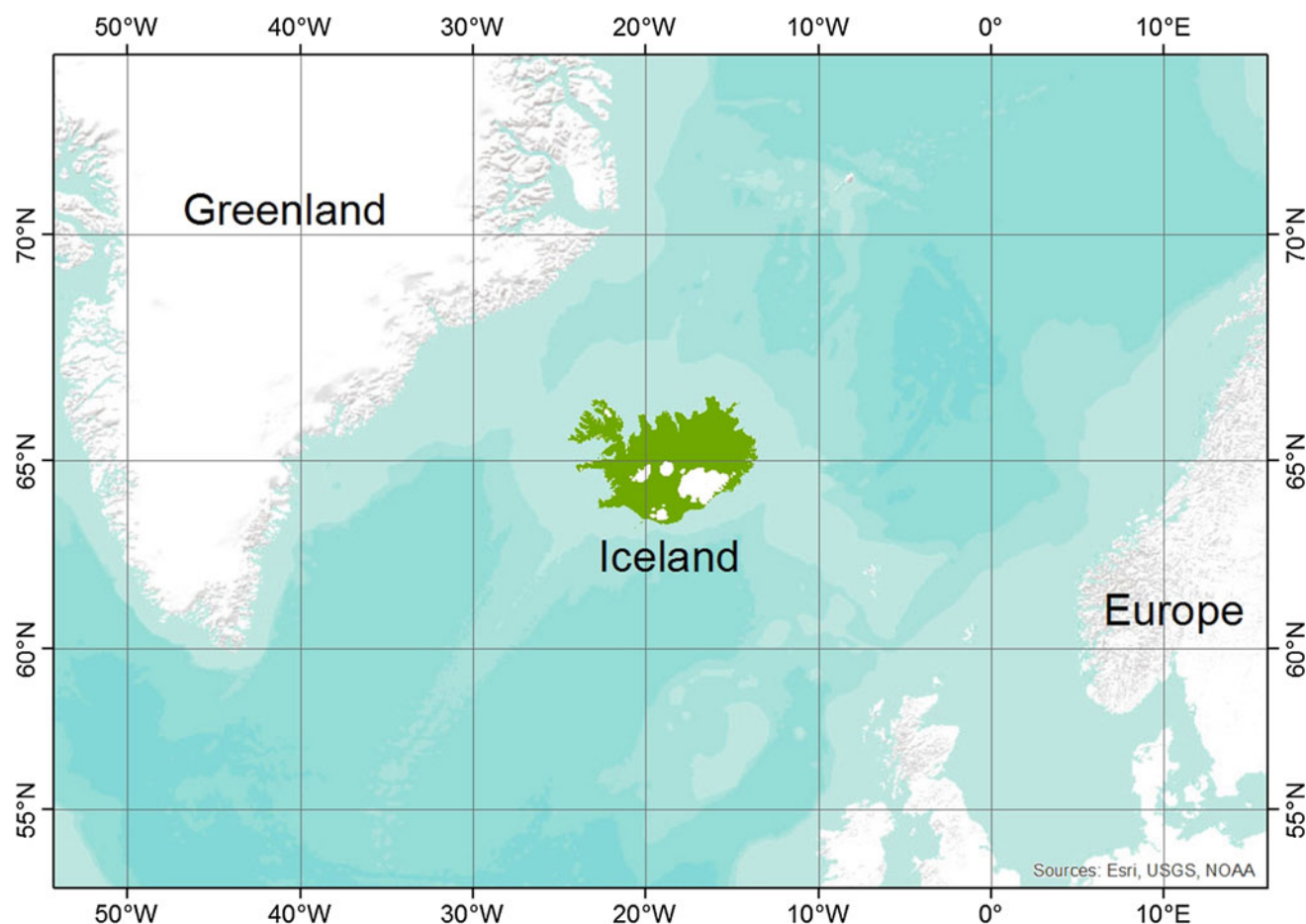


Fig. 2.1 Map showing the northerly location of Iceland. ESRI 2014; ESRI Basemaps

Olafsson et al. 2007). However, there are areas of low rainfall north of the Vatnajökull glacier with some areas receiving <400 mm rainfall. Humidity is usually as high as 75–90 %, but it can be quite low with cold dry air masses (see, e.g., Einarsson 1984). Rainfall is very common, but is often associated with long-lasting low intensity rainfall events. High intensity events do occur ($>100 \text{ mm day}^{-1}$), especially in the south and in relation to passing of high-energy low-pressure systems (Olafsson et al. 2007).

Due to the common occurrence of low-pressure areas and periodic occurrence of storms (cyclons) blowing from the Arctic, Iceland is a windy country in general (Einarsson 1984; Olafsson et al. 2007). Wind speed can reach >30 , and $>50 \text{ m s}^{-1}$ near mountains during severe storms, but wind speeds of $5\text{--}15 \text{ m s}^{-1}$ are quite common (see Icelandic Meteorology Office web page, www.vedur.is on wind).

2.2 The People

Iceland was settled by Norsemen after 874 AD with rapid population increase during the first century. Iceland was an “independent” country (if one can say so about the states of the early Middle Ages) with a parliament, called “Alþingi” established in 930 AD, with neither royalty nor a king. Ties with Norway, however, remained close. The Icelandic Sagas were written mostly in 1150–1300 but their subjects often took place in the period 870–1000 AD (i.e., long after the events described). Early Icelandic scholars include Snorri Sturluson, who wrote both the history of the Norwegian kings (Heimskringla, covering 600 years of history) and an important mythological and poetic textbook (Snorra-Edda), which is a source for the majority of what is known today

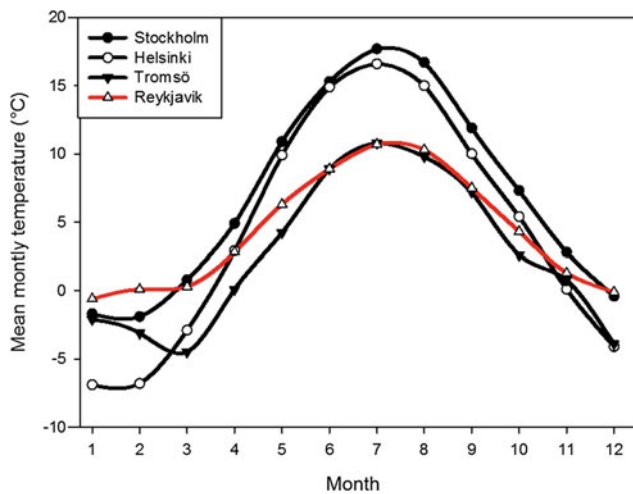


Fig. 2.2 Mean monthly averages for northerly cities. January and February are the mildest in Iceland (oceanic, Gulf Stream), but summer temperatures are considerably lower than in Stockholm (Sweden) and Helsinki (Finland), with more southerly and continental influences, but are similar as for Tromsø (69°N, 41°E) at the northern coast of Norway. Data are from yr.no, and may not represent same reference years. Using data from 1982 to 2012 (Table 2.1) gives about 0.5 °C higher means than presented here for Reykjavik

about the old German pagan religion. The early writings of the Icelanders, including the Sagas, provide an important glimpse into the natural history of Iceland at and soon after the Settlement. The Icelandic parliament is still called “Alþingi”, and can be considered the oldest operating parliament in the world. Figure 2.7 shows the landscape of the old site of the parliament (Þingvellir, SW Iceland, UNESCO World Heritage Site).

The country was increasingly ruled by a few powerful families after the Settlement period, which led to a civil war during the thirteenth century and finally Norwegian rule (however, with loose ties) in 1262. Iceland came under Danish rule from 1662, which remained until the twentieth century, with partial independence achieved in 1904 and 1918 and full independence was declared in 1944, when Denmark was under German occupation. The population declined during the Middle Ages due to ecosystem collapse, civil strife, cooling climate, and natural disasters, which included the catastrophic Laki volcanic eruption in 1783 AD (e.g., Karlsson 2000). The population remained between 35,000 and 60,000 from the seventeenth century until the

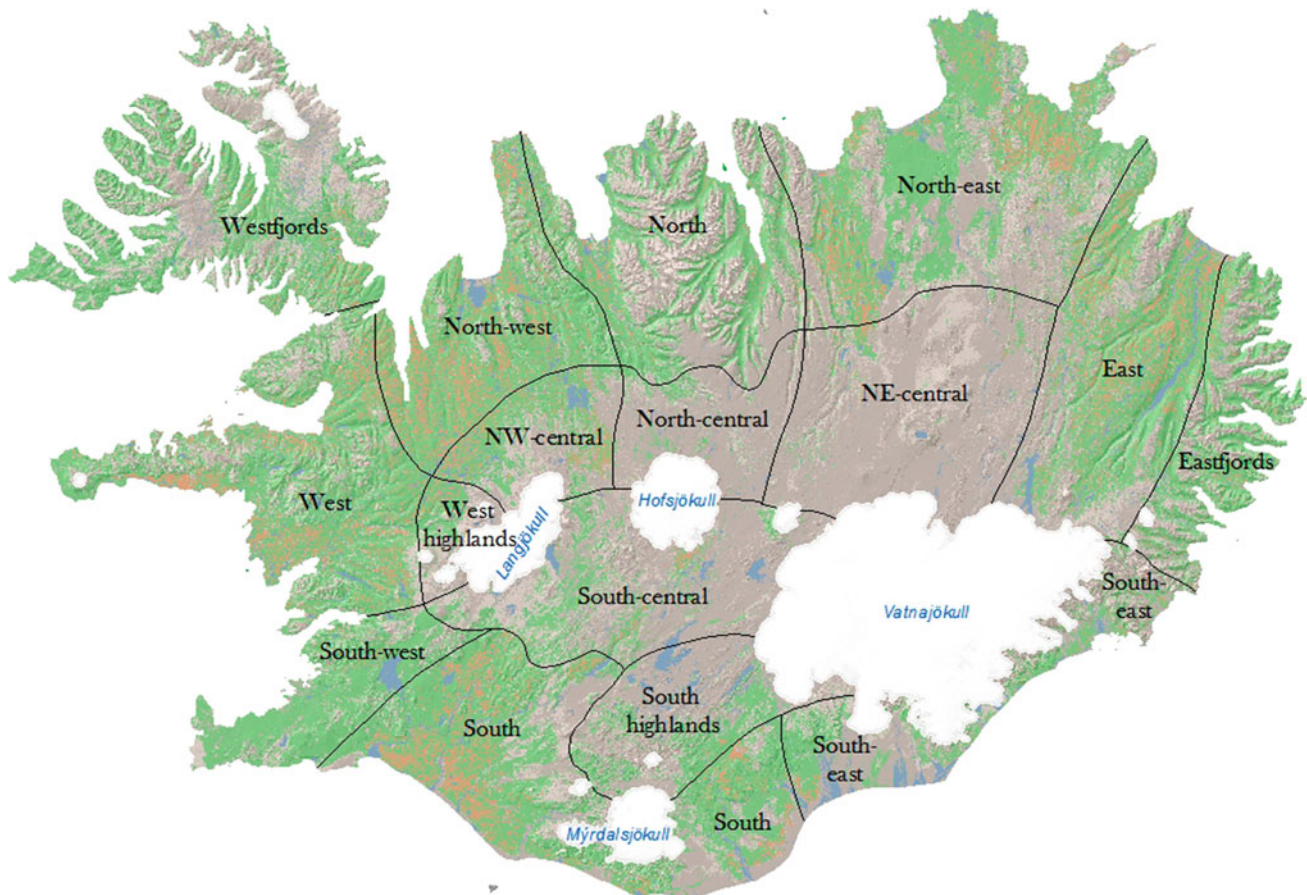


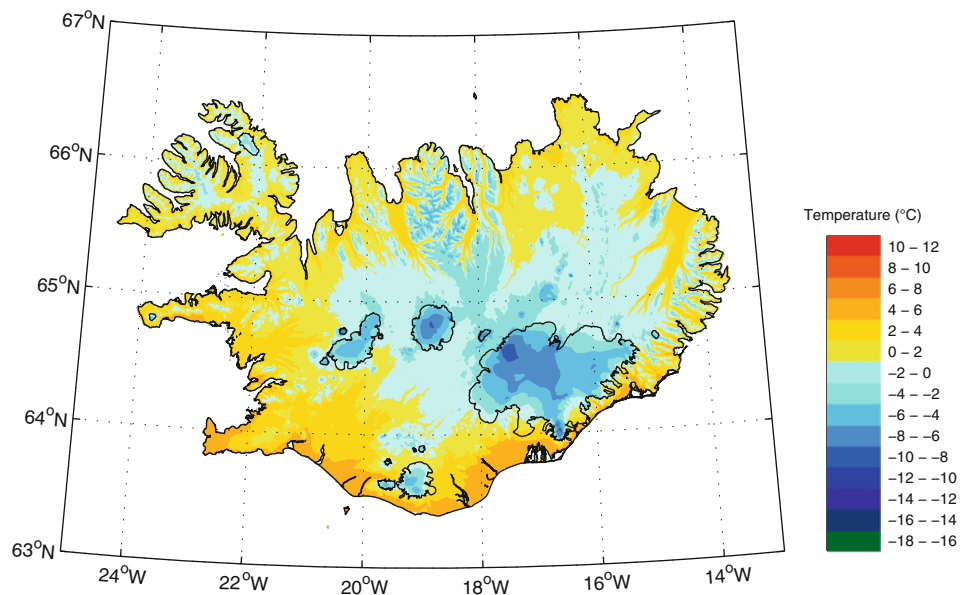
Fig. 2.3 The author’s perception of the geographic areas in Iceland, which are referred to throughout the book

Table 2.1 Typical climate in Iceland during 1982–2002

Weather station (region in parenthesis)	Temperature (°C)			Precipitation (mm)		
	Mean annual	January	July	Mean annual	January	July
Reykjavík (SW)	4.8	0.2	11.3	868	87	53
Bolungarvík (W.fjords)	3.7	−0.1	10.3	812	85	41
Akureyri (N)	3.9	−1.1	11.2	559	63	33
Egilsstaðir (E)	3.3	−1.8	11.0	813	110	42
Kirkjubæjarklaustur (S)	4.9	0.2	11.6	1,775	168	126
Hella (S)	4.7	−1.3	12.5	1,258	119	92
Hveravellir (C)	−0.8	−6.0	7.6	754	74	52

Data from the Icelandic Meteorological Office of Iceland, Bolungarvík since 1994

Fig. 2.4 Average annual temperature in Iceland during 1961–1990. Note that averages in Table 2.1 are for a different (warmer) time period of 1982–2012. Icelandic Meteorology Office web page (www.vedur.is), Björnsson et al. (2007a, b)



latter part of the nineteenth century, but rose rapidly during the twentieth century. Livestock numbers about 1700 AD were about 35,000 cattle, 280,000 sheep, and 26,000 horses (Karlsson 2000). The struggle for sustenance with limited winter fodder available for husbandry led to serious over-exploitation of land resources and soil erosion, as will be discussed in the last chapter of this book. The livestock numbers at about 1700 AD were not far from what they are today with about 75,000 cattle, 460,000 sheep, and 80,000 horses (see next section). Climate was believed to have been considerably colder during the Middle Ages than it is now, contributing to famine and ecosystem degradation (see the last chapter of this book).

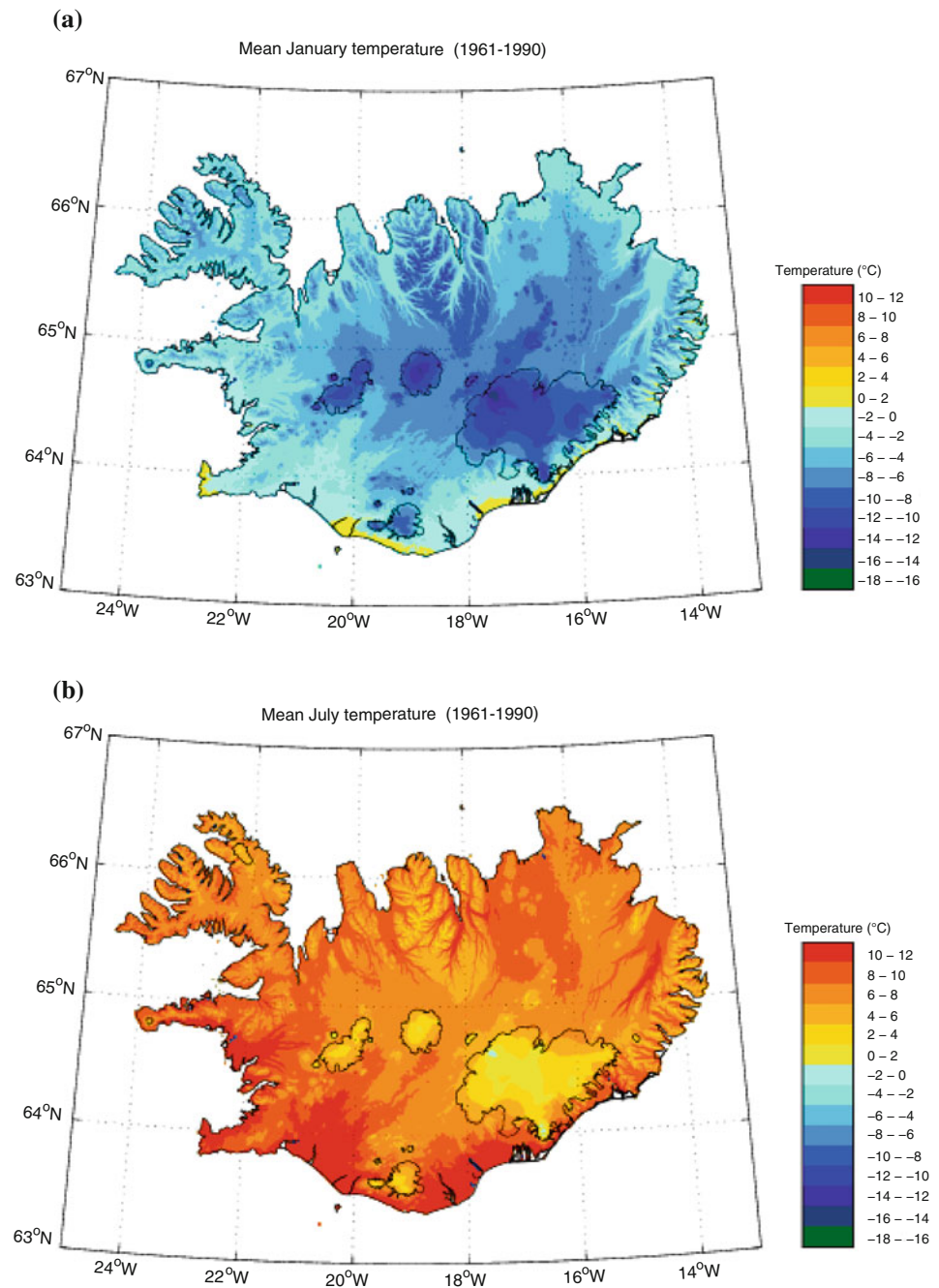
Before World War I, most Icelanders lived in rural communities, on farms or small fishing villages. The country was largely controlled by landowners and many civil rights were limited to them: “... that it had been a dominant policy in Iceland over the centuries that all adults who did not run a farm of their own should serve as

domestic servants in the homes of the farmers” (Karlsson 2000). Only landowners and government officials with very few exceptions were allowed to vote or to be voted to the parliament, with very slow change in the franchise until 1915 (Karlsson 2000).

Icelanders are about 320,000 today. About two-thirds of the population lives in the Reykjavík Capital area in Southwest Iceland. Agriculture is now only a small proportion of the total economic GDP (1.3 %) but a dominant factor in terms of control and use of land resources. Fisheries, industry (mostly smelters using hydropower and thermal energy), tourism, construction, and various services (including the financial sector) are the largest segments of Icelandic economy in terms of GDP (Statistics Iceland, www.statice.is). Tourism is growing rapidly.

Iceland has its own language, which has remained similar over the >1,100 years since the country was settled, which in part can be attributed to the isolation of the country during the Middle Ages.

Fig. 2.5 Mean temperatures in January and July for 1961–1990. Note that averages in Table 2.1 are for a different (warmer) time period of 1982–2012. Icelandic Meteorology Office web page (www.vedur.is) and Björnsson et al. (2007a, b)



2.3 Agriculture and Land Use

Iceland is among the least inhabited countries of the world with about 3.3 persons per km² but the EU average is about 112 and Scandinavia has 15–22 inhabitant per km² (Helgadóttir et al. 2013). Only one-fourth of the country is under 200 m elevation, where almost all of the population lives, bringing the population density in the lowlands to about 13 per km².

Active Icelandic farms are only about 2,600. The production, especially the dairy industry, can be considered grassland-based agriculture dependent on haymaking and grazing (see Helgadóttir et al. 2013; Guðmundsson et al. 2013). Figure 2.8a, b exemplifies the Icelandic farming landscape. Dairy production and the production of sheep meat constitute the major proportion of the Icelandic agriculture (data from Statistics Iceland February 2013; www.statice.is), with about 26,000 dairy cows and 75,000 cattle in all, and 460,000 winterfed sheep. There are only about 1,000

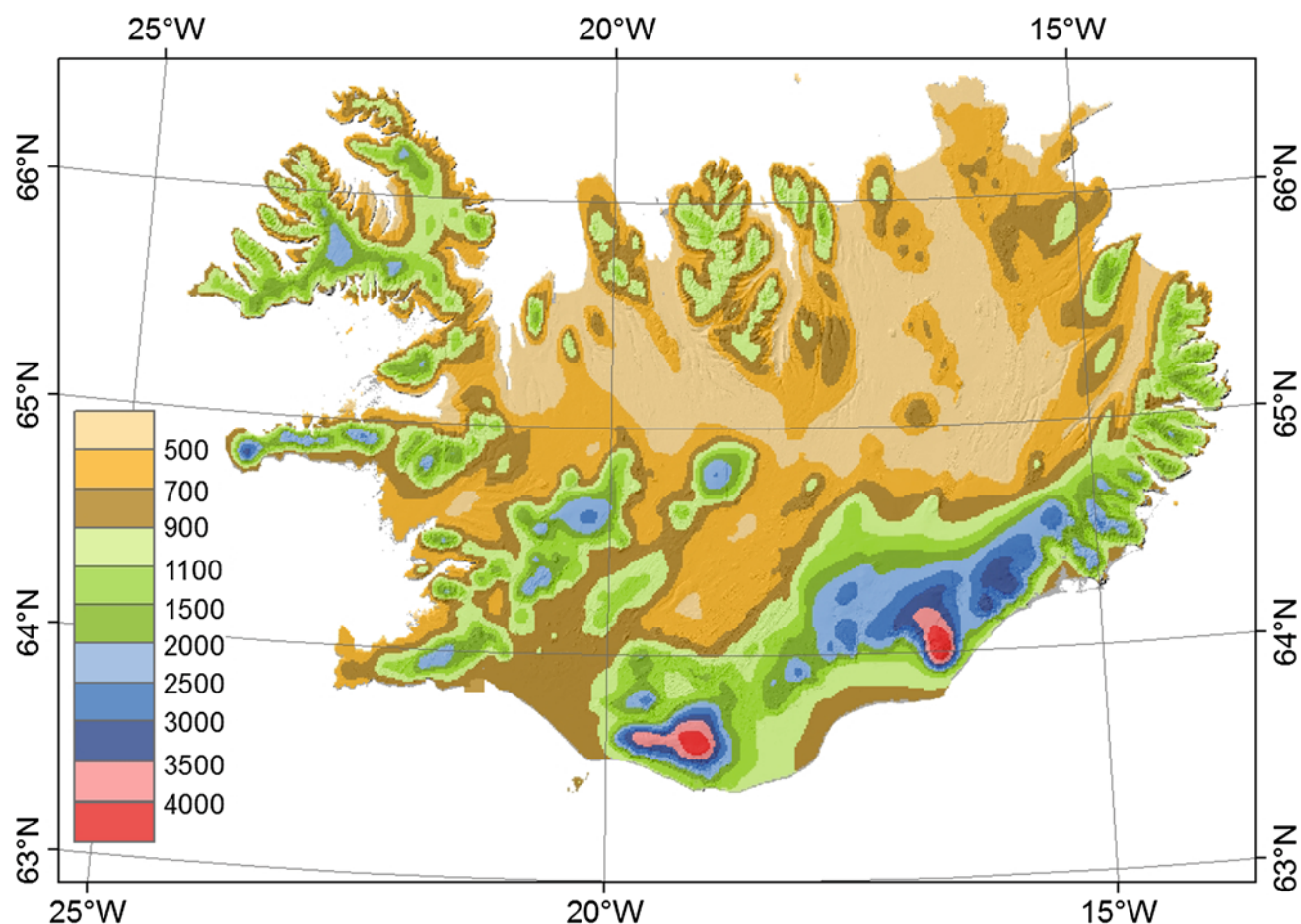


Fig. 2.6 Average annual precipitation in Iceland (1971–2000). Data from the Icelandic Met Office, Crochet et al. (2007), Crochet and Johannesson (2011). Prepared by SHB/AUI

goats and about 41,000 pigs. Horses are about 80,000, which is a high number compared to the number of humans, but horses are popular for recreation activities and they are also exported abroad. The average land area for each farm generally ranges between 500 and 2,000 ha, but hay fields are usually <100 ha, with 30–60 dairy cows and/or a few hundred sheep on each farm (Agricultural University Database).

The Icelandic livestock is in many ways unique, as these breeds, which were brought to Iceland 1,000–1,100 years ago, have remained in isolation in Iceland without mixing with other breeds during this time, maintaining an old important genetic pool (Adalsteinsson 1981; see also Helgadóttir et al. 2013). The livestock are unusually colorful, and the Icelandic horse (pony) possesses some unique gaits that make it a valuable international commodity and a popular riding horse (Helgadóttir et al. 2013). More than

150,000 horses of the Icelandic breed are found in other countries than Iceland (Helgadóttir et al. 2013).

Animals, except horses, are kept indoors during winter, which calls for haymaking and storing fodder for the winter. Cultivated land is 1,100–1,300 km² (Nytjaland data; Helgadóttir et al. 2013), but this number includes mostly permanent hay fields, which are plowed every 5–10 years. Cultivars commonly used in the hay fields include timothy (*Phleum pratense*), meadow foxtail (*Alopecurus pratensis*), smooth meadow grass (*Poa pratensis*), fescues (*Festuca rubra*, *F. pratensis*), and perennial ryegrass (*Lolium perenne*) (Helgadóttir et al. 2013). Indigenous species are also common, including smooth meadow grass, red fescue (*Festuca rubra*), tufted hairgrass (*Deschampsia caespitosa*), and bentgrass (*Agrostis capillaris*), especially in old hay fields (Helgadóttir et al. 2013). The soils of the hay fields are



Fig. 2.7 The medieval parliament site at Þingvellir, a UNESCO World Heritage Site. The area is characterized by active tectonic faults, with the depressions used for campsites and keeping horses in medieval times. *Photo G.Kr. Johannesson*

quite variable, but a large proportion is occupied by drained wetland soils, mainly Gleyic Andosols and Histic Andosols, but also Brown Andosols (soil classes explained later in the book).

Haymaking (Fig. 2.9) involves fertilizer amendments commonly in the range of $80\text{--}120\text{ kg N ha}^{-1}$. Total national use of N is about 10,000 tons (www.statice.is). Due to the andic nature of the soils in Iceland (see chapter on Andosols), there is a need for P fertilizers in Icelandic crop production, (about 3,100 tons in total annually; www.statice.is). In addition to hay, barley is grown on about 5,000 ha, and other crops include annual ryegrass and oats. Barley production is growing rapidly with improved cultivars and a warming climate (see Helgadóttir et al. 2013).

Both the sheep and dairy production are heavily subsidized by the government (for sheep: about equal to the income for selling the meat), and the subsidies rate among

the highest in the world. Furthermore, most sheep farmers amend their income by employment off the farm.

The dairy cows are grazed on good grazing land close to the barn during summer. The sheep are set free on open rangelands, which include much of the highlands during summer, generally from late June or early July to early September, when the sheep are gathered. They are left unattended, as there are no predators that feed on the sheep except for occasional killings by the wild fox (Arctic fox) when the lambs are young.

The highland communal areas with the least vegetation cover and with severe erosion problems have been judged unsuitable for grazing after an extensive survey by the Agricultural Research Institute and the Icelandic Soil Conservation Service (Arnalds et al. 1997, 2001). Grazing of sheep in the highlands has caused considerable controversy, but attempts to close some of the poorest highland grazing

Fig. 2.8 **a** Farming landscape in central North Iceland, the wide dots are bales of hay. **b** A beautiful location for a farm in South Iceland. *Photos* Askill Thorisson, AUI



lands have failed (see Arnalds and Barkarson 2003; Crofts 2011). Icelandic nature conservation NGOs and the OECD (2001) have been very critical of land use policies in Iceland, and especially the poor state of the highlands. The highland grazing of the poorly vegetated communal areas constitutes only a minor part of the total sheep grazing (Arnalds and Barkarson 2003); they are not important for agriculture in general as their use is often more linked to traditions rather than economic or sustainable land use.

2.4 Forestry in Iceland

At the time of Settlement, forest and shrubland covered up to 25 % of Iceland. At the beginning of the twentieth century, only three stands of a few hectares remained of the tall growing native birch (*Betula pubescens*), at Vaglaskógur, North Iceland, in Hallormsstaður, East Iceland, and Bæjarstaðarskógur, South Iceland (Fig. 2.10). These stands served

Fig. 2.9 Haymaking in West Iceland. Drying the hay was a major challenge during rainy summers until recently, but modern haymaking techniques are not as dependent on dry weather conditions. *Photo* Askell Thorisson, AUI



Fig. 2.10 An old native birch forest, Bæjarstaðarskógur, in Southeast Iceland. This is part of the few stands of tall growing birch that survived medieval times. *Photo* Asa L. Aradottir

as a seed source for extension of the birch forests throughout the twentieth century, but the spread was aided by natural succession in many areas protected from sheepgrazing (Aradottir and Eysteinnsson 2005; Aradottir 2007). Forests now cover about 1.2 % of the country (Snorrason et al. 2005; Traustason and Snorrason 2008).

There has been considerable effort to increase the extent of forests in Iceland since the early twentieth century, both with natural and introduced species. The aims of the afforestation programs vary, but include aesthetics, nature, and/or soil conservation, but the aim of some of the plantations is to create timber forests (Aradottir et al. 2013). These forests are becoming a prominent part of the Icelandic landscape, especially in East Iceland. Part of this program is driven by aims to sequester carbon to balance emissions in relation to the UN Convention on Climate Change (see Sigurdsson et al. 2007). Restoring native birch forests still remains a priority (Aradottir and Eysteinnsson 2005). Four introduced tree species are most common: Siberian larch (*Larix sibirica*), Sitka spruce (*Picea sitchensis*), lodgepole pine (*Pinus contorta*), and black cottonwood (*Populus trichocarpa*). A number of other tree species have been successfully introduced in Iceland. Currently, there is a debate about the use of these and other alien species in Iceland (see Chap. 4).

Other land use components that are increasing the stress on Icelandic soil systems include road construction and urbanization (Fig. 2.11). This has led to fragmentation of valuable ecosystems such as wetlands (Wald 2012), which still continues.

Fig. 2.11 Urbanization—road construction destroying valuable agricultural soil



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Regarding punctuation and Icelandic characters in citations: see section on punctuation in the Preface

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