

Less than 1% of the forests found by Iceland's 9th century Norse colonists remain today. Recently, a number of academic and popular works have used Norse land-use strategies and Icelandic deforestation as exemplars of unsustainable practices leading to social and environmental collapse. Yet, other research characterizes early Norse land-use strategies as resilient and sustainable.

Many questions remain unanswered about the timing, causes and processes leading to Icelandic deforestation. These include not only the strategies used by Icelandic households to acquire reliable sources of energy from their own woodlands, peat beds and farmyard wastes, but also the role of regional trade in the Icelandic fuel economy.



Iceland, showing the locations of Skógarnes – a pre-industrial peat quarry; Háls – a Viking period iron production site and small early medieval farm; and Reykholt and Gilsbakki, two medieval chieftains' compounds and later regional centers.

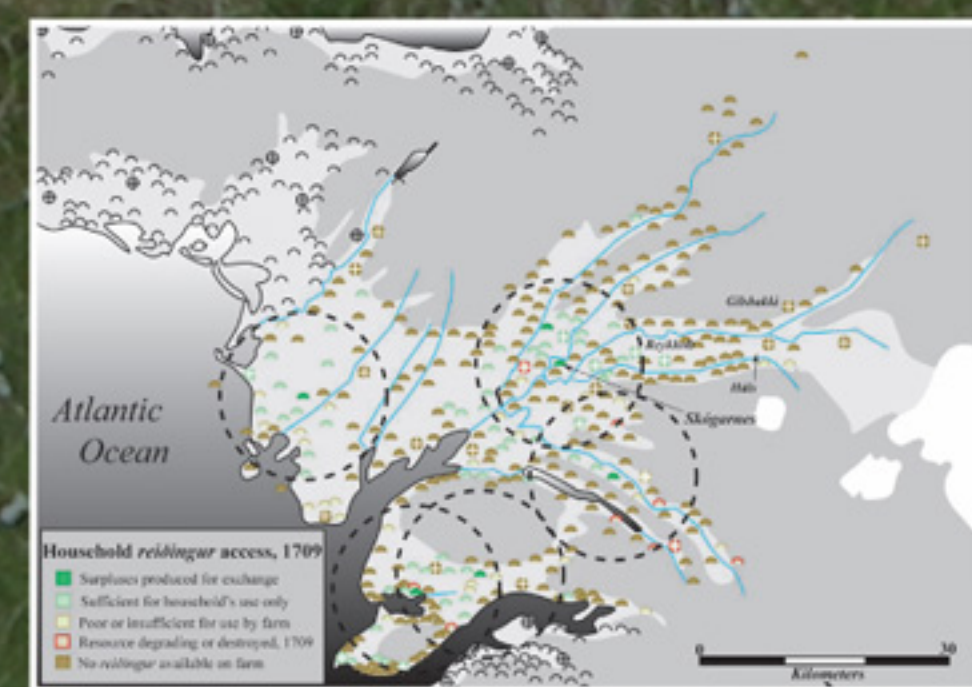
### For Peat's Sake

In 2008, test excavations, EM surveying and mapping at the site of Skógarnes, in western Iceland's Borgarfjörður district, documented specialized peat-cutting pits from which at least 11,000 m<sup>3</sup> of peat was quarried. Tephrochronological analyses and documentary sources suggest that the site, covering at least 12,000 m<sup>2</sup>, was active from ca. 1650-1850, the depths of the Little Ice Age.



The Skógarnes reidungur quarry as seen from the ground (far left), in satellite imagery (above, left: GoogleEarth; scale bar = 50 meters) and through electromagnetic surveying (above, right). EM suggests areas of both deep disturbance (blue, lower central portion) and shallower reworking (disrupted area of greens and yellows, upper right), over ridges in the underlying till structure with high amplitude (red) and low amplitude (blue) induced in-phase responses.

The primary resource sought at Skógarnes was reidungur, a light-weight peat comprised of felted twigs, leaves and detritus from mid-Holocene birch woodlands. Reidungur was a rare, highly valued resource used for making the packsaddle cushions employed in transporting heavy loads of lumber and charcoal over long distances. Early 18th century documents indicate that extracting reidungur and producing saddle cushions provided the site's owners with funds to acquire firewood and charcoal lacking on their farm and supplied an entire region with the cushions on which firewood traveled. The extent and timing of quarrying at Skógarnes therefore reflects not only one household's strategy for coping with local deforestation but also the intensification of a regional network through which wood and charcoal were moved from viable woodlands to areas with fuel deficits.



Reidungur occurs only in deep bogs with accumulated debris from pre-Norse birch woodlands. In 1709, only six farms in the Borgarfjörður district had sufficient reidungur deposits for commercial exploitation. Of these Skógarnes was the most productive. Five of these farms are shown within circles representing single-day horseback roundtrips to and from the quarries. Note: circles represent wealthy estates; half-circles, small farms.



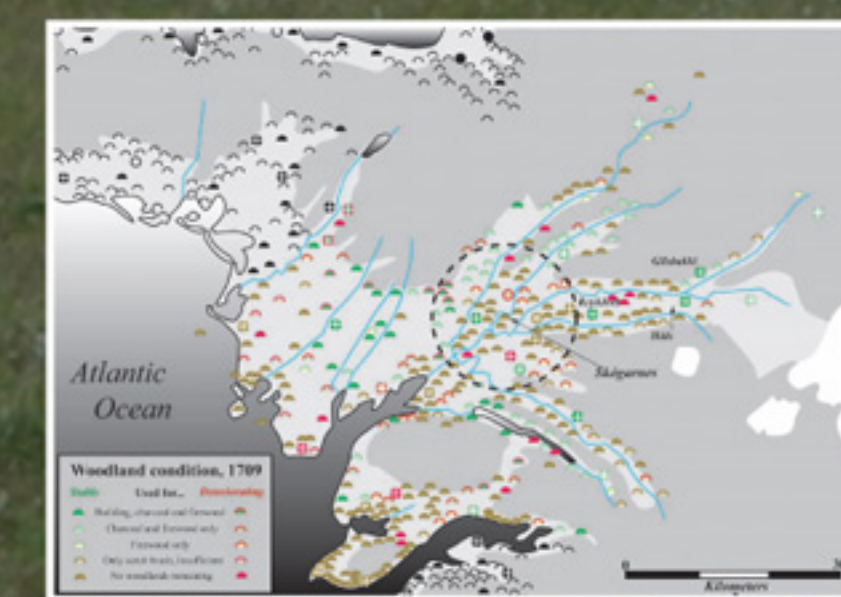
Wood and charcoal were transported from district to district on horseback, either lashed to wooden pack frames (left, 1-4) or loaded into wooden bins (right, 3). Reidungur, cut into sheets 5-10 cm thick and sewn into woolen or skin covers (left, 9-12) protected horses' backs when carrying such heavy loads.

Illustrations by Sögusetur Íslenska Hestisins ([http://www.skagafjordur.is/default.asp?cat\\_id=1785](http://www.skagafjordur.is/default.asp?cat_id=1785))

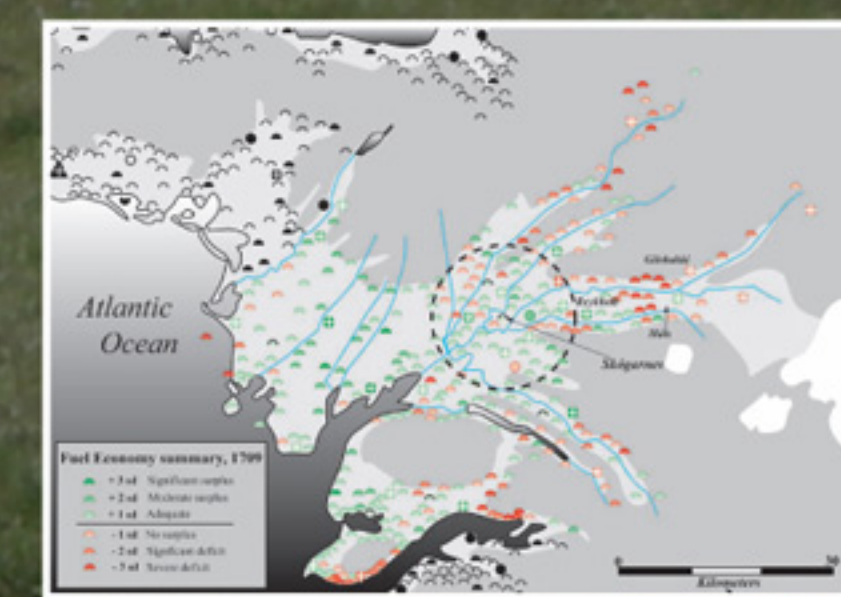
### Regional Impacts of the Early Modern Fuel Economy

Iceland's earliest land-register, Jarðabók, describes the condition and quality of peatlands, woodlands, and reidungur deposits during the early 1700s. In 1709, 60% of the 348 farms in the Borgarfjörður district had either no woodlands remaining or woodlands insufficient to supply their own needs. Of the woodlands remaining, 45% were reported to be depleting through over-use or had been destroyed during their owners' lifetimes.

The most active zones of deforestation occurred in lowlands where overlapping woodlands and peat deposits allowed farmers to clear forests for firewood and charcoal, while relying on their own peat deposits to heat and light their farms. The most fuel-depleted zones were upland valleys where deforestation was nearly complete and peat deposits were absent. Trade linked these zones, with horses carting firewood and charcoal from deforesting zones to those already cleared.



More than half of the farms (brown) in the Borgarfjörður district had no woodlands remaining in 1709. Of those with woodlands (green shades), nearly half were actively degrading or had been destroyed through overuse during the informants' lifetimes (red margins). By 1909, only a handful of farms – primarily large estates – had any woodlands left.



By 1709, higher-elevation farms and those near heavily populated coastal fishing stations were plagued by fuel deficits, while low-lying farms near the coast had fuel surpluses, primarily due to their access to undisturbed peat beds. Note Skógarnes' position midway between a network of fuel-starved valleys and lowland districts with surpluses.

### The Pace of Transformation

When did deforestation begin and when did it intensify in the Borgarfjörður district? Paleo-environmental investigations at Háls, 20 kms east of Skógarnes, suggest that limited clearances accompanied localized iron production during the Viking Age. Early medieval farmers subsequently practiced management strategies that encouraged the growth of woodlands on their farmsteads. However, a second wave of clearances, beginning in the late 12th century, is attested in both paleo-environmental records and medieval texts and was more enduring. Ever-decreasing amounts of birch pollen fell on the bogs at Háls from more distant woodlands until ca. 1650, when it disappeared completely.

The nearby estates of Gilsbakki and Reykholt owned extensive woodlands in 1709, yet increases after the 17th century in the thickness and ubiquity of ash deposits from burnt peat and dung at both sites suggests enhanced reliance

on secondary fuel sources. A six-fold increase in the frequency of intentionally burned bone at Gilsbakki from the mid-17th through mid-19th centuries further suggests increasing stress in this household's fuel budget. These diverse measures suggest that managed deforestation accompanied the first stages of colonization and settlement in western Iceland. While early medieval Norse land-use practices limited deforestation's pace, upland valleys were vulnerable to its cumulative effects.



Deeply-stratified deposits from the late 13th through the early 20th centuries at the elite estate and church center of Gilsbakki preserve long-term records of changing fuel use. Deposits before ca. 1750 (7-11) are dark with charcoal and contain little ash, while more recent deposits (1-6A) are marked by thick white, gray, orange and pink ash deposits from burning peat, dung, and bone.

By the 17th century, palynological, documentary and archaeological indicators suggest an intensification of Iceland's fuel economy marked by long-distance trade in fuel from lowlands to highlands, increasing deforestation, and an increased use of peat, dung, and bone in household fuel budgets. This shift occurred when Iceland's population had reached its lowest known levels, suggesting that cooler conditions during the Little Ice Age increased household needs for fuel at the same time that poor growing conditions stressed woodlands already reduced in size through centuries of management.

Acknowledgments: Research at Skógarnes and Gilsbakki was funded by the National Science Foundation's Archaeology Program while investigations at Háls were supported by the National Geographic Society's Committee for Exploration and Research. Material and logistical support for these projects was generously provided by Brown University, the Buffalo Museum of Science, Eimskip USA and Eimskip hf., the communities of Reykholtsdalur, Hvitársiða, and Hálsasveit, landowners at Kollslækur, Gilsbakki, and Skógarnes, and a small but dedicated crew willing to survive wet Icelandic summers.