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Early Mesolithic Hunter–Gatherers and Landscape Acquisition by the Arctic Circle

The Ipmatis valley 7000 BC–1 AD

ABSTRACT Archaeological and palaeoecological studies in the Arjeplog area of northern Sweden have verified the arrival of hunter–gatherers soon after deglaciation. After modelling and subsequently surveying the reconstructed shorelines of tilted watercourses, Early Mesolithic settlements dating to 8600–8000 BP (^{14}C years BP) were discovered. Makrosubfossil-, pollen- and charcoal analyses of peat stratigrafies and lake sediments corroborated that deglaciation was completed more than 1000 years earlier than has previously been postulated. Pollen records show that the early postglacial environment included complex plant communities lacking present day analogies, providing optimal subsistence conditions for the pioneer settlers. Studies of charcoal influx into lake sediments indicate that fires were more frequent than ever after, contributing to a productive natural environment. Regional studies in the Ipmatis valley in combination with in-depth analyses of selected archaeological sites, display that hunter–gatherers made the resources of the valley an integral part of their subsistence at an early stage. Landscape acquisition included not only the adjustment to existing conditions, but the actual manipulation of the environment. The interdisciplinary research approach has produced unique sets of archaeological and palaeoecological data. Results open new perspectives on human pioneer colonisation and landscape acquisition in relation to deglaciation and the development of postglacial ecosystems. The variety of methods applied sets a new standard for future research on early societies in sub-arctic regions.

KEYWORDS multidisciplinary research, archaeology, palaeoecology, Mesolithic, lake tilting, landscape acquisition, pioneer plant communities, nitrogen, fire

Introduction

Recent archaeological excavations in the Arjeplog area (Fig. 1) of interior northern Sweden have provided an entirely new perspective on the process of colonisation by human pioneers during the early postglacial period. Within the framework of the interdisciplinary research project "Man, fire and landscape," archaeological and palaeoecological research was conducted in 1999–2003 with the aim of identifying the earliest phase of human colonisation in interior northern Sweden in relation to landscape dynamics and ecological setting. The oldest settlement sites in northern Sweden, dating to 8600 BP (^{14}C years BP), were discovered after the non-uniform isostatic land uplift was taken into account and the shorelines of tilted lakes were reconstructed. Detailed archaeological surveys conducted in the Ipmatis valley, situated c. 20 km north of Arjeplog, have revealed cultural remains covering a period of almost 7000 years. This article aims to elucidate the development of hunter-gatherer societies in interior northern Sweden, and the reasons for their establishment specifically with regard to landscape acquisition and anthropogenic influences on the environment. Unless otherwise stated, all dates mentioned in the text refer to uncalibrated radiocarbon years BP. The term "indigenous" is used in accordance with the ILO convention's definition (see Lane 2006: 72).

Research strategy

The archaeological and palaeoecological investigations in the project "Man, fire and landscape" were focused on identifying early postglacial settlements in the interior of northern Sweden. The causes and course of pioneer colonisation and the ecological conditions of subsistence were central objectives of research as was the interaction between pioneer settlers and their environment. The effect of isostatic land uplift and lake tilting on shoreline displacement and settlement location was of specific interest.

The research procedure initially included the construction of an empirical lake-tilting model, based on calculated rates of non-uniform isostatic land uplift and the tilting direction (Bergman et al. 2003). Using shoreline displacement curves, the ancient shorelines of a number of selected lakes and watercourses at different points in time were reconstructed. Subsequent field surveys focused on the identification of prehistoric settlements located on ancient shores. More than 60 sites close to reconstructed shorelines were discovered. Excavations were carried out at 15 sites, with the primary aim of acquiring reliable radiocarbon dates. Extensive excavations were carried out at five of these sites, in order to record artefacts and other features at each site. Palaeoecological field work was performed parallel to

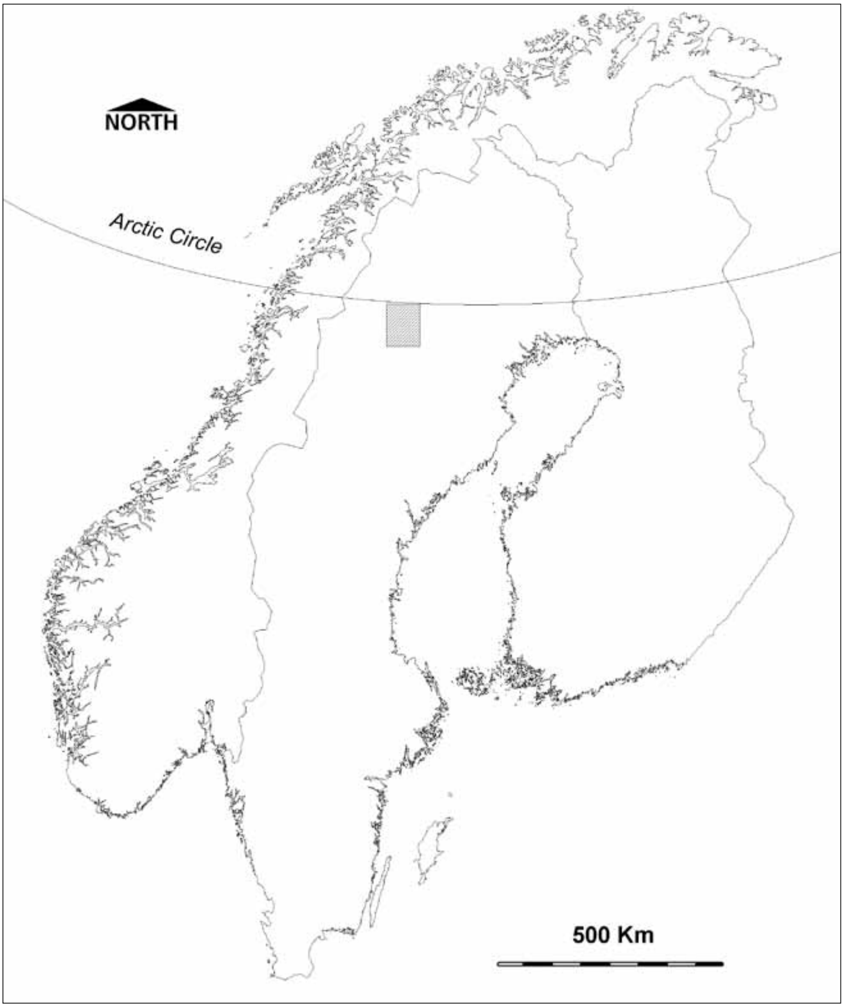


Fig. 1. Map of Northern Fennoscandia showing the location of the study area in Arjeplog.

the archaeological field investigations. This included the examination of peat and lake sediment samples already available from biological archives, in order to perform fine resolution pollen analyses (FRPA) and charred particle analyses (Hörnberg et al. 2005, Carcaillet et al. 2007). There were two overall aims of the palaeoecological analyses: to describe the environmental setting (i.e. the vegetation composition) from a landscape perspective and to identify the human influence on vegetation and fire use patterns in the area surrounding the sites. In order to locate close canopy sites with the deepest accumulations of peat, mires were surveyed using soil-penetrating radar (Bérubé 2001).

Glacio-isostatic land uplift, lake-tilting and landscape dynamics

The isostatic land uplift that followed the retreat of the Weichselian Ice continues to be an active process in Scandinavia, and is particularly pronounced in the coastal areas of the Baltic Sea (Ekman 1993, Berglund 2004). In northern Sweden, uplift rates decrease from east to west, resulting in a tilting effect. Since deglaciation, the landscape in this area has gradually tilted down towards the west (Ekman 1996, Påsse 1997, 2001, Hörnberg et al. 2004). In the Arjeplog area the direction of the gradient is c. 125° (ESE) and the gradient at 8500 years BP is estimated to have been 1.0 m/km which means that the tilting magnitude amounts to 10 m along a 10 km distance (for a detailed discussion on lake tilting see Bergman et al. 2003). The interior lakes and watercourses of northern Sweden are generally elongated along an east-west axis. This corresponds to the approximate tilting direction and thus the tilting effect strongly affects them. If a lake's outlet is situated at its eastern end, where the degree of uplift is the greatest, the opposite shores of the lake will be continuously encroached by water. In contrast, if the outlet is situated in the western part, the water line will recede. Consequently, the eastern parts of the beds of the water bodies will be lifted above the water line, while the western shorelines will be submerged. Lake-tilting is most evident in flat terrain, where minor changes in water level have had a significant effect due to the level topography. Shoreline displacement also depends on other topographic factors, such as the location of inlets, outlets, thresholds, soil and bedrock. All of these factors need to be considered when ancient shorelines are reconstructed. In areas with a shallow topography even minor changes on a vertical plane may have a significant impact on a horizontal plane. Early Mesolithic settlements may be situated several hundred meters, even kilometres away from present day shore lines.

In areas with glaciofluvial sediments, the shorelines of ancient lakes and watercourses are sometimes indicated by beach terraces at different levels, which are often connected to mires. Fault scarps bear witness to the immense seismic activity that occurred soon after deglaciation, when earthquakes are estimated to have reached magnitudes of 6.5–8 on the Richter scale (Lagerbäck 1990: 351–353, Olesen et al. 2002: 12). Faulting resulted in abrupt and radical landscape changes due to floods and landslides. Drainage of lakes, caused either by successive tilting or faults, resulted in the paludification of watercourses, turning them into mires. Large areas with fine sediments, which originally formed lake beds, were exposed to eolic processes that led to a build-up of dunes that may have covered original shorelines and archaeological sites. The effects of non-uniform isostatic land uplift on landscape formation also included shifts in mountain forest limits, and a continuous displacement of groundwater levels and outflows.

Deglaciation and vegetation

According to prevailing models of ice recession, parts of interior northern Sweden were still covered by ice in 8500 BP and deglaciation was not completed until c. 8000 BP (cf. Karlén 1979, Cato & Kjellin 1996, Lundqvist & Vilborg 1998, Stewart et al. 2000, Fjeldskaar et al. 2000, Påsse & Andersson 2005: 264). However, dating the ice recession in this region is difficult (Kleman 1992, Harbor et al. 2006). Recession rates are currently based on rather disparate data sets, none of which from the studied region, however (Cato 1987). Sampling from peat deposits and lake sediments, together with analyses of macrosubfossil material, pollen and charcoal, was conducted with the aim of reconstructing the vegetation present at the time of the pioneer settlers' arrival. The sampling was restricted to peatlands and lakes located above the highest estimated water level of major water bodies, which were largely unaffected by tilting. Unexpectedly early dates were obtained from the lowest levels sampled, just above the glacial clay (Tab. I). The palaeoecological data were confirmed by dates obtained from archaeological features, preferably pit hearths containing charcoal. These dated to 8630±85BP—8440±90BP (uncalibrated dates, Bergman et al. 2004a: 165), suggesting that the area became ice free more than 1000 years earlier than previously postulated (Fig. 2).

Pollen records show that the early postglacial environment included many complex plant communities which have no parallel in present-day ecosystems. Plant communities disappeared under stress during the Weichselian ice age, and their component species may have reformed into quite different assemblages during the ice recession. Arctic and alpine plants (e.g. *Dryas*, *Astragalus* and *Saxifraga alpinus*) appeared together with southern lowland species (e.g. *Hornungia*, *Sinapis* and *Armeria maritime*) shortly after the ice receded (Hörnberg et al. 2005). This mixture of plants formed unique communities that are very different from present-day ecosystems. It is likely that the plant communities were favoured both by the improved climate *per se* and other factors, such as dispersal opportunities, the generally high calcareous content of unleached mineral soils, and the lack of competition from established vegetation. The lack of modern equivalents to these pioneer communities makes interpretation of the palaeoecological record in relation to nutritional factors and climate extremely difficult (cf. Edwards et al. 2007). The timing of the Holocene thermal optimum (HTM) and the seasonality of climate in northern Europe is so far under much

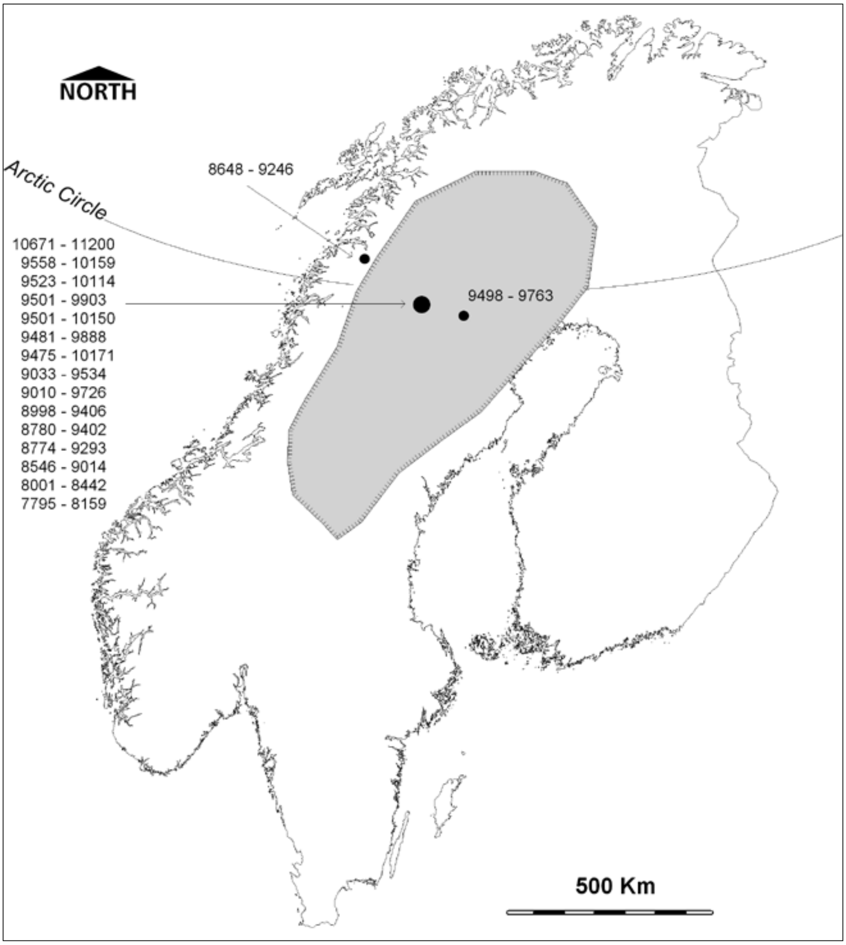


Fig. 2. Calibrated radiocarbon dates from biological archives and archaeological sites, in relation to the estimated size of the Weichselian ice sheet at c. 9300 BP (ice cover according to Alexandersson et al. 1995: 23 and Lundqvist 1998: 131).

dispute (Rosen et al. 2001, Larocque & Hall 2003, Andreev et al. 2005, Rohling & Pälike 2005, Kultti et al. 2006, Caseldine et al. 2007). Temperature could well have peaked (HTM) already before Mesolithic hunter–gatherers arrived to interior northern Sweden. The geological conditions were very unstable due to earthquakes, faulting and a rapid tilting of the early landscape which dramatically influenced local soil conditions and biological archives (Bergman et al. 2003, Hörnberg et al. 2005). Climatic factors affecting vegetation are easier to isolate at later periods when more stable conditions occurred and plant communities typical of the boreal forest (conifer-ericaceae-feathermoss communities) had established (Bradshaw & Zackrisson 1990, Hörnberg et al. 2004).

Tab. I. Radiocarbon-dated archaeological sites, lacustrine sediments, peat deposits and subfossil pine, Arjeplog, Sweden. Calibrations by Calib rev.5.01.

Site	Type of site	Lab. no	Reported age (^{14}C yr BP)	Calibrated age (2 sigma) BP
Döudden	Peat (360-361 cm)	Ua-20509	8695±105	9501-10150
Dumpok A*	Peat (167 cm)	Ua-19215	8795±105	9558-10159
Dumpok A*	Peat (174)		8660±80	9501-9903
Dumpok D*	Peat (260 cm)		8685±80	9523-10114
Dumpokjauratj Raä 1568**	Archaeological site (charcoal, Salicaceae)	Ua-19212	8630±85	9481-9888
Lattok***	Tarn	Ua-12632	9590±95	10671-11200
Lattok***	Tarn	Ua-18028	8420±150	9010-9726
Gublijaure	Drained watercourse	Ua-18685	8690±145	9475-10171
Raigejegge***	Tarn	Ua-12633	8195±80	8998-9406
Raigejegge***	Tarn	Ua-18017	8150±80	8780-9402
Lövnäs***	Tarn	Ua-18021	8355±115	9033-9534
Kåbdalis 4	Tarn	Ua-22562	8635±60	9498-9763
Bierre	Subfossil pine	Ua-22562	8065±80	8648-9246
Blomnäs, R1299	Archaeological site (charcoal)	Ua-15464	7930±95	8546-9014
Ipmatis, 1997:1	Archaeological site (charcoal, Pinus sylvestris)	Ua-15380	8120±75	8774-9293

* Published in Hörnberg et al. 2005.
** Published in Bergman et al. 2003.
*** Published in Carcaillet et al. 2007.

Some very rare plant genera have been discovered in material from the earliest plant colonisation period in the study area. Two of the more surprising genera to occur in the pollen assembly are *Malus* and *Allium*. *Hordeum* type pollen is also found in sediments from the pioneer period (Hörnberg et al. 2005, Hörnberg unpublished data). It is tempting to speculate about these genera and their possible use and spread by the pioneer settlers and verifications by macroscopic remains (especially at archaeological sites) would greatly help to interpret pollen finds.

Many of the alpine species that were important pioneer invaders (e.g. *Dryas octopetala* and *Astragalus alpinus*) have symbiotic relationships with nitrogen-fixing cyanobacteria, which allow them to produce the nitrogen they require for growth. Following deglaciation, nitrogen was not provided by the bedrock or mineral soils. Therefore, it had to be fixed from the air through biological and atmospheric processes in order for most plant species to establish. Sea buckthorn (*Hippophae rhamnoides*), now a lowland seashore species, extensively colonised newly deglaciated areas with exposed mineral soils. It grew as trees (Fig. 3) and, being a nitrogen fixer, contributed substantially to the build-up of nutrient pools and the establishment of ecosystems. Hops (*Humulus lupulus*), now totally absent from this region, may have covered these early tree stands (see Hörnberg et al. 2005 and Fig. 3). However, *Hippophae* and *Humulus* only successfully competed with other species under the conditions present when they initially established. Within a few hundred years after deglaciation, they were succeeded by more competitive tree species and ground vegetation. That succession may have little more to do with climatic changes and nutritional conditions may play a more important role. The positive nutritional effect of the pioneer nitrogen builders is clearly seen in the pollen record. An obvious increase in nutrient demanding ferns (*Polypodiaceae*) is thus observed at the end of the period with *Hippophae* vegetation. The nutrient capital built up by *Hippophae* and other nitrogen fixing plant communities was probably crucial not only for ferns but for many important processes in terrestrial and aquatic ecosystems during the early postglacial period.

Fig. 3. Sea buckthorn *(Hippophae rhamnoides)* at Leinøra, Norway. It is tempting to assume that the tasty and C-vitamin rich berries of sea buckthorn were used by the Early Mesolithic settlers.

The role of sea buckthorn as the main nitrogen supplier through fixation was later taken over by ground-covering feather mosses in association with cyanobacteria when typical coniferous forests developed (DeLuca et al. 2002). Ericaceous dwarf shrubs (*Vaccinium, Calluna* and *Empetrum*) gradually became more dominant in the field layer vegetation as leaching of top soils progressed and the calcium content decreased (lower pH). Thereafter, the productivity parameters were governed mainly by the decomposition of accumulated organic matter from coniferous trees and Ericaceae dwarf shrubs. The high polyfenol contents of humus effectively limited nutrient availability for most herbaceous plants by complex binding nitrogen (Zackrisson et al. 1997, Nilsson & Wardle 2005). The boreal forest had then acquired the controls that regulate present-day ecosystems, and has only been marginally modified since then by external factors such as climatic changes and progressive nutrient leaching (Iversen 1973, Bradshaw & Zackrisson 1990, Tallis 1991).

Forest fire was the only factor that could shift the boreal coniferous forest temporarily back to an ecosystem characterized by plant communities with higher productivity, more useful for humans and wild game. However, fire events were relatively short-lived and had little influence unless they were repeated (Zackrisson 1977, Zackrisson et al. 1996, Wardle et al. 2003). If repeated excessively, however, the burning of forests in subarctic environments can lead to severe ecosystem degradation due to nitrogen losses and by the elimination of nitrogen fixers (Zackrisson et al. 2004, Hörnberg et al. 1999, Deluca & Zackrisson 2007). Despite such long term changes, we conclude that fundamental, dramatic changes in plant communities and ecosystem functions mainly occurred within the first thousand years following deglaciation. From an archaeological perspective, elucidating the composition and development of these early post-glacial plant communities and their associated fauna is crucial for understanding the processes promoting pioneer colonisation, and its rapidity. Specific qualities of the plants in the primary succession communities, and their utility for early post-glacial settlers, remain largely unknown, and warrant much greater consideration in future research.

Early postglacial settlements

Settlement sites dating to 8600–8000 BP were discovered during the archaeological investigations, confirming the early arrival of humans in the area (Bergman et al. 2004a). There were various types of settlements with various functions, ranging from small field camps with a single pit hearth and no artefacts, to base camps containing several features and many artefacts. Sites are strategically positioned in the landscape, on promontories or islets, near channels and by streams. It appears that settlements were located in close proximity to shallow water bodies that provide rich fishing grounds. Osteological material from the oldest and richest site (Dumpokjauratj) includes burned fragments of reindeer (*Rangifer tarandus*), beaver (*Castor fiber*), pike (*Esox lucius*) and birds (unspecified), confirming that diverse subsistence sources were available, very similar to those present in subsequent periods (Bergman 1995). Reindeer was in clear predominance (89 % of the identified bones). The bones from the Dumpokjauratj site represent the

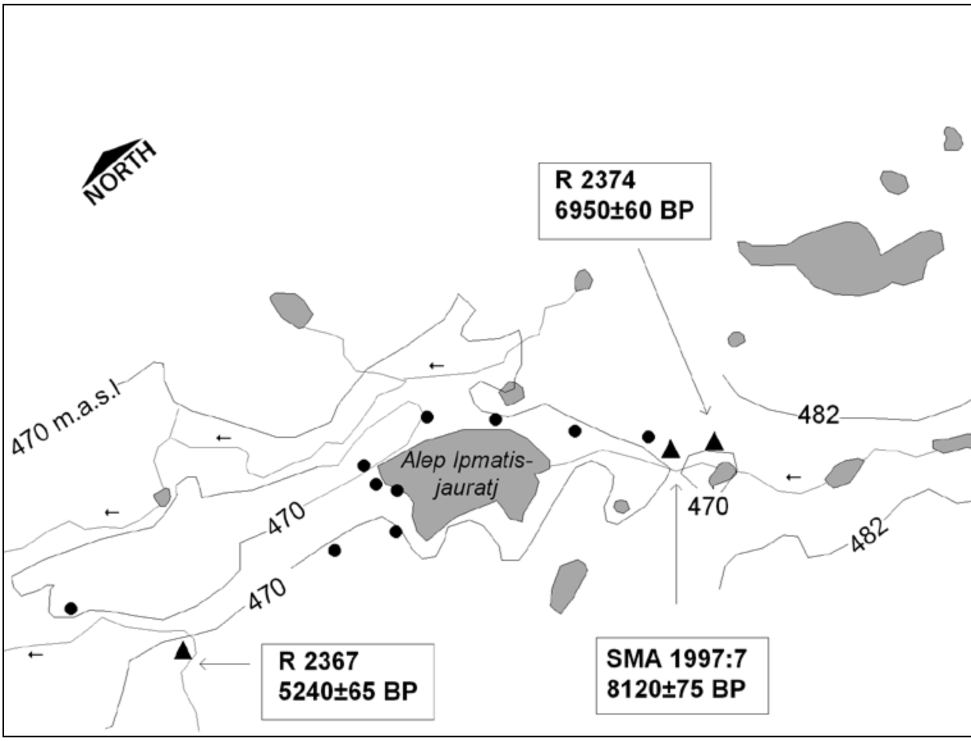
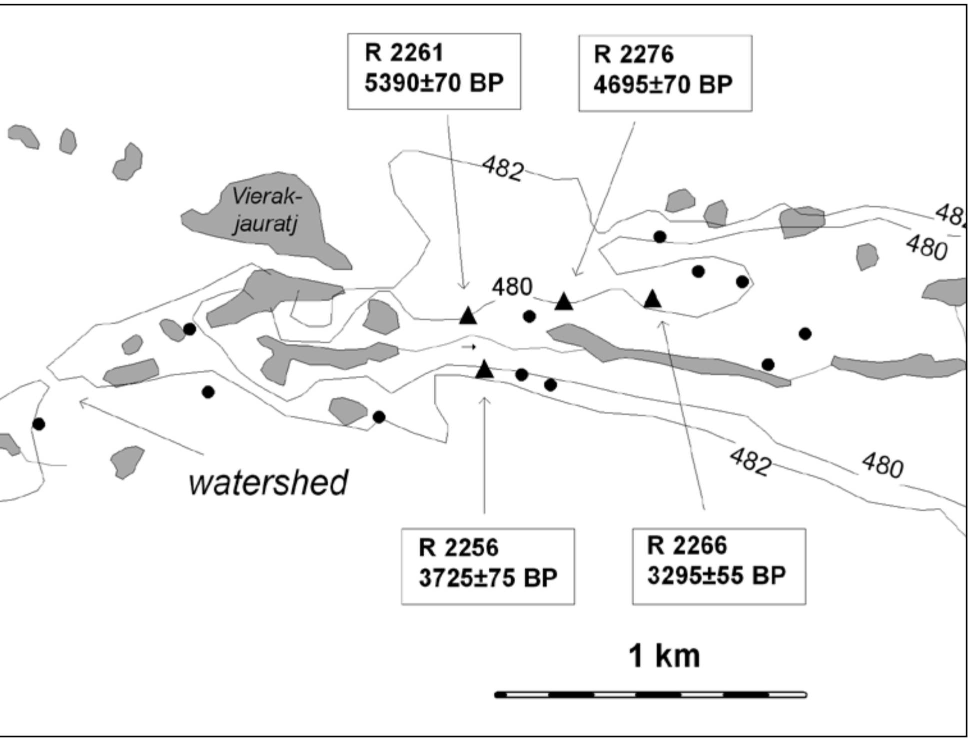


Fig. 4. Map of the Ipmatis valley and location of settlement sites in the Ipmatis valley, Arjeplog, Sweden.

oldest instance of reindeer bones in a north Fennoscandian archaeological context so far dated. Burned bones from elk were found on a lower terrace belonging to a later phase of occupation (Bergman et al. 2004a). In addition, evidence of complex yet selective exploitation of local stone indicates that the settlers had good knowledge of the occurrence and quality of rock material. The Ipmatis valley and the surroundings of the Dumpokjauratj site present rich and varied geological settings including quartz, quartzite and volcanic rocks suitable for the production of stone tools.

Overall, the archaeological data verify the early establishment of a hunter–gatherer society in the Arjeplog area. The speed with which pioneer colonisation occurred reflects the diverse subsistence options available in the environment of interior northern Sweden. However, it is difficult to discern whether the interior served as a separate resource area, or whether it was an integral part of a wider subsistence region comprising both coastal and interior areas. The oldest sites dated may represent a second phase of colonisation characterised by regionalisation (Fitzhugh 2004: 17), following an earlier phase that included scouting trips and seasonal migrations targeting specific resources (Bratlund 1996).



The Ipmatis valley

The Ipmatis valley, situated c. 20 km northeast of the municipality of Arjeplog, is characterised by moraines with zones of fine-grained sediment soils. The c. 8 km long valley basin is intersected by two major streams: one running from lake Lulep Ipmatisjauratj in a westerly direction through lake Alep Ipmatisjauratj and further west, while the other runs from lake Vierakjauratj eastwards into lake Västra Rebraur (Fig. 4). The present day streams, mires and tarns are the relics of a former river that ran through the valley from west to east. Due to non-uniform isostatic land uplift the river basin tilted westwards, eventually forming a threshold and dividing the water flow into two opposite directions. The topography, length and orientation of the river basin make it highly exposed to the tilting effect. Changes in the water levels and water flows illustrate the complex processes, including paludification, that have occurred in both the eastern and western parts of the valley. Although the lake tilting process has not been modelled in detail, its development can be outlined as follows: east of the watershed, water levels were alternately raised and lowered depending on the tilting, which led to blockage followed by sudden drainage of water through dams of fine sediment. This constantly changing landscape has created a resource area that hunter–gatherers used intensely during the entire prehistoric period and thereafter. Archaeological surveys have discovered 22 settlement sites close to ancient shore lines, eight of which have been excavated (Fig. 4), covering a time span from 8120±75 BP to 2095±70 BP (Tab. II and Fig. 5). The oldest dated settlements, east of the watershed, are located at the lowest elevations. These locations were revisited on later occasions when water levels had altered. On the west side of the watershed, lake tilting proceeded with successive lowering of water levels, seemingly without any dramatic alterations.

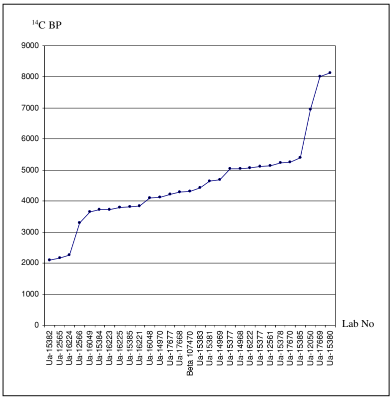


Fig. 5. Distribution of radiocarbon dates from excavated sites in the Ipmatis valley.

The distribution of dates obtained from radiocarbon-dated objects found in excavated sites indicates that the Ipmatis valley became a resource area that was more or less continuously used by hunter-gatherers from 8000 BP to 2000 BP (Fig. 5), corresponding to calibrated dates of c. 7000 BC—1 AD. The oldest site (No 1997:7, Fig. 4), dating to 8120±75BP and consisting of a single pit hearth with charred wood and fire-cracked stones, was located at the edge of a sandy terrace near a stream. No bone material or artefacts were found in or around the pit hearth. The campsite marks the beginning of human presence in the area and is typical of subsequent settlements in location, size and contents. Sites were small, generally comprising only a few pit hearths and very limited, if any, quantities of artefact material and burned bones. They represent short visits, probably connected with the exploitation of specific resources. This pattern is consistent over time. One of the sites (R2367, Fig. 4) provided information about the reasons for and characteristics of visits in the area. The site included at least eight features: a concentration of fire-cracked stones (F1, Tab. II), a roasting pit (F3, Tab. II), and six pit hearths with charcoal and fire-cracked stones (F4—F7, F9, Tab. II). Radiocarbon dates indicate that it was visited on a number of occasions. Furthermore, some features were stratigraphically separated due to eolic processes that resulted in repeated deposition of sand. Material found included a retouched flake, a retouched knife, flakes, microblades, and fragments of burned bones. Osteological analysis verified the presence of beaver bones, possibly from a single individual, in the area where fire-cracked stones were concentrated (F1, Tab. II). However, due to the high degree of

Tab. II. Radiocarbon dates from settlement sites in the Ipmatis valley, Arjeplog, Sweden.

Site number	Feature number	Lab number	Reported age (^{14}C yr BP)	Wood species
Raä 2367	F7	Ua-15378	5240±65	Pinus sylvestris
	F5	Ua-15377	5105±65	Pinus sylvestris
	F6	Ua-16222	5055±70	Pinus sylvestris
	F4	Ua-14968	5035±80	Pinus sylvestris
	F9	Ua-15377	5035±65	Pinus sylvestris
	F3	Ua-17668	4290±60	Pinus sect. sylvestris
	F3	Ua-17677	4215±60	Pinus sect. sylvestris
	F3	Ua-16048	4095±70	Pinus sylvestris
	F1	Ua-16221	3830±85	Not identified
SMA 1997:7	F1	Ua-15380	8120±75	Pinus sylvestris
	F1	Ua-17669	8020±75	Pinus sylvestris
Raä 2374	F2	Ua-12050	6950±65	Not identified
	F2	Ua-17670	5250±75	Not identified
	F2	Ua-12561	5145±55	Not identified
	F2	Ua-15381	4630±70	Pinus sylvestris
	F1	Beta 107470	4320+-50	Not identified
Raä 2266	F1	Ua-12566	3295±55	Pinus sect. sylvestris
	F1	Ua-12565	2160±55	Not identified
	F2	Ua-15382	2095±70	Pinus sylvestris
Raä 2276	F1	Ua-14969	4695±70	Pinus sylvestris
	F1	Ua-15383	4430±75	Pinus sylvestris
Raä 2256	F1	Ua-15384	3725±75	Pinus sylvestris
	F1	Ua-16223	3725±75	Pinus sylvestris
Raä 2261	F1	Ua-15385	5390±70	Not identified
	F5	Ua-14970	4130±70	Pinus sylvestris
	F6	Ua-15385	3810±70	Pinus sylvestris
	F4	Ua-16225	3800±75	Pinus sylvestris
	F2	Ua-16049	3645±80	Pinus sylvestris
	F3	Ua-16224	2255±75	Pinus sylvestris

fragmentation, only a small proportion of the bone material could be identified at species level. The location of the site, on the top of a low ridge near the point where a stream flows into a shallow lake, would have provided optimal fishing conditions. Evidently, the streams and waters in the vicinity of the site also provided access to beaver hunting grounds. Lithic material indicates that curation and repair took place during the stay. Pit hearths and roasting pits represent outdoor activities and suggest that visits were made during the summer period (Bergman 2006a). Altogether, the archaeological record indicates that the Ipmatis valley provided a resource area that was extensively used during the summer period, possibly in connection with hunting and fishing.

Landscape acquisition

The systematic regional approach of the archaeological investigations in the Ipmatis valley and adjacent areas, in combination with detailed study of selected sites, allows diachronic and synchronic analyses of landscape acquisition during the Mesolithic era to be conducted for the first time in interior northern Sweden. The functional diversity of sites and their strategic location, the selective exploitation of animal resources and the skilled use of local rock demonstrate a profound understanding of the qualities of the interior environment (Bergman et al. 2004a: 173). However, pioneer colonisation was not only an ecological process but also a social activity. Landscape acquisition included the naming of places and establishment of common frames of references. Mental maps had to be established in order for people to find their way to hunting and fishing grounds, campsites and quarries. The landscape was assigned meaning (Bergman 2006b: 145–147). Archaeological investigations suggest that hunter–gatherers made the Ipmatis valley an integral part of their range at an early stage. The location and size (features and artefacts) on registered sites (n= 29) indicate that the role of the Ipmatis valley in terms of the overall subsistence strategy seems to have remained largely unchanged over a period of almost 7000 years.

From an international perspective, the relationship between traditional economies and environmental change is a controversial issue (see e.g. Krech 1999). Recent research at the interface of social anthropology and ecology focuses on the use and management of natural resources by traditional societies (Berkes et al. 2000). Ethnobiological data on the use of edible plants among native North American societies show that the management of plant resources was a major concern, and a sustainable strategy for the use of resources. Plants were tended and maintained by pruning, selective exploitation and burning (Peacock & Turner 2000).

The emphasis of discussions on the subsistence basis of hunter–gatherers in Fennoscandia has generally been on faunal resources and animal food. However, plant resources may have been an equally important, or even critical, determinant of land procurement strategies and settlement patterns. The use of edible plants by indigenous Sami, specifically the use of Scots pine (*Pinus sylvestris*) inner bark, illustrates the significance of plant resources in the subsistence of traditional societies in sub-arctic areas (Bergman et al. 2004b, Östlund et al. 2004, Zackrisson et al. 2000). It seems reasonable to assume, therefore, that this would also have been the case in prehistoric times, and that plant resources were maintained in the following periods.

Forest fires were clearly frequent in this region during the early phases of forest development, shortly after deglaciation (Hörnberg et al. 2005, Carcaillet et al. 2007). Detailed studies of charcoal influxes into lake sediments indicate that fires were more frequent during this early postglacial period than they have ever been thereafter (Carcaillet et al. 2007). The factors responsible for the high frequency of fires are largely unknown, and distinguishing between fires arising from human activities and those arising from climate-based factors (lightning) is very difficult. Humans arrived as the build-up of organic material was beginning, and there is clearly a strong likelihood that hunter–gatherers ignited and spread fires. There is practically no location within the study area where human presence during the pioneer phase can be excluded. Observed correlations between archaeological features and the frequency of forest fires are inevitably imprecise, due to the limitations of using archaeological material for this purpose. Procurement strategies involving seasonal and extensive use of different resource areas may have included repeated burning and temporary abandonment of certain areas according to a logistic system. However, the archaeological data do not permit the patterns to be described at such high resolution.

Regardless of whether fires were ignited by humans (deliberately or accidentally), or caused by climatic or other factors, fire disturbances have probably resulted in the increased growth of various edible herbaceous plants and berries (e.g. *Epilobium*, *Rumex* , Oxyria, *Rubus*, *Angelica* and *Urtica*). Several of these genera were also important food plants for wild game. The succession dynamics of plants following fire disturbances may have played an important and integral role in subsistence strategies among Mesolithic hunter–gatherer populations (Mellars 1976, Bennett et al. 1990, Simmons & Innes 1996a, 1996b, Tipping 1996, Edwards et al. 2007). Considering the very early ranging in of a variety of landscape qualities into subsistence- and settlement logistics, and the establishment of differentiated resource areas, palaeoecological studies focusing on the identification of possible anthropogenic effects on the environment in the vicinity of Early Mesolithic sites were conducted. Indeed, human impact on vegetation was detected close to the oldest dated settlement at Dumpokjauratj, c.15 km SE of the Ipmatis valley. Fine-resolution pollen analysis (FRPA) from close canopy sites revealed vegetation changes that coincided with human occupation of the land. There were reductions in the abundance of *Pinus* and *Betula* trees, as well as shifts in the forest floor layer, including increases in the abundance of *Poaceae*, *Hippophaë*, *Humulus*, *Melampyrum* and *Rhinanthus* (Hörnberg et al. 2005: 21). Thus, the hunter–gatherers settling at Dumpokjauratj actively opened up the forest around the settlement. Similar anthropogenic effects on vegetation have been observed at Early Mesolithic sites in Great Britain (Smith et al. 1989, Bush 1993) and Germany (Bos & Urz 2003). Not only did the pioneer hunter–gatherers adjust to existing conditions, but they actively shaped their living space by manipulating the environment, creating a landscape in a literal sense.

Conclusion

Early postglacial settlement sites near ancient shorelines in the Arjeplog area were discovered as a result of the development of of a theoretical model of non-uniform isostatic land uplift and lake-tilting. Palaeoecological data and radiocarbon dating of settlement sites challenge the prevailing models of ice recession, suggesting that deglaciation was completed more than 1000 years earlier than previously postulated. Pre-boreal tundra-like vegetation prevailed only for a short period after deglaciation, and was replaced by forest vegetation within 500 years (Hörnberg et al. 2005: 20). These first forests were frequently disturbed by natural or anthropogenic fires. The early post-glacial ecosystem presented a productive and diverse environment that was attractive to hunter–gatherer societies. Pioneer colonisation was rapid, and indicative of a well-developed, flexible technology that could meet the challenges imposed by the environmental conditions. Landscape acquisition included the ranging of the landscape into logistic subsistence and settlement patterns, and into social and ideological frameworks. In addition, pioneer settlers interacted with and actively influenced their environment at an early stage. These findings are the first to verify such early human impact on the environment in northern boreal areas. The archaeological sites of the Ipmatis valley of Arjeplog, constituting a 7000-year long record of human presence and habitation, show that the logistic patterns of hunter–gatherer subsistence were established virtually at the outset of human occupation in the area.

Prior to 1999 the very limited number of Early Mesolithic settlements (<5) hindered any attempt at interpreting the process of pioneer colonisation. Although the present study has been conducted on a local and regional scale within a limited geographical area, the number of known Early Mesolithic settlements sites in interior northern Sweden have increased significantly. The present study opens new perspectives on early hunter–gatherer societies and landscape acquisition and the variety of methods applied sets a new standard for future research on early societies in sub-arctic regions.

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REFERENCES

Alexandersson, H., Karlén, W. & Nilsson, J. (1995). "Från istid till nutid," in *Klimat, sjöar och vattendrag* (Sveriges Nationalatlas), eds. B. Raab & H. Vedin, Höganäs: Bra böcker, pp. 22–29.

Andreev, A. A., Tarasov, P. E., Ilyashuk, E. A., Cremer, H., Hermichen, W. D., Wischer, F. & Hubberten, H. W. (2005). "Holocene environmental history recorded in lake Lyadhej To sediments, Polar Urals, Russia," *Palaeogeography, Palaeoclimatology, Palaeoecology* 223, pp. 181–203.

Bennett, K. D., Simonson, W. D. & Peglar, S. M. (1990). "Fire and man in post-glacial woodlands of eastern England," *Journal of Archaeological Science* 1990(17), pp. 635–642.

Berglund, M. (2004). "Holocene shore displacement and chronology in Ångermanland, eastern Sweden, the glacio-isostatic uplift centre," *Boreas* 33, pp. 48–60.

Bergman, I. (1995). *Från Döudden till Varghalsen. En studie av kontinuitet och förändring inom ett fångstsamhälle i övre Norrlands inland, 5200 f. Kr.–400 e. Kr.* (Studia Archaeologica Universitatis Umensis 7), Umeå: University of Umeå, Department of Archaeology.

— (2006a). "The roasting of plants: Sami tradition and the archaeological record," in ... en lång historia. Festskrift till Evert Baudou på 80-årsdagen (Archaeology and Environment 19; Kungl. Skytteanska Samfundets Handlingar 57), Umeå: Umeå University; Kungl. Skytteanska Samfundet, pp. 51–65.

— (2006b). "Den yttersta gränsen – om landskapstillägnelse i inlandsisens spår," in *Gränslöst – forskning i Sverige och i världen. Festskrift till Dan Brändström*, eds. K. Blückert & E. Österberg, Stockholm: Natur och Kultur, pp. 136–149.

— , Påsse, T., Olofsson, A., Zackrisson, O., Hörnberg, G., Hellberg E., & Bohlin, E. (2003). "Isostatic land uplift and Mesolithic landscapes: Lake-tilting, a key to the discovery of Mesolithic sites in the interior of Northern Sweden," *Journal of Archaeological Science* 30(11), pp. 1451–1458. (= Bergman et al. 2003.)

— , Olofsson, A., Hörnberg, G., Zackrisson, O. & Hellberg, E. (2004a). "Deglaciation and colonization: Pioneer settlements in northern Fennoscandia," *Journal of World Prehistory* 18(2), pp. 155-177. (= Bergman et al. 2004a.)

— , Östlund, L. & Zackrisson, O. (2004b). "The use of Plants as regular Food in Ancient Subarctic Economies: A Case Study Based on Sami Use of Scots Pine Innerbark," *Arctic Anthropology* 41(1), pp. 1–13. (= Bergman et al. 2004b.)

Berkes, F., Colding, J. & Folke, C. (2000). "Rediscovery of traditional ecological knowledge as adaptive management," *Ecological Applications* 10(5), pp. 1251–1262.

Bérubé, A. (2001). *Geophysical investigations of the Dumpokjauratj and Ibmatisjauratj archaeological sites of Lapland, Sweden*, Luleå: Division of Applied Geophysics, Luleå University of Technology, Sweden. (Unpublished report.)

Bos, J. A. A. & Urz, R. (2003). "Late Glacial and early Holocene environment in the middle Lahn river Valley (Hessen, central-west Germany) and the local impact of early Mesolithic people – pollen and macrofossil evidence," *Vegetation History and Archaeobotany* 12, pp. 19–36.

Bradshaw, R. H. W. & Zackrisson, O. (1990). "A two thousand year history of a northern Swedish boreal forest stand," *Journal of Vegetation Science* 1, pp. 519–528.

Bratlund, B. (1996). "Archaeozoological comments on Final Palaeolithic frontiers in South Scandinavia," in *The Earliest Settlement of Scandinavia and Its Relationship with Neighbouring Areas* (Acta Archaeologica Lundensia, 24), ed. L. Larsson, Stockholm: Almqvist & Wiksell International, pp. 23–33.

Bush, M. B. (1993). "An 11400 year record of paleoecological history of a British chalk grassland," *Journal of Vegetation Science* 4, pp. 47–66.

Carcaillet, C., Bergman, I., Delorme, S., Hörnberg, G. & Zackrisson, O. (2007). "Long-term fire frequency not linked to prehistoric occupations in northern Swedish boreal forest," *Ecology* 88, pp. 465–477.

Caseldine, C. J., Langdon, P. G., & Holmes, N. (2007). "Holocene climate variability and the timing and extent of the Holocene thermal maximum (HTM) in northern Iceland," *Quaternary Science Reviews* 25(17–18), pp. 2314–2331.

Cato, I. (1987). *On the definite connection of the Swedish Time-Scale with the present*, Sveriges Geologiska Undersökning, CA 68.

— & Kjellin, B. (1996). "Hav i utveckling," in *Hav och kust* (Sveriges Nationalatlas), ed. B. Sjöberg, Höganäs: Bra böcker, pp. 14–15.

DeLuca, T. H., Zackrisson, O., Nilsson, M. C., & Sellstedt, A. (2002). "Quantifying nitrogen-fixation in feather moss carpets of boreal forests," *Nature* 419, pp. 917–920.

— & Zackrisson, O. (2007). "Enhanced soil fertility under Juniperus communis in arctic ecosystems," *Plant and Soil* (in press).

Edwards, K. J., Langdon, P. G., & Slugden, H. (2007). "Separating climatic and possible human impacts in the early Holocene: Biotic response around the time of the 8200 cal yr BP event," *Journal of Quaternary Science* 22, pp. 77–84.

Ekman, M. (1993). "Postglacial rebound and sea level phenomena with special reference to Fennoscandia and the Baltic Sea. Nordic Geodetic Commission," in *Geodesy and Geophysics* (Publication of Finnish Geodetic Institute, 115), ed. J. Kakkuri, pp. 35–60.

— (1996). "A consistent map of the postglacial uplift of Fennoscandia," *Terra Nova* 8, pp. 158–165.

Fitzhugh, B. (2004). "Colonizing the Kodiak archipelago: Trends in raw material use and lithic technologies at the Tanginak Spring site," *Arctic Anthropology* 41(1), pp. 14–40.

Fjeldskaar, W., Lindholm, C., Dehls, J. F. & Fjeldskaar, I. (2000). "Postglacial uplift, neotectonics and seismicity in Fennoscandia," *Quaternary Science Reviews* 19, pp. 1413–1422.

Harbor, J., Stroeven, A. J., Fabel, D., Clarhäll, A., Kleman, J., Li, Y., Elmore, D. & Fink, D. (2006). "Cosmogenic nuclide evidence for minimal erosion across two subglacial sliding boundaries of the late glacial Fennoscandian ice sheet," *Geomorphology* 75, pp. 90–99.

Hörnberg, G., Östlund, L., Zackrisson, O. & Bergman, I. (1999). ”The genesis of two Picea-Cladina forests in northern Sweden,” *Journal of Ecology* 87, pp. 800–814.

— , Wallin, J.-E., Påsse, T., Wardle, D. A. & Zackrisson, O. (2004). “Holocene land uplift and its influence on fire history and ecosystem development in boreal Sweden,” *Journal of Vegetation Science* 15, pp. 171–180.

— , Bohlin, E., Hellberg, E., Bergman, I., Zackrisson, O., Olofsson, A., Wallin, J.-E., Påsse, T. (2005). “Effects of Mesolithic hunter–gatherers on local vegetation in a non-uniform glacio-isostatic land uplift area, northern Sweden,” *Vegetation History and Archaeobotany* 15, pp. 13–26.

Iversen, J. (1973). “The development of Denmarks nature since the last glaciation,” in *Geological Survey of Denmark*, V series, No 7, pp. 1–125.

Karlén, W. (1979). ”Deglaciation dates from northern Swedish Lappland,” *Geografiska Annaler* 61A (3–4), pp. 203–210.

Kleman, J. (1992). “The palimpsest glacial landscape in northwestern Sweden,” *Geografiska Annaler* 74A, pp. 305–325.

Krech, S. (1999). *The ecological Indian: Myth and history*, New York, London: W. W. Norton & Company.

Kultti, S., Mikkola, T., Virtanen, M., & Eronen, M. (2006). “Past changes in the Scots pine forest line and climate in Finnish Lapland: A study based on megafossils, lake sediments, and GIS-based vegetation and climate data,” *Holocene* 16, pp. 381–391.

Lagerbäck, R. (1990). “Late Quaternary faulting and palaeoseismicity in northern Fennoscandia, with particular reference to the Lansjärv area, northern Sweden,” *Geologiska Föreningens i Stockholm förhandlingar* 112(4), pp. 333–354.

Lane, P. (2006). “Oral histories and indigenous archaeology: An africanist perspective. Comments on Charlotte Damm (2005): Archaeology, Ethnohistory and Oral traditions: Approaches to the indigenous past,” *Norwegian Archaeological Review* 39, pp. 70– 73.

Larocque, I. & Hall, R. I. (2003). “Holocene temperature estimates and chironomid community composition in the Abisko valley, northern Sweden,” *Quaternary Science Reviews* 23, pp. 2453–2465.

Lundqvist, J. (1998). ”Weichsel-istidens huvudfas,” in *Berg och jord*, ed. C. Fredén (Sveriges Nationalatlas), Höganäs: Bra böcker, pp. 124–135.

— & Vilborg, L. (1998). ”Isavsmältning och israndlinjer i Sverige,” in *Israndslinier i Norden*, eds. S. Andersen & S. S. Pedersen (TemaNord 1998:584), København: Nordisk Ministerråd, pp. 61–81.

Mellars, P. (1976). “Fire ecology, animal populations and man: A study of some ecological relationships in prehistory,” *Proceedings of the Prehistoric Society* 42, pp. 15–45.

Nilsson, M. C., & Wardle, D. A. (2005). “Understory vegetation as a forest ecosystem driver: Evidence from the northern Swedish boreal forest,” *Frontiers in Ecology and the Environment* 3, pp. 421–428.

Olesen, O., Dehls, J., and Olsen, L. 2002. ”De første nordlendingers katastrofe-skjelv,” *Ottar* (3)2002, pp. 10–17.

Östlund, L., Bergman, I., & Zackrisson, O. (2004). “Trees for food – a 3000 year record of subarctic plant use,” *Antiquity* 78, pp. 278–286.

Påsse, T. (1997). “A mathematical model of past, present and future shore level displacement in Fennoscandia. Sveriges geologiska undersökning,” in *SKB Technical Report*, pp. 97–28.

— (2001). *An empirical model of glacio-isostatic movements and shore-level displacement in Fennoscandia* (SKB R-01-41), Stockholm: Swedish Nuclear Fuel and Waste Management Co.

— & Andersson, L. (2005). “Shore-level displacement in Fennoscandia calculated from empirical data,” *GFF* 127(4), pp. 253–268.
Peacock, S. L. & Turner, N. J. (2000). “Just like a garden: Traditional plant resource management and biodiversity conservation on the British Columbia Plateau,” in *Biodiversity and Native North America*, eds. P. Minnis & W. Elisens, Norman, Oklahoma, USA: University of Oklahoma Press, pp. 133–179.
Rohling, E. J. & Pälike, H. (2005). “Centennial-scale climate cooling with a sudden cold event around 8 200 years ago,” *Nature* 434, pp. 975–979.
Rosen, P., Segerström, U., Eriksson, L., Renberg, I. & Birks, H. J. B. (2001).”Holocene climatic change reconstructed from diatoms, chironomids, pollen and near-infrared spectroscopy at an alpine lake in northern Sweden,” *The Holocene* 11, pp 551–562.
Simmons, I. G. & Innes, J. B. (1996a). “An episode of prehistoric canopy manipulation at North Gill, North Yorkshire, England,” *Journal of Archaeological Science* 1996(23), pp. 337–341.
— (1996b). “Disturbance phases in the mid-Holocene vegetation at North Gill, north York moors: Form and process,” *Journal of Archaeological Science* 1996(23), pp. 183–191.
Smith, A. G., Whittle, A., Cloutman, E. W. & Morgan, L. A. (1989). “Mesolithic and Neolithic activity and environmental impact on the South-East fen-edge in Cambridgeshire,” *Proceedings of the Prehistoric Society* 55, pp. 207–249.
Stewart, I. S., Sauber, J. & Rose, J. (2000). ”Glacio-seismotectonics: Ice sheets, crustal deformation and seismicity,” *Quaternary Science Reviews* 19, pp. 1367–1389.
Tallis, J. H. (1991). *Plant Community History*, Chapman & Hall: London.
Tipping, R. 1996. “Microscopic charcoal records, inferred human activity and climate change in the Mesolithic of northernmost Scotland,” in *The early prehistory of Scotland*, eds. T. Pollard & A. Morrison, Edinburgh, UK: Edinburgh University Press, pp. 39–61.
Wardle, D. A., Hörnberg, G., Zackrisson, O., Kalela-Brundin, M. & Coomes, D. A. (2003). ”Long-term effects of wildfire on ecosystem properties across an island area gradient,” *Science* 300, pp. 972–975.
Zackrisson, O. (1977). “Influence of forest fires on the North Swedish boreal forest,” *Oikos* 29, pp. 22–32.
— , Nilsson, M. C. & Wardle, D. A. (1996). “Key ecological function of charcoal from wildfire in the boreal forest,” *Oikos* 77, pp. 10–19. (= Zackrisson et al. 1996.)
— , Nilsson, M. C., Dahlberg, A. & Jäderlund, A. (1997). “Interference mechanisms in conifer-*Ericaceae*-feathermoss communities,” *Oikos* 78, pp. 209–220. (= Zackrisson et al. 1997.)
— , Östlund, L., Korhonen, O. & Bergman, I. (2000). “Ancient use of Scots pine inner bark by Sami in N Sweden related to cultural and ecological factors,” *Vegetation History and Archaeobotany* 9, pp. 99–109. (= Zackrisson et al. 2000.)
— , DeLuca, T. H., Nilsson, M. C., Sellstedt, A. & Berglund, L. M. (2004). “Nitrogen fixation increases with successional age in boreal forests,” *Ecology* 85, pp. 3327–3334. (= Zackrisson et al. 2004.)