

Vegetation history in Mývatnssveit, Iceland

Report on fieldwork, 29 June – 27 July 2009

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This fieldwork was co-funded by National Science Foundation grant ‘Human Ecodynamics in Norse North Atlantic’, the Earth and Biosphere Institute (EBI), University of Leeds and Durham University. It forms part of our efforts to understand the landscape history in general, and past vegetation dynamics and modification by humans in particular, in Mývatnssveit, northern Iceland.

This field expedition had three specific aims:

- 1) To procure sediment sequences from a number of lakes in the Mývatnssveit region. This aim relates to an ongoing project to reconstruct vegetation history using pollen analysis, some results of which are already published [15, 17, 20].
- 2) To excavate a number of charcoal production pits and take samples for radiocarbon dating, to establish the timing of woodland exploitation across the region.
- 3) To undertake experiments to produce charcoal using traditional Icelandic methods, to improve our ability to interpret the archaeological data from charcoal production pits.

The fieldwork corresponding to each aim will be discussed in turn below.

1. Lake sediment coring

Lake sediment records have demonstrated their potential to provide useful landscape-scale summaries of vegetation history in this region. However, the limited research so far shows that different lakes yield differing records, so there is a need to replicate the results we already have in order to increase our certainty in our conclusions. In addition, we anticipate that woodland history is not identical everywhere across the region. For example, some areas on rough lava around Lake Mývatn are wooded at the present day, possibly because the rough terrain means that sheep are not able to graze away all the tree seedlings, allowing regeneration; it is not known whether these areas have always been wooded, or if there has been regeneration on a previously cleared landscape. We also know from studies of charcoal pits that some parts of the landscape which today are covered by heath were not cleared until at least the 12th century AD, some 300 years after the Norse Landnám. One branch of our current research is thus focused on developing new pollen records from the region, using a combination of lake sediments and peat sequences, with the intention of using semi-automated techniques to reduce the labour requirement of doing so.

In total, seven lakes were sampled in this field season, using a Russian-type corer and Kajak surface sediment corer from boats:

Skútustaðir pond: adjacent to the farm site at Skútustaðir, where excavation is currently taking place of an exceptional midden sequence spanning the period from Norse times almost to the present day. We would expect this site to hold a strong record of human activity.



“Birch lake”: one of a number of small ponds to the immediate NW of Mývatn, surrounded by birch woodland on rough lava terrain.

Smiðjutjörn (“Smithy lake”): a small lake west of Mývatn, bordered on the north side by a hill on which we later excavated a number of charcoal pits.



Sandvatn: a relatively large lake in a rangeland setting well to the south of Mývatn. This remote setting may have escaped early disturbance, although its high altitude (c. 300 m) and proximity to the edge of the modern inland desert may make it relatively sensitive to disturbance.

Kalmannstjörn: another large lake in a rangeland setting, just north of Mávvatn and close to another cluster of charcoal pits, representing upland settings in Reykjadalur.



Leirtjörn: a small lake immediately west of Vestmannsvatn, approximately halfway between Mývatn and the coast. An alluvial fan enters the lake and the sediments were relatively clay-rich, suggesting that they may record changes in the stability of slopes in the lake's catchment. A cluster of charcoal production pits occurs on the ridge to the west of this lake.

Yxnavatn: a small lake close to the coast and markedly different from the other sequences in containing very sandy sediments. There are charcoal production pits in the woods to the south of this lake, and another known cluster between here and Húsavík.



All sequences were taken at least to the Hekla-3 tephra (c. 800 BC), or to the base of the deposits. The cores were shipped to the UK where they are currently in storage at the University of Leeds.

At the time of writing, the first of these sequences, Sandvatn, is being studied for pollen and sedimentological characteristics by Rachel North, an MRes student at the University of Leeds, with the intention of publishing the results. Samples from this sequence are also being analysed for diatoms (by Graham Wilson, University of Portsmouth) and for testate amoebae (by Graeme Swindles, University of Leeds) with a view to reconstructing the history of the lake's trophic status. Analysis of a second core is expected to begin in the summer of 2010. Several candidates have applied for PhD funding to work on the material but, to date, none has been successful.

2. Excavation of charcoal production pits

This project will use a detailed case-study in northern Iceland to provide time-depth for our understanding of human impact and societal responses to environmental change in a semi-Arctic environment in the key climatic region of the North Atlantic. The research findings fit with three of

the main research themes for Natural Environment Research Council (UK); climate system, sustainable use of natural resources and Earth system science [1].

Research context

Timber procurement and the use of woodlands are key issues in the Norse and Medieval periods in the North Atlantic islands [2,3], necessitating a successful balance to be struck between a) the demand for wood for fuel, roofing and furnishings, boat-building and charcoal production for metalworking and b) the supply of timber in marginal environments. The demand for wood and timber meant pristine forest in Iceland was subject to substantial clearance, triggering severe soil erosion across the island [4,5]. This project will analyse the evidence for the timing and mechanisms of this deforestation in an area of northern Iceland, through the mapping and analysis of archaeological charcoal production pits.

Iceland is a unique 'island laboratory' to investigate past human-environment interaction, due to the Late Holocene pristine environment that the Norse settlers first encountered and the exceptional quality of the island-wide tephrochronology that provides very precise chronological controls for palaeoenvironmental and archaeological research. The first human colonization of Iceland, known as *landnám* (Old Norse, meaning "land-take"), occurred around AD 870 [6]. Researchers have estimated, through vegetation modelling and palynology, that up to 40% of the land surface of Iceland was covered by birch (*Betula pubescens* Ehrh.) woodland at *landnám*, much of it concentrated in the coastal lowlands [7, 8, 9, 10]. Present coverage of birch woodland in Iceland is less than 1%, and much of this is a result of active plantation during the 20th century [9], therefore current estimates suggest >95% of woodland cover in Iceland was removed in the period between *landnám* and the 20th century. One of the key research questions when assessing the impact of human settlement on the Icelandic environment is the timing of this deforestation. It has been argued from palynological evidence that this occurred very rapidly during the first centuries after *landnám*, primarily to create extensive grasslands for grazing and hay production [7, 11, 12, 13]. However, recent research by the team, in both southern [14] and northern Iceland [15], has challenged the timing of this *landnám* deforestation model, instead proposing that deforestation was a slower and more spatially-variable process across Iceland. We seek to test the timing of this *landnám* deforestation model using archaeological charcoal production pits. Charcoal production for extracting iron from iron ore and for metal-working was one of the main uses of wood in Iceland during the past 1100 years and charcoal production pits have been found in various parts of the country [14, 16]. It is likely that these pits were produced within or immediately adjacent to surviving birch woodland as it was easier to transport the small mass of charcoal produced than the large mass of wood required to make it. Therefore, detailed sampling and dating of the charcoal from these pits will provide a proxy record for woodland presence, utilisation and clearance.

A 15-year programme of inter-disciplinary research into human / environment interaction during the Norse period, has been undertaken in northern Iceland [17], focussing on the region of Mývatnssveit that contains the ecologically unique lake of Mývatn (Fig 1). Analysing the timing and nature of Norse deforestation has been an important research theme in this programme, as woodland use and deforestation were major drivers of landscape instability in this semi-Arctic highland environment. Recent archaeobotanical and palynological research in the region [14, 15] has suggested that the

picture of deforestation is more nuanced than a simple removal of trees in the late 9th and 10th centuries AD. For example, pollen analysis from Helluvaðstjörn, a small lake adjacent to Mývatn (Fig 1), has indicated a steady decline in the percentage abundance of tree birch pollen between *landnám* and c.1300 AD [16]. This pattern contrasts with the abrupt fall in birch pollen percentages immediately following the Norse colonization at almost all previously studied palynological sites in Iceland. Also, tree birch charcoal is ubiquitous in archaeological excavations of Norse and Medieval domestic sites in the region, suggesting significant woodland presence in Mývatnssveit until at least the 14th century [20]. Therefore, a picture of surviving, and possibly managed, Medieval woodland is emerging, rather than almost complete deforestation in the Viking period.

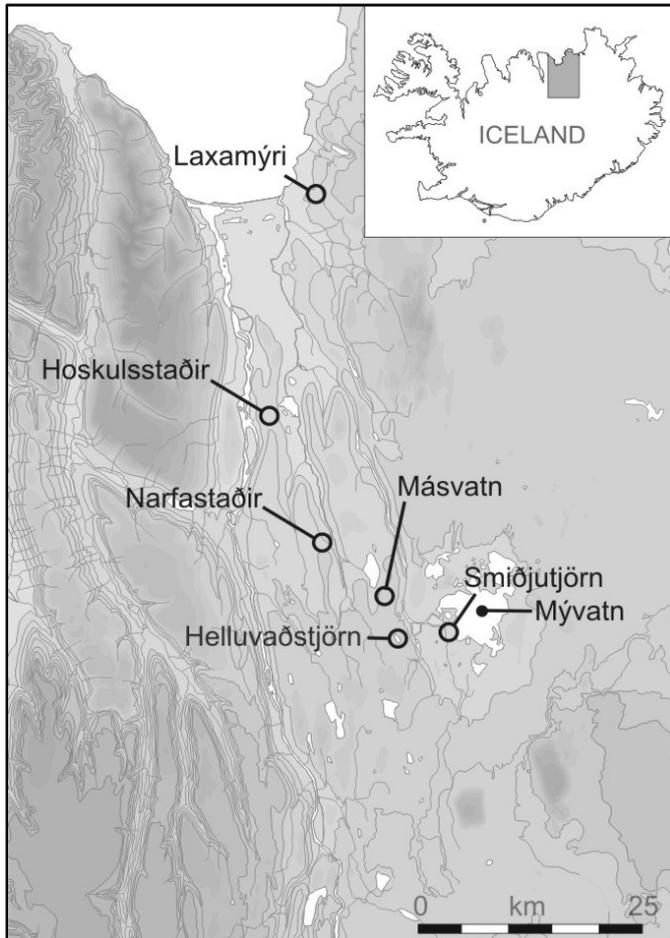


Figure 1: Location map of group of charcoal pits sampled in 2008 and 2009.

Research by the team in southern Iceland has demonstrated that detailed insights into woodland ecodynamics can be gained from synthesising the chronological and archaeobotanical evidence from archaeological charcoal production pits [14]. Hundreds of these pits have been located through aerial photography and field-walking in Mývatnssveit. 30 pits have been sampled from six groups of pits, on a transect running from the coast in the north down to lake Mývatn, located approximately 50 km to the south in the highland interior of northern Iceland (Fig 1). A key aspect of this research is establishing the timing of the use of these pits through the integration of tephrochronology and radiocarbon dating within a Bayesian framework, following the innovative methodology of Church et

al. [14]. One group of these pits at Hoskulsstaðir in the middle of transect, has already been radiocarbon dated to the 11th-13th centuries AD, as part of a pilot study funded by the Carnegie Trust for Universities in Scotland and the Leverhulme Trust. An application to NERC has requested 21 radiocarbon dates to greatly enhance and complete the dating programme. Detailed archaeobotanical research on the charcoal and associated carbonised plant macrofossils will be used to analyse the form and nature of Norse and Medieval forest and woodland use.

Detailed research questions and interpretive models

1. When was each pit used? If the traditional model of *landnám* Icelandic deforestation is correct then all the pits should date to the 9th-10th centuries AD. This chronological resolution is possible to achieve through the combination of the radiocarbon dates and the tephrochronology. The model has already been challenged through the 11th-13th century dates for the nine pits at Hoskulsstaðir and a picture of a less rapid deforestation and attempts at woodland sustainability would be supported by a wider spread of dates.
2. Do groups of pits have similar ages, as demonstrated by the previous radiocarbon dating results from Hoskulsstaðir? If so, this would suggest that specific areas of woodland in the landscape were being used and cleared at certain times. If not, this would suggest attempts at woodland sustainability were being undertaken, as argued by Church et al. in southern Iceland [14].
3. Is there evidence for a phased removal of woodland, from the coast in the north to the interior highland in the south? This testable hypothesis is based on the assumption that the earliest deforestation would start in the coastal regions where the very first settlers would have established their farms, and later deforestation would correlate with a gradual increase in settlement density towards the interior highlands of Iceland.
4. What wood was used and is there any evidence for woodland management? This will be assessed through detailed archaeobotanical analysis.

Sampling

Six groups of pits have been chosen that were located at approximately equal intervals along the north-south transect (Fig 1). The pits were easily identified in the field as they had a consistent and distinctive form of a depression up to 2m across and up to 1m deep, surrounded by a doughnut-shaped upcast of spoil (Fig 2). Up to five pits were chosen randomly from each group and sampled following established archaeological excavation techniques. The excavated remains from the 21 pits were very similar (see Fig 3 for a representative section), with every pit containing:

- two distinctive tephras bracketing the use of the pit. Each pit cut through Veiðivötn 940 and was overlain by Veiðivötn 1477 [15, 17], providing chronological information to be combined with the radiocarbon dates.
- a basal charcoal-rich fill, overlain by a mixed fill of redeposited turf and soil. It is assumed that the charcoal was left in the pit after the majority of the charcoal had been removed in antiquity.

A bulk sample was taken from the basal fill of each pit and wet-sieved, following Kenward et al. [18]. A single-entity birch roundwood fragment has been sampled and identified for AMS radiocarbon dating from each pit (Table 1). The outer ring and bark from charcoal fragments with leaf buds still attached have been chosen for AMS dating, as this contains radiocarbon incorporated in the final five years of growth before the cutting of the birch roundwood from the tree [19].



Figure 2: Charcoal production pit at Másvatn, prior to excavation (MAS CP1).

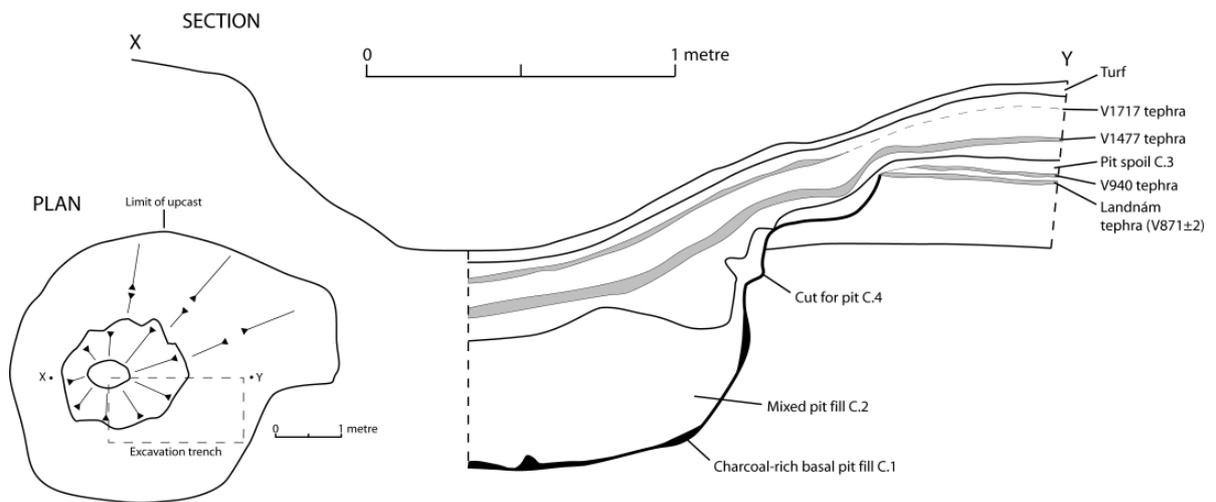


Figure 3: Quarter-section drawing of representative charcoal production pit at Másvatn (MAS CP1).

3. Experimental reconstruction of charcoal production

A pilot-study of experimental charcoal production was undertaken with the assistance of Inggi and Unsteinn of Narfastaðir. The experimentation was undertaken to improve our interpretive understanding of the archaeological remains recovered from the charcoal production pits excavated in Iceland [14, 17]. The following detailed research aims were outlined at the outset of the research:

1. To replicate and record the wood recovered from selected removal of branchwood from modern birch woodland, a technique of woodland management suggested from the archaeological remains.
2. To dig and fire an experimental charcoal production pit, using methods deduced from the archaeological record and 19th and 20th century documentary accounts of charcoal production in Iceland.
3. To excavate the experimental pits using standard archaeological techniques and to observe and record the remains to provide interpretive insights for archaeological charcoal production pits.

Methods

Inggi and Unsteinn kindly agreed to the removal of branchwood from selected birch trees in woodland that had been maturing for the past 30 years on the land of Narfastaðir farm in Mývatnssveit. Primary trunks and secondary branchwood were taken from multiple-trunked birch using hand axes. These pieces were then cut to create a series of primary, secondary and tertiary timber pieces. Each length of timber was measured and discs for ring counts removed from the base of each timber length to estimate the maximum age. All of the pieces were then cut to lengths of 50 or 80 cm length pieces and the small roundwood material trimmed. The maximum diameter of every timber piece was then measured. In this way, basic size and age estimates for every timber piece was quantified (Figure 4).

A small pit measuring approximately 1.0x0.8x0.4 m was dug using a spade. This was a smaller pit than the usual size excavated but only a small amount of wood was used during the experimentation to limit the amount of wood cut to the absolute minimum. The fire was started using lichen, small kindling from the trimmed birch roundwood and birch bark. The wood pieces were then placed systematically in size order into the pit in a pyramid fashion around the fire in the core of the pit. The wood was left to catch light throughout the pyramid (Figure 5). Once it was clear that the majority of the wood was on fire, turves were placed face-down from the edge of the pit to the top of the pyramid (Figure 6). The earth dug from the pit was then placed over these turves to create a sealed reducing atmospheric environment in the pit. The pit was then left for 48 hours to allow the wood to be pyrolised. Finally, the pit was half-sectioned and excavated / sampled following normal excavation procedures. The diameters of any remaining uncarbonised wood pieces were measured. Two experiments were undertaken in all.



Figure 4: Birch wood cut and ready for firing.



Figure 5: Initial open firing of the birch wood.



Figure 6: Covering over the experimental pit with turf and earth.

Preliminary findings

Laboratory analysis of the samples and measurement data is still ongoing but a number of initial field observations were made from the experimentation including:

- 1) Charcoal was produced in the centre of the first firing but a significant proportion had not been pyrolised following the covering over of the pit. It was therefore postulated that the wood had not been allowed to burn for a sufficient period of time prior to the placing of the turf and earth covering. Therefore, the wood was allowed to burn for a longer period of time before covering. This produced significantly more charcoal (Figure 7) but still did not completely pyrolise all of the wood pieces. Future experimentation would need to allow the wood to completely catch light and continue to burn for some time before covering over.
- 2) The smaller diameter pieces seemed to preferentially pyrolise compared to the larger pieces and so it seems that an optimum diameter of wood would have produced the best results. Further analysis is needed from the experimental results to verify the exact range of this optimum size before comparison to the archaeological record.
- 3) When removing the charcoal from the experimental pits, it was clear that most of the charcoal could be removed very easily and the only charcoal that was difficult to remove entirely was very small fragments or fragments that broke off from larger charcoal pieces. These fragments created a very thin layer across the bottom of the pit and were comparable to the fragmented material recovered from the base of the archaeological charcoal pits (see

Context 1 in Figure 3). This confirmed the interpretation used in previous research that basal charcoal pit fills were the remnants of unwanted charcoal fragments left in the pit after use rather than the desired charcoal product [14].

- 4) Certain large pieces of wood became carbonised on the outside but remained uncarbonised in the centre. These were easily identifiable and explain the occasional presence of large pieces of charcoal recovered from the backfill of archaeological pits, for example in mixed fill layers such as Context 2 in Figure 3. These large fragments usually consist of carbonised outer rings and then a void within the cavity, suggesting the uncarbonised wooden core had rotted away. These pieces were presumably discarded by the charcoal pit diggers and indicate the maximum diameter of wood used in the process at that time.



Figure 7: Charcoal produced in second experimental firing.

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