Animating soils
geoarchaeological approaches to past human-environment relationships in the Arctic

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“Now let us consider the nutrient chain, from rock to soil to plant to food to human beings. Calcium, for instance, from feldspar grains of granite, or from derived limestone, becomes available through soil formation to plants, which take up the calcium into underground parts, then into leaves, seeds, and fruits, which we eat directly, or which cows and other animals eat for us. An incredibly complex array of elements and compounds flows in balanced fashion into our bodies along the nutrient chain. We are what we eat. In a sense we [humans] are unique, moist packages of animated soil.”


http://soils.wisc.edu/facstaff/barak/fdh/The_Pleasures_of_Soil_Watching.pdf
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List of papers


III. Philip Jerand, Johan Linderholm & Philip I. Buckland. Geoarchaeology and soil formation in an Arctic setting: impact from 19th century herders and farmers. Submitted to Polar Record.

IV. Philip Jerand, Jonatan Klaminder & Johan Linderholm. The legacy of ecological imperialism on soil fauna: implications for Arctic research. Under review with Arctic, Antarctic, and Alpine Research.

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Author’s contribution

Introductory text

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Papers


Abstract

In this thesis, soils and sediments have been used as sources of information on past human activity in Arctic environments. The study has combined geoarchaeological methods and techniques with information from historical documents, ethnographic accounts, and archaeological remains to create integrated narratives of human-landscape interactions in the past. The thesis consists of two parts: an introductory text and four research papers.

In the first paper, social and cultural aspects of the spatial organisation of Sámi hearth-row sites are presented and discussed through an analysis of the soil from two sites in northern Norway (Steintjørna and Brodtkorbneset) and one from northern Sweden (Hobergsträsk). Based on spatial patterns in the excavated and analysed materials, a socio-spatial ethnographic model of the Sámi goahti (tent/hut) was challenged and new insights into spatial organisation were generated.

The second paper revisits Steintjørna in Norway and presented a geoarchaeological methodology for identifying spaces used for corralling or controlling reindeer.

The third paper deals with the human impact on soils from two contemporary sites representing short term, low intensity use, but under different socio-economic conditions. Snuvrejohka was a Sámi viste (camp site) in a high-altitude location connected to 19th and 20th century reindeer herding, whilst Maiva, was initially a farmstead that was turned into a tourist station, that later became a holiday cottage and lastly a research outpost. The interaction of humans with soils and sediments was explored using stratigraphic and spatial soil sampling strategies and analysis to provide interpretable data on land use.

The fourth paper approaches human impact from a different perspective, namely the introduction of invasive soil fauna in Arctic environments. An integrated cultural and natural historical approach, including soil sampling and analysis, was used to study archaeological and historical information at Maiva. The results suggest that earthworm driven bioturbation is a remnant of 19th and 20th century agricultural settlements, showing that ecological imperialism is present in Arctic Fennoscandia.

These studies have collectively and conclusively shown that human impact on soils is detectable, measurable, and essential for interpreting and understanding past events in human-environment relationships.
Sammanfattning (Summary in Swedish)


Den första artikeln presenterar och diskuterar sociala och kulturella aspekter av samiska härd-rader och deras rumsliga organisering. Jordprover från tre sådana lokaler analyseras, två belägna i Nordnorge (Steintjörna och Brodtkorbeset) och en i norra Sverige (Hobergsträsk). Analyserna tillsammans med fyndmaterialet uppvisar spatiala mönster som utmanar en inom arkeologin vedertagen etnografisk modell av den samiska kåtans rumsindelning, samtidigt som nya insikter kring härd-radernas rumsliga organisering presenteras.

I den andra artikeln återvänder vi till Steintjörna i Nordnorge för att med geoarkeologiska metoder identifiera och lokalisera områden på boplatsen där renar kan ha hållits inhägnade.


Den fjärde artikeln tar sig an mänsklig påverkan ur ett annat perspektiv, nämligen via introduktionen av invasiva markfauna i arktiska miljöer och utgör en integrerad kulturhistorisk studie, där arkeologiskt och historiskt källmaterial kombineras med geoarkeologisk provtagnings analyser. Här påvisas att bioturbation förorsad av daggmaskar är en kvarleva från en jordbrukskolonisering under sent 1800-tal och tidigt 1900-tal, och att ekologisk imperialism existerar i arktiska Fennoskandia.

Sammanfattningsvis framhåller avhandlingens studier att mänsklig påverkan på jord är detekterbar, mätbar och samtidigt väsentlig för att tolka och förstå förhistoriska och historiska människor och deras samspelem med miljö och landskap.
1 Introduction

“What happened here?” is arguably the most rudimentary question archaeology undertakes to answer. However, obtaining the necessary information and formulating an interpretation is often a far more complicated endeavour. When dealing with soils, two supplementary questions are usually worth asking; what is happening here and what could have happened here? All three questions are essential to studies of soil formation.

Soils form where the atmosphere, biosphere, hydrosphere and lithosphere converge and consequently studies of soil need an interdisciplinary approach (Brevik et al. 2015:117–118). In addition, the material qualities of soils are diverse and complex. A multitude of disciplines study soil with a variety of theoretical and methodological approaches; geologists, biologists, chemists, geographers, physicists, and archaeologists all use a suite of analytical techniques to produce and extract information about different soil characteristics. In archaeology, soils provide invaluable information regarding environmental conditions and human impact on the environment (Holliday 2004). Given the fact that soils are integral to archaeological investigations, in that they are vital to site formation processes, their study should be integral to all archaeological research endeavours.

Schiffer (1975) argued that the archaeological record is a static and three-dimensional structure of materials existing in the present. The remains that make up the record undergo transformations during their lifetime, and when they are discarded or deposited cultural and noncultural formation processes continue to impact upon them. Cultural formation processes represent activities by humans, such as the discarding of worn out or broken everyday items like pottery, tools, furniture, and general waste from food preparation and discard, defecation etc. This category also includes disposing of the dead, and even the leaving behind of usable items when abandoning a site, for whatever reason. These activities transform the material from a systemic context to an archaeological context (Schiffer 1972; Schiffer 1973). By contrast, aeolian deposition, erosion and animal burrowing are listed amongst the noncultural formation processes that effect culturally deposited materials.

Knowledge of the past can be obtained by modelling and analysing the various transformations acting on the archaeological record (Reid 1973; Reid et al. 1975; Schiffer 1973; Schiffer 2016). This modelling can be done through archaeological laws. C transforms describe cultural formation processes and relate to variables concerning the behavioural and organisational attributes of a sociocultural system. N transforms (Schiffer 2016; Schiffer & Rathje 1973) concern the interaction between culturally deposited material and the environmental
processes in which the material was deposited. These two factors provide a means for modelling the site formation processes, in terms of spatial, formal, quantitative, and relational attributes. In the last two decades geo-ethnological studies have been published that study both C and N transforms in tandem (Shahack–Gross 2017).

The term “soil archive” is sometimes used when referring to soil as a carrier of information, and this term is often used interchangeably with “soil memory” (Targulian & Bronnikova 2019). However, when information is filed in an archive, it usually enters a static state, so when this analogue is applied to soils it can be argued that it becomes inaccurate, as soils are rarely static. Targulian & Bronnikova (2019:232) eloquently demonstrate this in their paper on soil memory:

“The concept of an archive implies a certain repository of documents, the main purpose of which is to preserve them intact. The concept of soil as an archive may be partially true for buried soils, but it does not fit the “living” soils on the surface, whose memory continuously or periodically changes with time. It is difficult to imagine an archive, in which previous documents are changed under the influence of newly submitted documents. Close to the concept of soil archive is the idea of soil as a book, a chronicle. Again, this idea may be true for buried paleosol sequences, in which changes in the factors of soil formation and pedogenic processes were recorded in the periods from burial to burial. However, ideas about a book-like recording of events are more appropriate to sedimentary rocks, where each layer of sediment records and remembers the natural conditions of a certain period of sedimentation.”

The principle of soil memory is the perception of soil and the soil cover as carrying information about the development and interaction of the biosphere, geosphere and human society (Targulian & Bronnikova 2019). The theory of soil memory was developed in the 1970s and is modelled on the ideas of Vasily Dokuchaev, that the landscape is mirrored in the soil (Bockheim et al. 2005; Targulian & Bronnikova 2019). This palimpsest-wise concept is based on the gradual transformation of parent material (C horizons) into mineral horizons (B, A, and E horizons). In geoarchaeology, this theoretical concept can be helpful for making interpretations. Human activity impacts upon and alters the natural formation processes in the soil, and these disturbances are in turn affected by the same ongoing natural processes, consequently the confines and characteristics of C and N transforms can appear vague and indistinguishable.

Whilst we might agree that for sedimentary systems, a more book-wise memory and record can be utilised, where sedimentation and epigenesis create a layer by layer deposition of the sediments (Targulian & Goryachkin 2004), it is apparent that living soils represent a dynamic, as opposed to static, record. However, even
though soils represent an evolving repository of all the accumulated information discussed above, soils still fail to impress most people, it seems. A lot of people only notice soils when driving by ploughed fields, doing garden work, or when it is being eroded, and if they do think about it at all, they probably find it homogenous, lacklustre, dull, and inanimate. However, soils are formed by broken rocks and minerals (by in situ weathering or ice, water, or wind erosion) and they are mixed with flora and fauna consisting of various fungi, bacteria, and invertebrates. Soils are dynamic and full of biological activity that is and always has been crucial for life on our planet (Cresser 2013).

Soils, sampling, and soil samples are terms that will frequently occur in this thesis. Soil is the loose surface material that covers most land, and sampling is the process of selecting and collecting a smaller and manageable version (sample) of a larger group (soil in this case).

1.1 Background

My interest in archaeology is quite broad; I have never wanted to study only a single type of phenomena, pertaining to a certain time, culture, or environment. My initial PhD project focused on semi-subterranean dwellings (a large shallow pit surrounded by a mound or midden of fire cracked stones and other refuse material, 10-20 m in diameter) in northern Sweden, and the transition from the Mesolithic to the Neolithic, circa 4200 BC (Baudou 1992). The chronology of these dwellings has been based on radiocarbon dated charcoal collected from the bottom and top layers of the middens and from cooking pits in the floor area. 14 such dwellings were included in the making of this chronology, and 12 could be said to fall within the span of 4600-2500 BC (Lundberg 1997:118). Key artefacts thought to be distinctive for the Neolithic, are slate tools, particularly of red slate (Baudou 1992:62). The chronology of these slate finds has partly been modelled on the same radiocarbon dating that has defined the dwellings, as slate tools and flakes were found in the layers of refuse that formed the middens, but also from coastal sites where the tectonic uplift was used as the basis for dating (Lundberg 1997:161). To examine these results and conclusions, the primary reports from surveys and excavations were needed, but these seemed to largely be unavailable or difficult to get hold of, as many were unpublished or stored in archives yet to be accessible. After conducting field work and writing two reports on such dwelling sites (Jerand 2018, 2023), I realised the project would need to be much larger than anticipated, considering the issues with chronology and the inaccessibility of the primary material.

Unsure how to progress with my PhD project, I turned to previous work with Sámi hearth-row sites in northern Norway and northern Sweden. Together with my supervisor I organised another field trip to a Sámi settlement at Snuvrejohka,
north of lake Torneträsk, which was done simultaneous with sampling of another site (Maiva) closer to the lake. The site of Maiva was chosen for study due to the potential for investigating historical impacts on Arctic soils that were modified through the artificial introduction of earthworms. This site offered an opportunity to directly assess anthropogenically modified soils and the impacts of an invasive species in an Arctic environment. I also organised a field trip with Mattias Sjölander, a fellow Ph.D. researcher to Atoklimpen, to investigate stállo-foundations. With material from the hearth-rows and the three new sites I found myself with an abundance of material and data, leaving me with a difficult choice, what to remove? Stállo-foundations are very interesting and debated features (Fjellström 1985; Holm 2016; Kjellström 1983; Liedgren & Bergman 2009; Manker 1960; Storli 1994; Wepsäläinen 2011) and Atoklimpen is a magnificent cultural, natural, and spiritual environment, which is why I decided to save that study for another time and place. However, a technical report on the fieldwork and parts of the analyses has been produced (Jerand & Sjölander 2020). The formation and development of Sámi heritage is very interesting, and I believe that it should be elevated in historiographies. Irrespective, the approaches presented and discussed in this thesis could have been undertaken and implemented on any human settlement site. Human spatial behaviour is present regardless of cultural or chronological boundaries. Fundamentally, we use things, living and dead, we use our surroundings, for various reasons. These activities leave imprints, even though the things are long gone, and the surroundings have changed, the soil remembers.

1.2 Ethical considerations

None of the papers in the current thesis make use of sensitive information as stipulated in article 9.1 in the General Data Protection Regulation (European Commission 2016) regarding ethnicity, religious, or political beliefs, union membership and others.

The final geoarchaeological datasets are available on Zenodo, DOI 10.5281/zenodo.8020591, and made available under the Creative Commons Attribution 4.0 International license (CC BY 4.0). The data management follows the FAIR guiding principles (Wilkinson et al. 2016).

Undertaking research in Sápmi and on Sámi prehistory and history can be a complex matter, given Swedish colonial history. Sápmi is the land of the Sámi, encompassing a large geographical area including the Kola Peninsula to the east, the Norwegian Atlantic coast to the west, North Cape in the north and Dalarna and Trøndelag to the south (Ojala & Nordin 2019). However, its borders are contested in some areas, and it is understood and represented differently depending on various factors (Ojala 2009, 2014). Sápmi can be seen as a
heterogenous landscape with similarities and differences in social, economic, political, and religious aspects (Bergman & Ramqvist 2017; Fjellström 2020; Norstedt & Östlund 2016). In this thesis, Sápmi is perhaps underused as a geographically and environmentally delimiting region, partly because of this heterogeneity. However, most descriptions of traits and locations of regions and places in the thesis have been made for certain environmental or climatological reasons, therefore it has been more appropriate to designate Arctic as a regional descriptor in the studies undertaken here.

I have consequently tried to use north Sámi nomenclature for things and practices, mostly since the majority of the source material has used this terminology. Regarding geographic names, the naming used by Lantmäteriet (the Swedish Land Survey) has been used consistently, often with variations or translations from Wiklund (1910). Working with Sámi archaeology in Sápmi, I have tried to be as open, communicative, and respectful as possible. Regarding the fieldwork I did at Atoklimpen (mentioned in the introduction) and at Snuvrejohka, both conducted in 2019, I had a dialogue with the County Administrative Board and contacted Sámi villages and associations to present the studies, in terms of aims, the extent of impact on physical archaeological remains, and for consultation. This approach is very similar to the law of consultation in questions dealing with the Sámi (SFS 2022:66), which was issued in 2022.
2 Objectives

This thesis principally deals with questions regarding human impact on various environments in the Scandinavian Arctic, with an emphasis on semi-nomadic pastoralism and agrarian colonialism. By studying soils, sediments and soil formation, the aim is to deal with issues of human impact and spatial organisation. The analytical framework and methodology originate from the environmental and ecological fields of research, whilst the subject matter considered is traditionally related to the realms of the humanities, material culture, ethnographic and historical records. This obviously necessitates a synthesising approach in an interdisciplinary manner.

As noted previously, soils contain and retain information on human activities over time and various analytical techniques can produce data that is fundamental to the formation of archaeological interpretations and the testing of hypotheses. Human use of space and behaviour is of particular interest to archaeology, and is related to the prevailing economy, function, traditions, and spiritual beliefs (Binford 1982; Hodder 1982; Simek 1984). Whether the traces of these activities are randomly or structurally formed is something that archaeologists constantly strive to determine from the available evidence. Obviously, the ability to interpret the archaeological record and thus generate a generalised understanding of past human action forms the basis of archaeological investigation. Increasingly, it is apparent that we can use the information from soil studies from very different contexts and chronologies to enhance these studies and develop a more nuanced understanding of past human behaviour.

The overall objective of this thesis is to try and bridge the gap between ecological approaches and humanistic interpretations. The following thematic topics are addressed:

1. Spatial and stratigraphic sampling (paper I and III)
2. Ethnographic and experimental analogies (paper I and III)
3. Human impact by faunal proxy (II and IV)
4. Multiproxy approach (source pluralism) (I, II, III and IV)

These topics are explored in terms of: how geochemical analyses can be used to interpret past human activity; how interpretations of archaeological features can benefit from these analyses; the advantages and limitations of geochemical techniques; and the spatial nature of the archaeological record and its relationship with materiality, cultural heritage and chronology.
3 Materials and Methods

This thesis utilises an approach that combines insights from archaeological investigations and historical documents, and links them with soil formation, land use, and interpretations of geochemical analyses. This combination of sources is a modified variant of the historical research method “source pluralism” (Myrdal 2012). It is integrated with multiproxy analysis (Grabowski & Linderholm 2014, 2022), where sets of data are assessed in relation to each other, on the basis that the credibility of the information generated is enhanced when different sources correspond. Data have been produced and compiled from a wide array of sites, resulting in a substantial mass of empirical evidence, almost 1400 soil samples have been analysed using up to six geochemical and geophysical parameters.

3.1 Field sites

The studied sites derive from various locations in northern Sweden and Norway (figure 1).

Figure 1: Location of the case studies. Two hearth-row sites, Steintjørna and Brodtkorbeset, are located on the western side of the Pasvik River. The third hearth-row site, Hobergsträsk, is situated close to the shore of Lake Östre Hobergsträsket in Skellefteå municipality. The Sámi settlement site ‘Snuvrejohka’ is located on the eastern side of Snuvrejohka River, north of Lake Torneträsk. The Maiva site is located on an area of land named Jèbrènkèddē, on the northern shore of Lake Torneträsk. Basemap data sources: Esri, FAO, NOAA, USGS, and Earthstar Geographics.
The selection of sites is a combination of happenstance, strategy, and research interest. The common denominator being settlements in northern, boreal and/or Arctic environments. The opportunity to work with the three sites consisting of so-called ‘hearth-rows’ presented itself during my MA education, when I was invited to participate in the excavations of Steintjørna and Hobergsträsk and was tasked with sampling the sites and recording the excavation using a total station. The final Sámi site was selected for its geographical location. It was a settlement located in the Torneträsk region, next to the Snuvrejohka river and close to a site (Maiva) that was part of another investigation. This settlement was younger than the hearth-rows and of a more temporary nature. It was chosen as a modern reference to the other sites. Its location in a high-altitude setting was also of interest as soil formation at high-altitude locations is an overlooked field of research. The final site was a 19th and 20th century homestead on the northern shore of lake Torneträsk. The site, called Maiva, had been a focus of research dealing with the effects of invasive earthworms, and how they contribute to bioturbation, microporosity, and decomposition of organic matter in soils (Blume-Werry et al. 2020; Klaminder et al. 2023; Wackett et al. 2018). Our focus was on land use history and tracing human activity.

3.1.1 Hearth-rows

Hearths are the type of archaeological feature that usually define settlements from the younger Iron Age to Recorded History (Sw. *historisk tid*) in the mountains and woodlands of northern Sweden (Hedman 2003). Hearth-rows are an unusual site type for a number of reasons. They consist of several rectangular hearths, some measure up to 2.6×1.5 m (cf. figure 2), which is rather large considering that a superstructure of circa 5 m in diameter may have housed the hearths (Halinen et al. 2013; Hedman & Olsen 2009; Hedman et al. 2015; Jerand et al. 2016). Also, they are organised in a systematic and linear pattern, with regular and even intervals. Most sites are located above 450 m a.s.l and nearly 80% are adjacent to rivers or small lakes, but not situated directly on the shoreline (Bergman 1995:203; Seitsonen & Viljanmaa 2021). They appear during the Viking Age and the early Medieval period (800–1300 AD) and are thought to represent a new way to organise domestic space, and it has been hypothesised that they may also reflect new environmental preferences (Bergman et al. 2008; Bergman et al. 2013; Halinen et al. 2013; Hedman & Olsen 2009; Hedman et al. 2015; Olsen 2019). They can be found throughout interior Sápmi, in northern Sweden, Norway, and Finland, and, as recently published data show, they are also found in Russia on the Kola Peninsula (Murashkin & Kolpakov 2019). The changes in Sámi settlements, are accompanied by changes in burials and sacrificial sites, which are often attributed to an emerging social differentiation within Sámi societies, perhaps relating to the status and prestige of successful
hunters, herders, or traders (Olsen 2019). All three sites considered in the current study comply with the general dating of hearth-row sites.

The hearths can have a compact stone packing, which was the case at both Steintjørna (kulturminneId 148462), seen in figure 2, and Brodtkorbeset (kulturminneId 116714). The solidity and size of the constructions, together with the location of the site and the associated faunal material, have been interpreted as indicative of winter habitation (Olsen 2019). The lack of such internal stone packing at the site of Hobergsträsk (L1937:7352) could then perhaps indicate a difference in seasonality.

The material from the sites discussed in this thesis consists of soil samples collected using various spatial sampling strategies. Samples were consistently collected from B horizons, where minerals and organic matter can accumulate, migrating from A or E horizons.

Figure 2: Photo of hearth 2 at Steintjørna with an interpolation of inorganic phosphate extracted with a citric acid method (CitP), in ppm P. The interpolation was made using Inverse Distance Weighting (IDW), where values assigned to unknown points are calculated with a weighted average of values available at the known points. The IDW was made in ArcGIS Pro, a desktop GIS application from Esri. Finds are marked with white circles and bones with orange circles, where size is determined by weight (g). Unburnt bones are marked with a black cross in the centre of the orange circle. The photographic scale placed next to the hearth is 2 m long. Photo by Bjørnar Olsen, University of Tromsø.
The site of Brodtkorbneset was excavated and sampled in 2008 and 2009, as part of the research project Hunters in Transition. The investigation was led by the director of the project, Sven-Donald Hedman together with Professor Bjørnar Olsen (University of Tromso). Samples were collected by Professor Emeritus Roger Engelmark and Associate Professor (now Professor Emerita) Karin Viklund (Umeå University) during the first year and by Radoslaw Grabowski (Umeå University) during the second year. Two grids were placed over the site, one larger grid encompassing all of the hearths and the surrounding area, and one denser grid over the hearths and the areas adjacent to the hearts.

Steintjørna was excavated in 2012 and 2013, again expertly directed by Sven-Donald Hedman and Bjørnar Olsen. I designed the sampling strategy and collected the samples. A large grid was placed over the site in combination with a hearth focused approach, where each hearth and the area of a presumed dwelling superstructure was targeted with the intent of capturing spatial disposition within said structures. A similar strategy was applied to Hobergsträsk but focusing on locating and delimiting the boundaries of the probable superstructure.

Figure 2 (above) shows hearth 2 at Steintjørna, illustrating the size and structural details, finds and bone distribution, and the correspondence of soil P with deposited bone material. Both the burnt and unburnt bone material was mainly deposited to the east of the hearth, something all hearths from each site had in common. Even though the cardinal direction differed between sites, these patterns were identical within each site. When bone material was rare, soil P still exhibited the same spatial orientation.

3.1.2 Sámi viste
The Snuvrejohka viste (L1993:368) is located on an area of land between the river Snuvrejohka and a smaller mountain stream. It is at the edge of the tree line in a distinctive mountainous environment, above the highest coastline. During an archaeological survey in 1999, six hearths and one kåtatomb (the remains of a Sámi dwelling, encompass both lávvu and goahti) was registered as a Sámi viste (a site with dwelling features from the Middle Ages and Recorded History with at least one kåtatomb, stállo-foundation, house foundation or hearth (RAÄ 2021)). The area surrounding three hearths in the north-western part of the settlement was sampled with an open-end soil probe (figure 3).
The site was deemed to be a few hundred years old at most. Therefore, material was mainly collected from E horizons, as phosphate may not have been fully relocated during the time of post-soil formation. Sample points were placed along two transects, that were of a southwest-northeast and southeast-northwest orientation. Additional samples were collected in a small grid encompassing the three hearths. To access the site, one had to undertake a 4 km uphill trek over blocky moraine peppered with wetlands, carrying the sampling equipment and instrumentation for measurements. This was a limiting factor regarding the number of samples that could be collected.

3.1.3 The Maiva site
The Maiva cabin and its surroundings make up an interesting and picturesque environment (figure 4). Situated on the northern shore of Lake Torneträsk in a sub-alpine birch forest, the Lapponian Gate (Sw. Lapporten) and other dramatic landscape features are visible across the large lake of Torneträsk.
Today, the cabin is used as a research outpost, but it has a history as a holiday cottage, a tourist station, a Sámi settlement, and a farmstead. It has, probably, always been located in an area used as grazing land for reindeer. The site was sampled with an open-end soil probe in a 20×20 m grid, encompassing visible archaeological features and structures. Points of interest, such as house and goahti foundations, were targeted with denser grids. Areas where different stages of soil formation had been identified when coring for the larger grid, were targeted for stratigraphic sampling, here, soil profiles were documented, and several samples were collected from each profile. The archaeological remains found on the site were documented, and together with sampling and information from various archives, the remains and structures could be related to different phases of land use.

3.2 Methods
Geoarchaeology is based on a set of general laws, encompassing the chemical, biological and physical sciences, and the resultant models are applicable to archaeological problems irrespective of chronological, cultural and
environmental setting (Shahack–Gross 2017). However, it has been suggested that geoarchaeological studies should be integrated with other sources (Goldberg & Macphail 2006).

Most of the analytical methods applied in this thesis have been established in geoarchaeology for some time (Arrhenius 1934; Carter 1993; Clark 2004; Dearing 1994; Engelmark & Linderholm 1996; Holliday & Gartner 2007; Thompson & Oldfield 1986). Numerous studies have demonstrated the capabilities of citric acid extractable phosphate analysis, magnetic susceptibility, and loss on ignition as techniques for detecting areas of human activity, increasingly so when used in a multiproxy approach (Clark 2004; Devos et al. 2011; Engelmark & Linderholm 1996; Grabowski & Linderholm 2014, 2022; Linderholm et al. 2019; Liversage et al. 1985; Milek & Roberts 2013).

The appeal of X-ray fluorescence spectroscopy (XRF) lies in its combination of practical and economic advantages together with the non-destructive nature of the analysis (Shackley 2018). Furthermore, measured samples can be stored for future reference or used for other types of analysis. In the soil analytical process, samples already undergo rigorous pre-treatment, including homogenising grain size in the form of hand or machine grinding. For spectroscopic analyses of soils, the complexity of the soil matrix imposes difficulties (Kaniu & Angeyo 2015; Nawar et al. 2019). Grain size and organic content may enhance scattering and increase background noise, thus the signal-to-noise ratio and detection limits of elemental concentrations can be low, as high background noise can mask subtle fluorescent peaks making certain elements more difficult to identify and quantify (Kaniu et al. 2012).

In the studies undertaken for this thesis, the analysis was conducted using a Thermo Scientific Niton XL5 Analyzer (Ag anode, 6– 50 kV, 0–500 uA, 5 W max), connected to a Thermo Scientific™ portable test stand (figure 5). The reference calibration ‘Soil Mode’ was used for quantification.
Figure 5: pXRF laboratory setup at the Environmental Archaeology Laboratory (MAL). Soil samples are kept in 'medicine cups' with customised lids that allow analysing through mylar plastic film, which have minimal impact on the measurements.

Sample size is an important aspect of XRF analysis, and in order to optimise the analytical procedure an experiment was conducted where a certified reference material (PACS-2) with known elemental concentrations was measured repeatedly at different sample sizes. Although initially free from moisture following the freeze-drying process, the materials, which contain sea salt, can pick up moisture during subsequent operations. Therefore, the material should be dried to a constant weight before use, and drying for several hours at 105°C has proved to be a relatively simple method to achieve a dry weight for most purposes (NRC 2009). Repeated analysis has demonstrated that the elemental concentrations of this certified material are stable for at least 10 years when adhering to the advice for proper storage (NRC 2009).

The results of the sample size experiment can be seen in figure 6. As can be seen from the results, the experiment shows that the instrument had difficulties detecting Se (Selenium), Cd (Cadmium), Sb (Antimony) and Hg (Mercury) and quantifying Co (Cobalt), Ni (Nickel), Ag (Silver) in the analysed material. Out of the different sample sizes, 2 g and 5 g were the most accurate, with 10 g and 15 g
being close in accuracy. Previous research from a late Bronze Age site in southeastern Sweden has shown that Ca (Calcium), Mn (Manganese), Cu (Copper) and Zn (Zinc) accumulated in feature and settlement samples, whilst Fe (Iron), Co and Cr (Chromium) characterised control samples collected from a field surrounding the site (Linderholm & Lundberg 1994). When studying the measurements for these elements, 5 g appears to be slightly more reliable. Consequently, the material analysed with XRF in this thesis has been weighted to 5 g.

Figure 6: Table of reference and measured values (ppm) to the left and a PCA Model of the values in the table, UV-scaled and centred. The table shows the certified reference values (column named REF) of all elemental concentrations in individual rows for the PACS-2 material. Each following column (0.5 – 15 g) shows the averaged elemental concentrations measured with the pXRF used in the studies of this thesis, in order to find out which sample size were the most similar to the certified values. The comparison is demonstrated in a principal component analysis (PCA), where most of the variation in data can be described in fewer dimensions, showing that the first component explains 84.2% of the variation in data, and that the variation of 2, 5, 10 and 15 g is more similar to the certified reference values.

3.3 Sources

Many different sources of various types have been utilised in this thesis. Several (mainly historical and archival sources) are covered in more detail in the individual papers, whilst some (e.g., ethnographic, and digital sources amongst others) will be examined further below.

3.3.1 Ethnographical sources

Ethnography is a discipline entangled in writing, where the ethnographer tries to pen experiences onto paper. This is a complicated process made more arduous by the action of multiple subjectivities and political constraints, which the
ethnographer cannot control (Clifford 1983:120). To counteract these limitations, many ethnographies claim to appear as a ‘supplier of truth’, but they are faced with the rhetorical problem of convincing readers that objectively obtained information is not subjectively created (Clifford 1983:120–123).

The use of ethnographic analogy is common practice in archaeological interpretation, the term ‘archaeological ethnography’ was introduced in the 1970s and has come to signify the introduction of ethnographic methods into archaeological research or the merging ethnographic and archaeological practices (Hamilakis & Anagnostopoulos 2009:65–66). Such analogies and models allow for the testing of hypotheses in a way that is otherwise difficult to obtain when dealing with the tangible and intangible proxies of past human life. They can function as pathways into social, cultural, and religious aspects of the human mind, which ordinarily tend to transcend the materiality of archaeological remains. Ethnographic data can inspire arguments and ideas, rather than serve as absolute explanations of past human behaviour (Forsberg 1985:8).

For instance, Sámi bear graves (dated between 200-1700 AD with an emphasis on 1000-1300 AD (Myrstad 1996:46)) and the rituals connected to these burials, were documented by ethnographers in the 17th and 18th centuries. Some of these burials and most ethnographic accounts of them are relatively recent, and in theory understandable in terms of their form and function. The problem for archaeologists is that whilst written sources describe the complex ritual activities associated with these phenomena, these are mostly invisible in the archaeological record (see Myrstad (1996) for a thorough account and summary). However, certain aspects of the written sources can and have been tested with prehistoric remains, showing that the archaeological material exhibits both similarities and variations to the ethnographic sources regarding how these activities were exercised (Myrstad 1996:53–54).

Ethnographic models are frequently applied in the archaeology of indigenous peoples (Colwell-Chanthaphonh 2009; Hamilakis & Anagnostopoulos 2009). In Siberia and North America, ethnographers have studied, documented, and analysed various indigenous peoples (Binford 1990; Grøn 2011; Grøn & Kuznetsov 2003; Strong 2005; Yates 1989). In Japan, ethnographic sources have described and mapped spatial and conceptual elements of Ainu dwellings (figure 7), which have been used to analyse and interpret spatial structures and cultural meanings (Ohnuki-Tierney 1972).
As inferred in the bear graves example, the Sámi people have encountered their share of ethnographers throughout history and such sources are common features in interpretations of Sámi archaeology that deal with settlement patterns, settlement functions, social organisation, religion, and cosmology (Mulk 1994:17).

One frequently cited ethnographer in Sámi archaeology is Gustav Ränk, who was active in the mid-20th century. Ränk (1949) presented basic principles for spatial arrangements in the Sámi goahti (figure 8), and this publication has since been widely cited in archaeological studies dealing with Sámi settlement remains and spatial analysis (see Aronsson 1991; Barlindhaug 2012; Berg 2001; Bergman 2006; Fossum 2006; Halinen et al. 2013; Hedman 2003; Hedman & Olsen 2009; Hedman et al. 2015; Jerand et al. 2016; Karlsson 2006; Nilsen 2015; Odner 2001; Storli 1994; Yates 1989), something that has been challenged recently (Jerand et al. 2016).
Figure 8: The spatial arrangement of a Sámi tent (after Ränk 1949). Occupying the centre of the tent was the hearth (árran). The two larger areas (luojddo/loaiðu) were mainly used as sleeping quarters and seating places. Close to the entrance, there was an area where firewood was stored (uksa). The area opposite the entrance (boassjo/boaššu) was dedicated to cooking and managing wild food products and had a smaller back entrance in which game and sacred products would be brought, in order to avoid passing through areas where ordinary activities took place (Ränk 1949:101). This smaller and sacred entrance connected the boassjo with an area outside of the tent, which was dedicated to religious offerings (Rydving 1995).

Ränk studied Sámi tents from a variety of areas in Russia, Finland, Sweden, and Norway. Even though he noted regional differences in how space was used amongst the family, he found a distinctive pattern in how space was arranged within the tent. The living area was divided into five spatial units, each with specific functions. These units were further associated with male or female activities and religious practices. However, in his studies, Ränk also noted an older spatial arrangement, where the tent was divided into nine units (figure 9), often demarcated with horizontally placed logs.
Such theoretical models based on ethnographic studies have often been applied rather uncritically to archaeological situations. This is irrespective of the fact that the fundamental aspect of models is that they are subjectively created representations of phenomena in specific places at certain points of time and have rarely been tested empirically (Nakoinz 2018). Time is of central importance in archaeology. Treating the past as something static and immutable, tantamount to the present, only adds to the post-processual notion of the total and unavoidable subjectivity of archaeological interpretation. Change, rather than continuity, should be expected. Sámi prehistory and history has traditionally been perceived as static and homogeneous (Ojala 2012:157). Recently however, and perhaps reflecting the realisation that the past is not static, an emphasis has been placed on research into variation, change, and the dynamics of Sámi societies (Ojala 2012:157). However, we must accept that accounting for change in models can be difficult, but we also need to realise that disregarding change, in an interpretative sense will ultimately result in conclusions that misrepresent the reality.

We often think that we are similar to past humans, that we can identify and feel empathy with them, but historical times were assembled according to different sets of rules (Deetz 1996). The contrast between the present and the past is considerable, and with every new technological advance, this contrast becomes greater. The past is increasingly explained, described, and narrated in numbers, sequenced genomes, and multivariate statistics, but fundamentally these narratives remain unauthorised if they fail to account for the nature of society that we see through the lenses of ethnographic and anthropological studies.
3.3.2 Digital sources
An archive of digital data that has been of significant use is The Swedish National Heritage Board’s (RAÄ) database for archaeological sites and monuments (KMR). It is a database that is integrated in all commercial archaeology in Sweden and can be accessed by anyone through the service Fornsök. As of June 2023, the database contained 808 184 geometric shapes, distributed on 512 727 points, 78 214 polylines, and 217 243 polygons (KMR 2023–06–09). However, 70 745 of the sites and monuments consisted of multiple geometries, meaning that there were 737 439 unique archaeological sites and monuments in total. Data is mainly registered by museums, county administrative boards, and companies and organisations concerned with commercial archaeology, such as those conducting archaeological surveys and excavations. It is a database that is heavily fragmented, as all archaeological remains in Sweden will never be found, documented, and registered. It is also incredibly biased, as the main driver for commercial archaeology is exploitation, meaning that areas attractive for construction, infrastructure or the extracting and exploiting various natural resources are also the areas that will be targeted for archaeological work. In northern Sweden, this bias is distinctive along the large rivers, where hydroelectric power plants were constructed in the mid-20th century, and along the coast, where the larger cities are situated and where infrastructural density and the pressure for development is higher.

The linguistic structure of KMR stems from the prevalent nomenclature used in Swedish archaeological surveys of the later parts of the 20th century. The terms, definitions, and characteristics of the archaeological remains and monuments in the database are connected to RAÄ’s list of archaeological remains (Sw. Lista med lämningstyper och antikvarisk praxis), which is used when entering new sites into the database. The list contains all types of sites and monuments that can be registered in KMR, their definitions, informative comments specific to the definitions, possible attributes concerning area of use and type of feature, and the antiquarian assessment recommended by RAÄ. The latter determines whether the site or monument is protected by law or not, and if so, by which law. The protection of sites and monuments classified as fornlämnning is covered by the 2nd section of the Historic Environment Act (SFS 1988:950). Sites and monuments classified as övrig kulturhistorisk lämning are not covered by the direct protection of said law but are included in the opening paragraph of the 1st section: “The protection and conservation of our cultural heritage is a matter of national concern. Responsibility for cultural heritage is shared by everyone. Individuals and public authorities shall demonstrate consideration and care, with respect to cultural heritage. Persons who are planning or executing works shall ensure that damage to cultural heritage is avoided or limited.” Regulations that may imply different forms of protection, limitation or considerations regarding cultural heritage can also be found in The Swedish Environmental Code (SFS
There are no guidance documents from the government to RAÄ that demand a digital system for managing cultural heritage, but there are regulations saying that RAÄ shall provide digital geographic data regarding the objects protected through the Historic Environment Act (RAÄ 2013). Initially, in 1937 when RAÄ was tasked with a systematic recording of archaeological sites and monuments above ground, the register was analogue, as opposed to digital, and connected to the maps of The National Survey, with time it also became a tool for community planning and to some extent for research, and with this change in use, its purpose also evolved (RAÄ 2013).

The digitisation of the register started in the early 1980s and finished in 2003 (RAÄ 2013). This transition resulted in a decreased geometric resolution of the data as archaeological sites and monuments marked by hand on analogue maps (the Economic map, with a scale of 1:20 000 in parts of northern Sweden) were transferred, also by hand, to a digital format. The condition of these maps probably varied since they had been carried and used in a wide array of different weather conditions for varying lengths of time and in containers suitable for trekking. In 2008 the analogue register was archived at the Antiquarian and Topographic Archive (ATA), by then it consisted of roughly 10 000 surveying books and 40 000 maps (RAÄ 2008).

In general terms, it is important to be aware of the provenance of data. For KMR it is essential, as information has been generated and added to the register since 1937, and new data is being produced on a daily basis, consequently the information can have different meanings depending on when and where it was gathered (RAÄ 2016). The interpretation of a type of feature or monument will have changed over time, but older entries in the database might not have been updated and are still using the older interpretation. An example of this is the so-called Assebakte graves, rectangular stone-settings, often 2×1 m, with an apparent spatial organisation, that were interpreted as cremation burials (Simonsen 1979). The hypothesis was tested and refuted, and it was concluded that the stone-settings were hearths associated with Sámi settlement sites (Hedman & Olsen 2009). The work and interpretation of Simonsen canonised the term Assebakte grave as the most common classification designated to rectangular hearths in Norway, and this misleading term still lives on in Norwegian cultural heritage repositories and survey reports (Hedman & Olsen 2009).
The definition of what constitutes a fornlämning and övrig kulturhistorisk lämning has changed multiple times since the 1930s, and older interpretations can have another implication today since the recommendations for antiquarian assessments will have changed. In 2014 the Historic Environment Act was changed to, among other things, include a time limit (1850 AD) to the definition of what could and should constitute a fornlämning, which affected a major part of the registered sites and monuments.

Considering that the main purpose of the database was never to be a primary research tool, it is still a fantastic repository of archaeological data and possesses immense possibilities for archaeological research. However, in order to ethically use data from KMR, certain guidelines should be adhered to.

Data ethical topics have been suggested by Hand (2018), and include the need to:

- keep a record of how data are modified and manipulated,
- understand the provenance/origin of the data,
- treat the metadata as rigorously as the data,
- have an explicit data management plan,
- have systems in place that allow data to be corrected and deleted if necessary.

For KMR additional topics could be added, considering the issues raised above. Working with multiple sites and monuments in a large-scale manner, including for instance all sites of certain types in a specific region, is problematic and requires a systematic approach and knowledge of the database and the studied objects. Take for instance, the remains of house foundations from Recorded History, which should encompass building remains that cannot be included in other categories, such as various industries, farm lots, Sámi goahti and lávvu. If research interest lies in various barns, outbuildings, and cabins in agricultural settings, rather than the remains of buildings connected to fishing grounds and reindeer herding, the dataset must be dismantled in some manner. This information can be digitally available, if the object has been added to KMR after the digitisation or if the object has been part of a quality-enhancing effort by the RAÄ. However, for most objects this data can only be accessed by reading the scanned survey books linked to each specific object. This can be extremely time consuming when working with large datasets. There are, however, ways to approach this, for instance by posing queries to the dataset, in order to highlight objects of interest. An example of such a query could be to select all features that are located within a set distance from hearths, lakes, or fossil fields. The queries should be customised with regard to the sites or monuments of interest and can be increasingly specific as the selection process advances.
Digital methods have become increasingly important in cultural heritage research, as finding materials and information stored in online repositories are dependent upon such methods (Ambrosiani & Larsson 2022). Simultaneously, the requirement of different forms of source criticism is apparent, in order to understand the availability of data through different online services and how to utilise said data in an ethical manner and in concordance with the FAIR principles.

3.3.3 Source criticism

The site biography of paper 3 is built on several sources. An emphasis has been placed on Swedish and Norwegian church archives, encompassing written sources such as birth, baptismal, wedding and death records, communion registers, catechetical examination registers (Sw. husförhörslängder) and parish records (Sw. församlingsböcker). The original documents are stored at the Swedish National Archive (Sw. Riksarkivet) and at the National Archives of Norway (No. Arkivverket), but they are also available through their search services, the Digital Research Room, and the Digital Archives respectively. Other historical sources that have been incorporated into the study include census records, the archive of the Sámi bailiff (Sw. lappfogde) in North Bothnia’s northern district, the Swedish Tourist Association yearbook, and the Swedish Newspaper database which is maintained by the National Library of Sweden (Kungliga biblioteket, KB). Many of these could also be used for assessing, strengthening, or validating information about the history of Snuvrejohka and its surroundings (Svonni 1999).

In the 1860s the protocols of the Swedish catechetical examination registers were revised and the quality of the recordings increased (Lext 1984). A methodological issue when dealing with these records is that a person could have been recorded as living in a certain location, while actually residing somewhere else (Lext 1984). In the last decade of the 19th century, the catechetical examinations were replaced by the parish records. This transition resulted in, among other things, a decreased potential to discover people who, in violation of the law, had moved without informing the proper authorities (Lext 1984). As urban development and industrialisation progressed, people became more mobile, and this increased mobility meant that migration within the parish became more frequent. One challenging aspect of this intra-parish migration, from a research perspective, is that it was not always documented in the parish records (Eckeryd 2017).

Of the churchly and cameral sources from the 19th and 20th century, the catechetical examination registers contain all family members on one page, with dates for births, weddings, and deaths. When tracking an individual and their origins these registers provide multiple traces for identifying and finding
individuals and identifying errors made by the clergy. The catechetical examinations registers have a chronological flow in the sense that all individuals have a reference to the book they were transferred from and the book they would be transferred to. This chronology was connected to the church’s control of the populations’ knowledge of Christianity, which differs from the event-based recordings of births, baptisms, weddings, and deaths. The data in an examination register can be related to other sources, where event-based records and earlier and later examination registers are compared to the original source.

In this thesis a source criticism that emphasises the use of complementary sources have been applied, sometimes called constructive source criticism (Myrdal 2012; Ågren 2018). There are advantages and disadvantages when working with multiple sources. For instance, whilst the structure and systemisation of the parish records cover the whole population of the parish at certain points in time, migrants may not have as detailed information, if the migration was recorded at all. By comparing this occupational data with other sources, certain parameters can be validated or rejected.

The following example highlights how limitations of one source can be compensated for by another source. According to the oral sources ‘Tull-Anders’ came to Torneträsk in the early 20th century. Anders Olof Andersson is not mentioned in the migration records until 1917, where he is entered as a migrating Norwegian. His two daughters’ entries in the parish records state that they are the daughters of Anders Andersson ‘at Torneträsk’, however, they are recorded in the migration records in 1909 and 1910. The son is not mentioned in any source except in the record for deaths and burial in 1907, and in the book of confirmands together with his oldest sister in 1905. With the information regarding Anders Andersson’s children, it is possible to say that he likely came to Torneträsk before 1917.

When the following data is considered, the chronology becomes clearer. In 1905 the Sámi of Talma report to the Sámi bailiff of illegal buildings at the area around Jebrijock. 1900–1901 is when they first reported unwanted and unauthorised activity in that area, by Norwegian workers, in the form of two birch and peat goahti, keeping of goats, fishing, grouse trapping, and conveying spirits to the railway workers on the other side of the lake.

To support the interpretation that the abovementioned Norwegian is Anders Andersson, the Sámi bailiff’s annual report can be used, where the bailiff in 1919 writes about Anders Enoksson Sarri having settled at Jebbren, where A. O. Anderssons cabin was situated. To further consolidate the identification of ‘Tull-Anders’ as Anders Olof Andersson, a passage from Söderhamns Tidning can be scrutinised. Here, a travelogue author writes: “a few kilometres from the cabin...
the lonely fisherman »Tull-Anders» has his peat hut and permanent abode...”, as he describes the landscape and vegetation surrounding a tourist station on the northern shore of Lake Torneträsk. The tourist cabin, named Jebrenjokkstugan or Jieprenjåkkstugan, was opened in 1909 by the Swedish Tourist Association (Birger 1909), and is today partly owned by Abisko Intresseförening och Idrottsklubb. Situated 1.5 kilometres from the Maiva cabin, it should not be confused with the tourism phase of Maivatjåkkostugan in the late 1940s.

Another example is mentioned in paper 4, where a land surveyors map indicated agricultural fields near the Maiva cabin (LM 25-kij-18:66). An archaeological survey of the specified area found no traces of such activities, and furthermore the podzol on blocky moraine did not seem optimal for such activities. Historical documents and maps made by land surveyors are often used in archaeological surveying, but as this example highlights, these resources need to be used with some caution.
4 Discussion

Soils contain untold stories of human life wherever the two interact, tales of land use and spatial behaviour have been the focus of this thesis. Additional insights may be gained from the soil when integrated with studies of other mediums of information, such as ethnographic accounts and historical documentation.

4.1 Sámi archaeology

The spatiality of hearth-row sites has been discussed in papers 1 and 2. The spatial dimensions of these sites are intriguing, and patterns can be seen in the placement of the hearth constructions, the constructions themselves, waste dispersal, and potentially also in the function/role of certain hearths. Whether this spatiality is connected to chronology, function or traditions, culture, and beliefs is yet to be determined.

In many Sámi communities and for Sámi culture and identity, reindeer hold a special place. The history of reindeer herding and pastoralism in a Sámi perspective is debated (Bjørklund 2013) and there are those arguing for an early introduction during the first millennia AD (Andersen 2011; Aronsson 1991; Bergman et al. 2008; Hedman 2003). Others argue for an intensification during the mid and later parts of the second millennia AD (Mulk 1994; Røed et al. 2018; Sommerseth 2011). The arguments and positions outlined above are not all mutually exclusive. Considering arguments for a re-arrangement of social structures (Bergman et al. 2013), and the use of new environmental preferences (Olsen 2019), a shift from an economy centred around hunting to one focusing on herding seems plausible.

To find a way forward within this topic of research, we need to turn to scientific methods, and a combination of different techniques to test hypotheses formed on the basis of cultural historical sources. Soil studies have proven valuable in agricultural and domestic archaeology, in the form of detecting and delimiting the use of manure and controlling animals in stalls, booths, or stables (Grabowski & Linderholm 2014, 2022). Osteological analyses have demonstrated how bone refuse was managed and that wild animal products were mixed with bones from sheep/goat in deposits at both Steintjørna and Brodtkorbneset (Hedman et al. 2015). It is difficult to distinguish sheep bones from goats due to similarities in bone morphology (Vretemark 2019), and even though the few that could be identified at Steintjørna and Brodtkorbneset proved to be bones from sheep (Vretemark 2019), it is likely that goats were favoured by reindeer herders as they were more durable and could be brought on travels over mountains, to the inland and coast (Harlin 2009). The presence of bones from sheep/goat is strongly
indicative of animal husbandry (Vretemark 2019), meaning that the concept of husbandry was definitely known to the inhabitants.

Regarding soils, it is unlikely that the analytical methods utilised in this thesis can distinguish between traces of reindeer and traces of sheep/goat, and corrals identified by chemical traces could theoretically have housed either or both. Stable isotope studies of reindeer bones from the 11th to the 20th century have demonstrated different practices in the management of reindeer, such as foddering (Fjellström et al. 2020), and ancient DNA analysis has shown that a genetic replacement of reindeer took place during the 16th and 17th centuries in northern Fennoscandia (Røed et al. 2018). A way forward on this issue, could be field work on suitable sites, with an integrated approach of multiple methods and techniques, encompassing scientific methodologies such as DNA and soil studies alongside ethnographic accounts and historical documentation, that also considers perspectives on landscape and taskscapes (Seitsonen & Égüez 2021).

4.2 Sampling
A concern in geoarchaeology is to choose an efficient strategy for collecting soil samples. Acquiring representative sets of data is essential for making interpretations that are unbiased. The result of many analytical methods, e.g., those discussed in this thesis, are strongly dependent of the material that is analysed. What we sample is, unsurprisingly, decisive for the outcome, and this also applies to the question of where we collect our samples from. If the context of the sample is not fully considered, the possibility to interpret the analytical results will be significantly limited, no matter which analytical method is being discussed.

A fundamental requirement in sampling, is that the collected sample reflects or represents the phenomenon or object of study. In archaeology, there are no absolute, one-to-one, relationships between what we perceive to be the remains of past human activity and the actual activity that once transpired (Swedberg et al. 2016). Additionally, the implications of the quantitative results and potential variances may be difficult to determine, and even harder to make meaningful interpretations of. A contextual understanding of what we sample is thus of utmost importance, particularly considering how complex and obscure archaeology can be. This understanding may be easier to obtain with the help of other source materials, as this thesis tries to demonstrate. We cannot always, or perhaps, should not always, reduce archaeological phenomena to their smallest constituent, or to what we deem to be their main component (Swedberg et al. 2016).
Geoarchaeological analyses relate to physical material and are dependent on sampling. As highlighted in paper III, soils are defined by various biological and chemical characteristics that are of both horizontal and vertical dimensions (Dick et al. 1997). Furthermore, human activity is spatially and temporally variable and not a static phenomenon (Engelmark & Linderholm 2008; Evans & O’Connor 2005), as outlined earlier in the discussion of the use of ethnographic analogy.

Taphonomy and soil formation are natural processes that are constantly ongoing and as such should be considered when sampling, as they can influence or partially explain the analytical results. Taphonomy is the study of the processes that affect how organic remnants, like plants, animals, and humans, accumulate and preserve in soils and sediments (Goldberg & Macphail 2006; Linderholm 2010). The rate of decomposition may differ between materials and is affected by the prevailing *in situ* conditions. Taphonomy is an important part of the preservation of many archaeological materials. If the significance of taphonomy is neglected in the sampling strategy, the risk for non-representative material and misinterpretations of data will increase. Soil formation processes influence taphonomy, as do the factors that influence the soil formation process itself.

The sampling strategy is determined by the researcher and the research questions should be pivotal when choosing the design of the sampling and the number of samples to be collected (Holliday 2004). The sampling strategy should also be customised to the phenomenon being studied. It may be necessary to approach an archaeological feature differently, compared to, for instance, a larger area. Indeed, different types of features may require varying sampling strategies (Campbell et al. 2011).

Sampling of larger areas can be undertaken in different ways and samples are usually collected from specific horizons in the soil. In podzols, the illuviation horizon is often of extra interest, since phosphate concentrations tend to increase here as a result of the breakdown of organic acids that are important for fixing phosphates in acidic soils (Crowther 1997:101). However, as paper I and paper II pointed out and paper III demonstrated, in historical contexts the eluviation horizon might be more suitable. The sampling points can be distributed in various ways over the area, often with equal intervals with a denser interval close to objects of interest, such as features. Investigations of this sort have, within archaeology, often relied on systematic sampling strategies (Wells 2010), called mesh or grid sampling (see Entwistle et al. 2000; Marshall 2001). Bulk samples are usually collected from features, targeted on specific layers with a mix of soot and charcoal. It is generally the sediment that is deemed to represent the activity or function of the feature that is of interest. This implies, problematically so, that the analytical response of a feature only reflects a preselected and subjectively defined layer, no matter what the selected analytical method is. To illustrate this,
we can turn to the ‘cultural layers’ of the Sámi viste at Snuvrejohka (paper III). Samples collected from these layers contained up to 40 % calcium, while the average concentration of calcium in other samples were around 0.6 %. Given these results, we need to consider whether the samples from the ‘cultural layers’ are representative of the various human activities connected to the hearths? Or do they simply reflect the fact that pieces of burnt bone were found when sieving the samples?

4.3 Human interactions and relationships

The various relationships and interactions between Sámi, settlers, and tourists have been visible throughout the work in this thesis, especially surrounding the Maiva site. Many of these are mentioned in paper 4, to various degrees. The Vittangi settlers of 1871 supposedly had a good relationship with the Sámi in the area, yet they still chose to poach reindeer in order to survive the harsh winter, instead of asking for help. Anders Olof Andersson, or ‘Tull-Anders’, had, according to oral traditions, a working relationship with the Sámi, until his mental health deteriorated, and he used dynamite to frighten and threaten his Sámi neighbours. The archival material contradicts this to some extent, since it was apparent from the annual report of the Sámi bailiff that he had been contacted by the Sámi village asking him to do something about the intrusion on their pasture grounds. When the Sámi, Anders Enoksson Sarri, started using the area after Andersson had left, the Sámi village once again contacted the Sámi bailiff in order to move Sarri, as he had settled on pastureland important for reindeer grazing.

At the tourist cabin, Maivatjåkkostugan, the diary written by one of the directors, gives the impression of a friendly, respectful, and mutually appreciated relationship between the cabin administrators and the Sámi, perhaps best illustrated with a page from the diary (figure 10). These are all examples of how social relationships between individuals can vary, regardless of cultural, economic, and ethnical circumstances.
Figure 10: Excerpt from diary, Maivatjäkkostugan 1947, “Our best friends were the Sámi, who were of invaluable help to us”. The top photo shows the shore of Lake Torneträsk with the stables on the right hand of the photograph. The bottom photo shows the Maiva cabin from southeast. Courtesy of Anna Berglund.
Stories similar to those covered in paper 4 have taken place elsewhere. There were numerous tourist stations that were established in similar fashions during the early and mid-parts of the 20th century, for instance Storulvåns fjällstation located 2 km from the farmstead Tjatjasen, where the tourist station was built on an abandoned Sámi viste in 1925 (L2020:1467). Whether or not the relationships were generally good or if conflict ensued is difficult to tell as the written accounts are predominantly of a colonial perspective. Several of the travelogues portray Sámi in a demeaning manner, as an example we can use the accounts of a hiker travelling in the mountains of Jämtland, near Tjatjasen. As the author travels into the mountains, describing the natural environment in graphic detail and in lavish words, he encounters a herd of cows, sheep, and goats and an “admirably ugly lapp girl” (Skånska Aftonbladet 1886).

The complexities of colonial relations in Sápmi have been emphasised in research, and the agency of the Swedish state and the Swedish church in relation to the Sámi has been discussed (Ojala & Nordin 2019), as has the scholarly view of the Sámi and Sámi material culture (Nordin & Ojala 2018). But was this opinion of and attitude towards Sámi prevalent amongst the general non-Sámi population? The neighbouring settlers, the railway workers, the miners, the tourists, etc, how did they perceive the Sámi? As others or outsiders? Does the travelogue excerpt above only exemplify a derogatory use of language, or is it founded on notions of racial, ethnic, and cultural inequality? If this is a sign of ingroup bias, would it also affect other outsiders - groups or individuals? Such as a “Norwegian” widower, fisher, and settler, with the unflattering epithet ‘Tull’ (odd), who lived illegally with his three children on reindeer pasture lands in the backwoods of Lake Torneträsk, smuggling spirits to the railway workers.

The fate of Anders Olof Andersson, or ‘Tull-Anders’, is peculiar and tragic, but not unique. Circa 5 km west of the Maiva cabin, a man called the Bear-hunter lived a life resembling that of Anders Olof Andersson. His actual name was Lars Erik Larsson (b. 1856) from Leksand (HLA A II a/7). His occupation was also that of a fisherman, but he worked as a tourist guide in the area surrounding Lake Torneträsk in the early 20th century and competed with “the Raider” (Sw. röfvaren) for customers (Kleman 1908). He lived in a peat hut on the shore of Lake Torneträsk (figure 11).
The Bear-hunter passed away in 1926, after falling down the stairs to the basement of the school in Abisko (Norrskensflamman 1926). The building next to the school was the store that Anders Olof Andersson visited four years earlier, and where he also fell down a set of stairs suffering injuries that caused his death.

4.4 Alpine farmsteads

Tjatjasen and the farms built by the Vittangi settlers and Anders O. Andersson were common in the alpine regions of northern Sweden, and the impact they had on environments and soils needs to be highlighted. By using KMR it is possible to obtain a rudimentary view of agricultural remains in alpine regions (figure 12).
Figure 12: Remains, from KMR, situated within 1 km from of alpine regions. Black dots mark house foundations, white squares indicate agrarian remains, and orange triangles mark farmsteads. Data sources: Earthstar Geographics and Riksantikvarieämbetets kulturmiljöregister (KMR) 2023.

Farmsteads have been identified either by name in the register or if they were indicated by name in the Land Survey’s placename register. The agrarian remains in figure 12 include fossil fields, clearance cairns, cattle sheds, and farm lots.
As mentioned previously, KMR is and will always be incomplete. It is also biased towards areas with high exploitation and frequency of surveying. The alpine regions of Sweden are underrepresented in both respects, and the circumstances presented in figure 12 are therefore fragmentary, as the actual presence of agrarian remnants is much greater. Since there are no optimal databases available that contain all former alpine farms (Sw. fjällägenheter), other sources must be examined, preferably in conjunction with data from KMR. The archive of the Sámi bailiff in Norrbottens northern district contain files regarding alpine farms in the northern parts of Norrbotten County between 1913–1971 (HLA F XIII 1), but these have not been digitised yet. An archive containing corresponding documents for Västerbotten County has been scanned (HLA F XI a), and the geographical location of identified farms is shown in figure 13.

Figure 13: The alpine farms of Örnbo (A1–2), Dainanäs (B1–2), and (C) alpine farms (black inverted triangles) in Dorotea, Vilhelmina, Stensele, Tärna, and Sorstele parishes, mentioned in the archive of the Sámi bailiff in Västerbotten County (HLA F XI b/1). The limit of cultivation is marked with a brown dotted line, while parish borders are marked with blue lines. Basemap data source: Earthstar Geographics.

The environments of two examples are highlighted, Örnbo and Dainanäs. Örnbo was established in 1894 and deserted in 1957, whilst Dainanäs, also established in 1894, was made inactive in 1945 (HLA F XI b/1). Figure 13 show satellite images and photos of the two sites, where buildings and cleared/open areas are
visible, as these two sites are cared for by the County Administrative Board. Abandoned farms that have not been seen to in the same manner, are being reclaimed by nature, as cleared areas are overgrown by trees and vegetation. However, the presence of invasive soil fauna at these sites cannot be determined from satellite images, and the potential impact on soils and environment induced by earthworms may be ongoing and unnoticed.

Between 1916–1944 there were 164 registered alpine farms in Västerbotten County, a few were never realised, most lasted several years, and some are still inhabited today. The documents in the Sámi bailiff’s archive contain information about the total size of each farm, including worked and potential arable land. The archive also includes details on how far each farm was from its nearest neighbour, the distance to roads, and how many horses, cows, sheep, goats, pigs, and poultry each farm had. This abundance of information, combined with targeted fieldwork, could be a way forward in understanding and documenting the impact of this somewhat forgotten era in Swedish colonial history.
5 Concluding remarks

As stated at the outset, the main objective of this thesis was to try and bridge the gap between ecological approaches and humanistic interpretations. That separation will probably always be present, as research traditions, nomenclatures, and procedures are likely to be lost in translation, at least to some extent. If bridging the gap is impossible, then this thesis has, perhaps, at least contributed to reduce the distance between them.

The main conclusion of this thesis, based on the discussions in all four papers, is that the integration of geoarchaeological data with other records, i.e., archaeological, historical, and ethnographical, enables the use of the former as a resource for addressing questions pertaining to issues not only within the soil, but on or above it. Increased and more structured integration between geoarchaeology and other disciplines operating within the realm of cultural heritage is argued to be a favoured approach for conducting high quality research.

Archaeologists are mindful of considering ethnographic and historical evidence when generating authorised accounts of the archaeological record, and when drawing conclusions from it. However, the issues concerning the use of ethnography and anthropology must also be recognised and scrutinised in order to reduce the potential limitations inherent in each discipline.

In addition to the topics that were addressed in chapter 2, the thesis also accentuates aspects of cultural heritage research that might be overlooked. As shown in paper 4, tourism, even when small-scale, has impacted cultural and natural environments in many ways, and perhaps to a larger extent than is generally assumed. The archaeology of ‘subalterns’ (Sw. obesuttna), crofters, cottagers, artisans and workers who lived under precarious circumstances and conditions, and that usually left few or no traces in governmental maps and records, has of late received increased research interest (Hansson et al. 2018; Nilsson et al. 2020; Nilsson et al. 2019). In an Arctic context, the impact of historic and prehistoric humans might be extra susceptible to being unnoticed, as the idea of wilderness and pristine landscapes and environments will always be appealing and intriguing to most people.

Are there any environments that have not yet been impacted by humans? In the Arctic a variety of human and non-human land uses contest for space. They influence each other in different ways, sometimes they cooperate but often, they cause conflict. Many interests compete against each other and there are national, economic, local, and indigenous actors involved in these. The Government Offices of Sweden have developed a Swedish strategy for the Arctic region highlighting
overarching themes, and advocating for peaceful, stable, and sustainable development in the Arctic, and for the strengthening of Sweden’s Arctic profile by making use of the knowledge and resources available in Sweden (Government Offices of Sweden 2020). Research is emphasised as being an important component in the peaceful and sustainable development of the Arctic, as is education, which is laudable.

However, the research that is mentioned within the strategy is polar research dealing with climate and environment. Cultural heritage and research on cultural history is omitted, together with many other fields of research. The cultural heritage in the Arctic is fragile and exposed to a harsh climate and environment. In many instances of environmental and climatic change, humans are or have been involved in various ways and degrees, something this thesis is an example of. Disregarding cultural history in such a context would perhaps not be a constraint for sustainable development, but nevertheless in terms of Arctic research it would not be strategic.
Paper summary

Paper I presents the fundamental methodology and approach applied in the thesis. Soil from three hearth-row sites, comprising multiple rectangular hearths organised in a linear pattern, were sampled, and analysed. These features are associated with Sámi settlements, and generally dated to 800–1300 AD. An increased understanding of the spatial behaviour and waste dispersal at these sites was provided, as the study showed repeating spatial patterns in excavated material and the analysed data, challenging the use of an ethnographic socio-spatial model in archaeology.

Paper II further examines the chemical properties of soil from a hearth-row site in northern Norway. A multiproxy approach consisting of several analytical parameters was used to identify spaces used for corralling or controlling reindeer. Two areas with increased amounts of organic to inorganic phosphate are highlighted as potentially being the result of fertilisation from small-scale reindeer management.

Paper III explores human impact in Arctic soils by comparing two historical sites north of Lake Torneträsk. Two contemporaneous sites, one dominated by small-scale agricultural activities and the other by reindeer management, were investigated via soil studies. Stratigraphic and spatial strategies were used for collecting soil samples. The sites were compared by applying soil chemical and physical methods, and the analytical outcomes are discussed in detail. Human impact on soils was detectable at both sites, although the results differed in terms of soil phosphate accumulation, changes in magnetic susceptibility, and enrichment by certain heavy metals.

Paper IV presents a site in Arctic Sweden, located around contemporary Arctic research infrastructure, where invasive soil fauna has been introduced. Earthworms from previous land use have caused bioturbation in what are often considered to be ‘pristine’ Arctic soils. Soil preserved underneath the remains of a house foundation was used to highlight the fact that the soils were not bioturbated before the house was built. A review of archived historical documents combined with archaeological survey and soil sampling and analysis, enabled a reconstruction of the site’s biography with high chronological resolution, including historical land use. The onset of bioturbation could be constrained to the expansion of pre 20th century settlers. The results give cause to revisit previous interpretations regarding the presence of invasive soil fauna in Arctic and alpine settings and shows that ecological imperialism should also be considered when studying the soils of Arctic Fennoscandia.
References


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**Digital and archival sources**


