Long-term landscape change can be understood as the total sum of human impacts and natural change over many different timescales. The major indicators of this landscape change are the changing nature of woodland and soils. Therefore, by understanding the changing patterns of woodland and soils it is possible not only to interpret the processes and effects of change in the natural environment, such as rates of soil erosion and deforestation but also changing cultural practices, such as causes and timing of farm abandonment and extent of historical resource exploitation and management. Studies of past environments are important as they offer valuable insights into the relationships between people and climate change, and about how people respond to the challenges that environmental and climatic changes pose.

Identifying the cultural elements of landscape change is a complex issue however, especially in areas with a long or culturally mixed record of human history. For example, the landscape and woodlands of Scotland have changed considerably as a result of both human impact and climate change over a timescale covering the last 5000 years. When the Norse arrived in the west coast of Scotland at the end of the eighth century for example, the landscape had already undergone thousands of years of change influenced by human impact, yet was still probably very different to today. Developing hypotheses for human-environment relationships for an area such as Scotland is therefore complex. Evidence for the nature of landscape change and human impact and response is less ambiguous, however, on an island like Iceland, where recent and relatively well-documented cultural settlement is combined with a high-resolution chronology. Iceland was permanently settled less than 1200 years ago and uniquely some details of settlement are known from historical records including laws, sagas, medieval historical writings and genealogies. Landscapes in Iceland are also responsive to changing climate, as Iceland is situated at the Polar Front at the meeting of warm and cold air masses and at the convergence of polar and south Atlantic ocean currents. Furthermore, precise dating...
control in Iceland is possible because of the wide distribution of well-dated layers of volcanic ash or tephras.

**Tephrochronology**

Tephrochronology refers to the identification, correlation and dating of volcanic ash layers, in order to establish a chronology and is a technique that can be applied to a range of archaeological, geological, geomorphological and palaeoecological questions. Although the majority of tephrochronological studies have taken place in relative proximity to volcanic eruptions where ash forms visible layers several centimetres thick, tephrochronological techniques have also been applied to areas of distal fallout such as Scotland. Icelandic microtephra (i.e. not visible to the naked eye) was first identified in Scottish peats in 1987 and has been utilised in research seeking to understand the patterns and mechanisms of distal fallout, as well as contributing to environmental studies. For example, a volcanic ash-layer in peat from northern Scotland was identified as fallout from the Hekla 4 eruption in Iceland and was found to coincide with an abrupt decline in Scots pine (*Pinus sylvestris* L.) pollen frequencies c. 4000 BP. As an example, the discovery of this tephra in Scotland has therefore provided an isochrone or time-equivalent marker horizon, with which to investigate the timing of the Holocene 'pine-decline' and the influence of volcanism on postglacial environmental change.

In Iceland, tephrochronology, based on a combination of field stratigraphy and supported by the geochemical analyses of key layers of volcanic ash, has been used extensively in dating farm ruins in an archaeological context. However, the use of tephras in analyses of environmental change, particularly in connection with archaeological questions contributing to the debate on human adaptation to a changing landscape and climate, is a relatively recent and developing field. Soils in Iceland are composed predominantly of andisols formed by the accumulation of fine grained aeolian sediments and are separated by horizons of volcanic ash. Since the settlement of Iceland, increases in aeolian sediment accumulation can be related to increases in the rate of soil erosion in the immediate surroundings (less than 1km). Sediment accumulation rates, and by proxy, soil erosion rates, can hence be calculated from stratigraphic
profiles by measurement of the sediment accumulation between two tephras of known age.

Settlement and landscape change in Iceland

Although much of the interior of Iceland consists of uninhabitable deserts, mountains and glaciers, prior to the arrival of the Norse c. A.D. 874, the lowlands along the coast and some valley systems reaching into the interior were dominated by birch forests, separated by wetlands at lower altitudes and willow, grasses and moss at higher altitudes. Archaeological evidence indicates that the settlement of Iceland progressed quickly with most habitable areas being settled in less than a few decades. Recent palaeoenvironmental evidence from pollen and soil stratigraphic research supports this assertion with a drop in birch pollen beginning immediately after the eruption of the Veíðvátn volcano system in A.D. 871. Macrofossil
evidence from south east Iceland indicates that large swathes of forest in some areas were cleared within 30 years of settlement, with only small areas of woodland surviving through to early modern times in the highland margins.

The early economy of Iceland was based on cattle raising and shepherding, which produced a scattered settlement pattern as the distance of neighbouring farms is determined by the fodder-producing capabilities of the intervening land. The first settlers arriving in Iceland established a way of life similar to that they left behind in western Scandinavia and sought out sites with good potential for fodder production such as wetland meadows, large outfields with south facing slopes for growing additional fodder and sheep grazing as well as sites with access to highland summer grazing areas and opportunities for hunting and fishing. The selection of lowland wetlands for initial settlement would have required clearing of the forests to create settlements and hay fields. Subsequent decline in woodlands at a distance from the settlements were driven by the need for wood for fuel and for charcoal to create iron from low-grade bog ore for creating and maintaining the sharp edges on tools needed to cut fodder.

Evidence for widespread soil instability associated with early human impact is comprehensive and convincing and has been greatly aided by the application of tephrochronology, particularly the existence of the so-called landnám tephra layer. The landnám tephra was deposited after the eruption of the Veíðvátn volcanic system in A.D 871 and is significant because the timing of the eruption coincides almost precisely with the historical dating of the beginning of Norse settlement. Consequently, this tephra horizon, which is widely distributed across Iceland, represents a clear demarcation in the sediment stratigraphy between changes in the environment and rates of soil erosion occurring before settlement and that occurring after. In south Iceland, for example, research utilising tephrochronology shows that the rate of sediment accumulation over the settlement period increased by more than an order of magnitude, most likely caused by a combination of forest clearance and the impacts of grazing animals.
Resource exploitation in Eyjafjallahreppur, southern Iceland

Eyjafjallahreppur is a region located in the south east of Iceland (Figure 1). On the slopes between the margins of the Markarfljót river to the north and the Eyjafjallajökull glacier to the south, lie nearly 40 farms, both settled and abandoned, and the continuous settlement of some farms since the early days of settlement testifies to the utilisation of the landscape by people for a significant period of time. Although the present-day farm infields and their environs are well vegetated, and the inland area of Þórsmörk is forested by birch and willow, extensive upland areas are degraded, having suffered from significant increases in soil erosion rates since human settlement.

Figure 1. Woodland change in southern Iceland. By the end of the thirteenth century A.D., the progressive loss of woodland in the southern Markarfljót valley had reached Þórsmörk; here farms sites were abandoned and the surrounding woodlands survived through seven centuries to the present, while they continued to be used as a vital and major source of charcoal for farms in the region.

The extensive erosion of upland soils has led to the deposition of thick aeolian sediments in the lowlands, which are divided by layers of tephra that mark the instant in time at which a volcano erupted.
This area of Iceland has a particularly well-established tephrochronology and most identifiable historical tephra layers in the region have been dated. Furthermore, the combination of rapid soil accumulation and continuous volcanism in the area throughout the historic period, has resulted in the formation of high resolution soil stratigraphic profiles, which can be utilised to test hypotheses of human-environment processes and interactions.

By piecing together the evidence of environmental change across several groups of settlements in a regional landscape (in this case across the region of Eyjafjalhreppur), linkages can be made between farm abandonment and cultural change, woodland decline and soil erosion. At the lowland farm of Mörk, tephra layers in peat sections show that extensive woodlands once existed in the area of the present homefields, but that the woodlands were cleared between A.D. 870 and 920, and probably even within the first 30 years of settlement. Up valley in Langanes, charcoal production pits have been preserved in aggrading soil profiles containing a number of tephra profiles, which have been used to date the use of birch wood in the area to between A.D. 877-1295. Yet, there are no woodlands present in this area today, and in fact, no charcoal production pits have been found in the area that post-date the fourteenth century. Further up valley (approximately 30km east of Mörk) in Þórsmórk, at the inland margins of the valley, isolated areas of woodland survive to this day, despite this area also being intensively managed for charcoal production through to early modern times. A similar pattern of progressive woodland destruction up valley, with continued survival of woodland in isolated areas close to the upland ecological margins, has also been identified in other southern Icelandic valleys such as Þjórsárdalur. The implication from the environmental record (that is not evident in other historical records, for example,) is that actions were taken to conserve woodland resources before they were completely destroyed.

In Þórsmórk where the woodlands survived, four abandoned farm sites are known whose occupation has been dated to between the late ninth and late thirteenth centuries on the basis of written records and artefact evidence from the sites. Recent environmental work has shown that the occupation of these sites coincided with major localised episodes of erosion, but that following abandonment of the
farm sites, the area began to regenerate and soils began to reform. Precise dating of the erosion and regeneration is again given by the distribution of well-dated layers of volcanic ash. A previous argument made for abandonment of these sites has been that, lying at the upland limit of settlement in the region, they were abandoned as a consequence of the localised erosion of grazing lands after the introduction of grazing animals to the area. This explanation would fit well with the chronology of landscape change. Yet, unlike areas further down valley, there is evidence in Þórsmörk that woodland survived the period of occupation. Therefore, although abandonment is probably related to the soil degradation, the final push may have been driven by the need to conserve a diminishing supply of woodland. Perhaps it was only once the woodlands down valley had been destroyed that people recognised the importance of conserving the surviving remnant in Þórsmörk, with the result that after the farms (and probably associated livestock) were removed, the woodland came under control of the larger lowland farms and the church and subsequently survived. A key conclusion arising from this example is that even when exploitation of a resource and related environmental degradation appears ill-conceived (in this case with regards to the near-total destruction of native woodland), successful conservation measures were employed in at least some of the areas before the resource was totally lost.

**Questions of scale**
Questions of scale in human-environment research are critical and it is crucial that the human dimension is evaluated at spatial resolutions ranging from individual settlement sites and landholdings to groups of settlements in regional landscapes. For example, by taking a regional landscape approach, this research illustrates how the fate of farms at the upland limits of settlement may have been affected by the changes in the lowlands. The conclusion in Eyjafjallahreppur is that despite localised soil erosion and landscape degradation, the key environmental change that determined abandonment was most probably the reduction of woodland and the need that arose from that to conserve the surviving woodland at the upland margin. Methodologically, the research raises other questions. Following on from the research in Iceland, I developed a methodology based on the use of islands as natural laboratories which I tested extensively in the Faroe Islands (which
do not have a tephrochronology of visible layers) as part of my PhD thesis. It is left to be seen if this methodology could be further developed and applied to Scottish questions of historical human-environment relationships based on the testing of specific hypotheses.

Endnote
This paper relates to a talk given to the Society in November 2007 based on research initially carried out for a Masters Degree by Research in Geography at the University of Edinburgh. Thanks to Andrew Dugmore and Mike Church for their additional research.

Bibliography


