People – Plant Interrelationships

Historical Plant Use in Native Sami Societies

Anna-Maria Rautio
Faculty of Forest Sciences
Department of Forest Ecology and Management
Umeå

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Cover: A Sami man carefully harvesting inner bark from a Scots pine tree in Inari, Finnish Lappland. In his hand he holds the horn-tool *vyetkim,* which was used to separate the bark from the wood.
(photo: T.I. Itkonen 1914/Finnish National Board of Antiquities)

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Abstract

Different plants have played an important role historically in the subsistence of the native Sami people of northern Fennoscandia. Generally, their use of plants have however been regarded as less vital in their overall subsistence and in comparison to the domesticated reindeer and the hunted game and fish. Also, the impacts of early human plant use on specific plant-populations and the overall ecosystems which they inhabited have often been overlooked in research.

In this thesis the traditional Sami practices and extent of plant use from the 1550s until 1900 was studied from two main perspectives; First) the cultural significance of Scots pine inner bark and *A. archangelica* was evaluated, in the perspective as a discrete form of resource utilization within a larger set of activities which constitute overall Sami subsistence, Second) The human impact of land use from a perspective of plant use was quantified and evaluated. Special emphasis in this thesis was placed on the role of Scots pine (Pinus sylvestris L.) and garden Angelica (*A. archangelica ssp. archangelica* L.).

My results show that: 1) Scots pine and *A. archangelica* are two of the Sami cultural key-stone species, since they were qualitatively vital for survival in these northerly regions. 2) It is possible to manage and maintain stable populations of *A. archangelica* by conducting harvest according to traditional Sami practices, indicating that it is likely that the Sami did not only gathered but also enhanced certain wild plants. Furthermore, the Sami harvest of different Scots pine resources on a regional scale, was shown to be sustainable throughout the study period. 3) Northern Fennoscandia can be considered a domesticated landscape, even long before the onset of agriculture. The Sami have moved over large areas, but they made well informed decisions on what resources to obtain at what times. 4) A combination of methods from different fields should be used to understand Sami plant use in a subsistence context. By combining methods it is possible to understand both the details of how and why Sami used different plants, but also to investigate historical Sami subsistence at different spatial scales.

Keywords: forest history, interdisciplinary research, Scots pine inner bark, *A. archangelica*, ethnobotany, human land use, hunter-gatherers, subsistence, mobility

Author's address: Anna-Maria Rautio, SLU, Department of Forest Ecology and Management, SE-901 83, Umeå, Sweden
E-mail: anna-maria.rautio@slu.se

I kärt minne av *Elisabet Henriksson*

Tack för att du öppnade dörrar till andra världar.

Det finns mitt i skogen en ovanlig glänta som bara kan hittas av den som gått vilse. Gläntan är omsluten av en skog som kväver sig själv. Svarta stammar med lavarnas askgrå skäggstubb. De tätt sammanskruvade träden är döda ut i topparna där några enstaka kvistar vidrör ljuset. Därunder: skugga som ruvar på skugga, kärret som växer. Men på den öppna platsen är gräset underligt grönt och levande. Här ligger stora stenar liksom ordnade. Det måste vara grundstenarna i ett hus, jag kanske tar fel. Vilka levde här? Ingen kan ge upplysning om det. Namnen finns någonstans i ett arkiv som ingen öppnar (det är bara arkiven som håller sig unga). Den muntliga traditionen är död och därmed minnena. Zigenarstammen minns men de skrivkunniga glömmer. Anteckna och glöm.

Gläntan av Tomas Tranströmer

Contents

List of Publications

This thesis is based on the work contained in the following papers, which are referred to by Roman numerals in the text:

I Rautio, A-M., Josefsson, T. & Östlund, L. (2014). Sami Resource Utilization and Site Selection: Historical Harvesting of Inner Bark in Northern Sweden. *Human Ecology.* 42: 137-146.

II Rautio, A-M., Norstedt, G. & Östlund, L. (2013). Nutritional Content of Scots Pine Inner Bark and Ethnographic Context of its Use in Northern Fennoscandia. *Economic Botany.* 67(4): 363-377.

III Rautio, A-M., Axelsson-Linkowski, W., Josefsson, T. & Östlund, L. \`They followed the power of the plant´. Analysis of historical Sami harvest and use of *Angelica archangelica ssp. archangelica* in northern Fennoscandia. (*manuscript*)

IV Rautio, A-M., Josefsson, T., Axelsson, A-L. & Östlund, L. A quantitative analysis of pre-industrial use of Scots pine resources in northern Fennoscandia: sustainability and spatial patterns of native Sami land use. (*manuscript*)

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Abbreviations

A.D.	Anno domini
B.P.	Before present
CMT	Culturally modified tree
dbh	Diameter at breast height
DW	Dry weight
FW	Fresh weight
NAD	Nicotine adenine dinucleotide
NADP	Nicotine adenine dinucleotide phosphate
NFI	National Forest Inventory
P:A	Plant to Animal
TEK	Traditional ecological knowledge
TNR	Tjeggelvas nature reserve

1 Introduction

Throughout human history, the procurement of food has been the greatest challenge to survival, and it is also the activity which is considered to have had the greatest influence in shaping human societies and their relationships to nature the most (Lee 1968). Food is not just an assemblage of biological items; it is also a cultural construction (Minnis 2000). Your food habits reveal information about your background, such as your age, gender, class, life circumstances and above all what culture you belong to. In the distant past, people consumed localized resources, which obviously differed greatly between geographical regions. Environmental constraints set limits on how and when resources could be acquired. Does this mean that nature played part in the formation of human cultures? And in this process, did human culture affect nature? Ethnobotany has been defined as the study of the interrelationships between people and plants; meaning that plant use is reflected in both the human culture as well as in the ecosystems being used (Pearsall & Hastorf 2011). In this thesis I explore people–plant interrelationships focusing on the native Sami people in northern Fennoscandia. I seek evidence for such interactions in both the Sami culture and the northern boreal forest which they have inhabited for thousands of years.

Over the course of history, many aspects of people’s food habits have changed, maybe most importantly *how* we obtain our food. Indeed, the question of `how´ has been considered so important that societies were traditionally classified dichotomously, as `before´ and `after´ the onset of cultivation (cf. Childe 1936, Bettinger 1991). Human development was viewed as a unidirectional process of transformation from simple hunter-gatherer societies to complex agriculturalists, i.e. from those who simply found their food to those who made their food (cf. Smith 2001). The way in which the true nature of a people was perceived was aligned with this division, i.e. hunter-gatherers were considered to be primitive and culturally backward, while agriculturalists were seen as culturally complex (cf. Krech 1999). The Neolithic revolution came to be regarded as a major turning point in human history. According to Kelly (1992), cultivation required a sedentary life-style and this reduction in mobility caused societal changes affecting, for example, food storage practices, trade, territoriality, gender work patterns and changes in demography, to name only the most important factors. However, over time the so-called middle-ground between these two main subsistence strategies received increasing attention (cf. Smith 2001), as evidence of intensive management and cultivation by native peoples emerged, especially from North America (Deur & Turner 2005). By the 1960s and 70s the complex natures of hunter-gatherer life-styles were recognized and the – often very advanced – strategies that they used to adapt to nature were being acknowledged (Lee 1968). Ford (1985) and Harris (1989) presented new models and theories that treated human development as a continuum between food *procurement* and food *production,* rather than as two steady states. Subsequently, the management of wild plants was recognized as wild food production, a subsistence strategy which was shown to be more than merely a stepping stone in an evolutionary pathway leading from foraging to farming (Peacock 1998).

Smith (2001) argues that the timing of the advent of agriculture should be pushed further back in history, and that the intentional or unintentional domestication of species is the real demarcation point. For it to be possible for humans to begin agricultural practices, it was necessary that hunter-gatherers already had a basic knowledge of how plants grow and spread (Terell et al. 2003); in that sense the initiation of agriculture meant a change in intensity rather than in kind (Rindos 1984). Terell et al. (2003) argues that placing societies in a forager-farmer continuum will not contribute much to an understanding of how people in the past actually made their living and how they related to their surrounding environments. Instead these authors, propose that by classifying the skills by which the resources were retrieved, either as behavioural (adapting to the resources available) or tactical (manipulating a resource to fit one's needs), important social changes over time can be observed. Furthermore, they suggest that an entire landscape can be considered to be domesticated when the people (or animals) inhabiting that place know how to make a living there, regardless of whether the species used are true domesticates or not.

Clearly, the view of hunter-gatherers has changed much over time, both from a scientific perspective and also amongst the general public. As the historian Dening (1996), expressed it:

> “...history is always a metaphor of the past and a metonym of the present”

This implies that we, the people of today, in some sense construct our own history. Hunter-gatherers have consistently been represented as a significant `other´ in comparison to the western world and they have often been stereotyped using contradictory terms, especially with respect to what we are not (Krech 1999). Kaskija (2012) describes the phenomenon in his thesis of the Punan Malinau, a forest dwelling people of Borneo, as:

> “They have provided contrast and therefore served as a kind of mirror, in which we have reflected ourselves, our own supremacy or our drawbacks and failures”.

The traditional view of hunter-gatherers has also influenced interpretations of the ecosystems which they inhabited. Areas that were geographically remote, or marginal from a demographic perspective, which were actually the homelands of hunter-gatherer societies, have often been thought of as *pristine* or *untouched*, simply because the people inhabiting them were considered to be too few in number, and their technology too rudimentary, to leave any long-lasting effects (cf. Peacock 1998). However, the importance of historical anthropogenic disturbance has gained increasing attention during the last couple of decades from ecologists, aiming to understand the structure and functioning of present-day ecosystems (Östlund et al. 1997, Delcourt & Delcourt 2004, Bürgi & Gimmi 2007, Josefsson et al. 2009). The effect of even low-intensity anthropogenic land use has been shown to persist over centuries (Foster et al. 2003, Freschet et al. 2014). Retrieving quantitative data on pre-industrial land use over large regions and landscapes is essential if we are to fully understand the ecological impacts of that land use (Day 1953). However, such data are often very difficult to obtain, mainly because historical population numbers, territory sizes and details of specific practices used for resource extraction are usually not known (ibid). Goldewijk and Verburg (2013) have suggested that in order to improve reconstructions of historical land use per capita more empirical data on a local scale is needed. They also argue that the ecological methods, such as pollen analysis and dendrochronology, can be used to increase our knowledge about the ways in which past land use varied spatially.

Answers to questions of why, how, where and when specific resources were extracted and used are fundamental if we are to increase our overall understanding of past societies, including their mobility and settlement patterns and their impacts on the surrounding environments. Furthermore, it is important to know how intensively plants were harvested in time and space in order to understand the ecosystem effects of such usage. In this thesis I set out to explore the native Sami people's historical use of, and relationships with, two specific plants growing in northern Fennoscandia, Scots pine (*Pinus sylvestris* L.), whose inner bark is used, and *Angelica archangelica* ssp. *archangelica* (L.) as these have been considered to be two of the most important plants in the historical diet of the Sami (Qvarnström 2006, Eidlitz Kuojok 1969).

1.1 Research context and contributions

Northern Fennoscandia differs in several important aspects from most other parts of Europe. It was, and still is, populated by native peoples; the onset of agricultural colonization was very late; and the impact of cultivation on the land has been minor. Today it is still a marginal area from a demographic and geographic perspective. The area is covered partly by the northern boreal forest and partly by the subarctic tundra. The low temperatures prevalent in this region influence both primary production and species diversity (Wiegolaski 1997), which are low in comparison to those of temperate regions. Despite this, people have subsisted here for millennia.

In 1977, the Swedish government acknowledged the Sami as an indigenous people of Sweden and in 2007 they ratified the United Nations' Declaration on the Rights of Indigenous Peoples (Sametinget, www.sametinget.se). Studies from northern Fennoscandia exploring people´s traditional subsistence patterns have largely focused on the roles of hunting, fishing and herding of animals, while the use of plants has not received so much attention (but see Bergman et al. 2004a, Fjellström 1997, Östlund et al. 2009). In native Sami culture, for example, the reindeer has been of crucial importance, providing people with fur skins, transportation, raw material for producing tools and, last but not least, valuable dietary proteins (Fjellström 1985, Hansen and Olsen 2006, Hultblad 1968). An understanding of Sami culture, their world-view and their relationship with nature has therefore been synonymous with an understanding of people—reindeer relationships and research on Sami history has largely focused on this specific aspect of the Sami economy (cf. Bergman et al. 2013). Probably this is in part because the archaeological record is usually devoid of plant material (Forsberg 1985) while objects relating to hunting and fishing, such as projectile points and fishing hooks are more common (Bergman et al. 2004a). However, the use of plants has been identified as an important component in Sami subsistence well into historical times. It is known that people adapted to the low productivity of environments in this region by moving across the landscape to find more resources (Hultblad 1968), processing food to prolong durability, practising storage, changing their diets and trading `sought after´ resources (Eidlitz Kuoljok 1969).

However, to date there have been no published studies from northern Fennoscandia which have attempted to quantify historical plant use or to interpret its importance within the Sami diet. As knowledge on plant use within the Sami community itself has declined during the last 100 years, researchers have turned to historical documents and ethnographic accounts, such as those of Linné ([1732] 1969), von Düben ([1873] 1977), Rheen ([1671] 1897), Graan ([1672] 1899), Lundius (1905) and Læstadius (1928). Previous Sami ethnobotanical research includes the work of Drake (1918), Eidlitz Kuoljok (1969) Fjellström (1963, 1985, 1997, 2000, 2005) and Svanberg and Tunón (2000), to cite the most important studies. These previous works have focused on the compilation of information about the use of individual plant species, addressing the most common fields of use for these plants and the general practices adopted. However, information on specific harvest techniques, processing of raw plant material, storage and the logistics of transport from harvest sites to sites of preparation and consumption are poorly understood. Moreover, timing of harvests, nutritional content of plant material, quantities harvested and potential management methods used for specific resources have not previously been addressed. Such information is, however, crucial if we are to advance our understanding of the role of plants within the Sami diet and the ecosystem effects of the use.

Recently several important papers have dealt with the overall ecosystem effects of early human land use in the northern boreal forest (Freschet et al. 2014, Josefsson 2010a, Josefsson 2009, Karlsson et al. 2009), although on a localized scale. However, we still lack an understanding of the large scale ecological impacts of pre-industrial land use in these regions. A prerequisite for such understanding is quantitative data on past human use of certain resources in a spatially defined area.

1.2 Objectives

The fundamental research questions addressed in this thesis focus on people-plant interrelationships and in particular how these interactions are manifested both in human culture and in the inhabited environment. There is specific emphasis on how, historically the Sami harvested and used Scots pine inner bark and *A. archangelica*, as these two plants have been interpreted as being the most important in Sami culture. They have also been given by far the most attention in historical narratives about Sami plant use and hence they provide the best opportunities for further studies. The study area covers Northern Fennoscandia, a region within the northern boreal and sub-arctic zones that is characterized by a sharply seasonal climate and low-productivity environments. The timeframe of this study covers the period 1550—1900, during which the Sami subsistence mode (sensu Krupnik 1993) was extremely diverse and included reindeer herding, hunting of wild game, fishing and the use of wild plants. In order to fully understand peoples' subsistence, there needs to be an increase in our knowledge about the use of plants *per se*. Furthermore, plant use should be analyzed in the context of a diverse and highly complex subsistence economy and finally, the impact of plant use on the surrounding environment must be quantified and described.

The main foci of this thesis are two aspects of plant use:

1) Evaluating the cultural significance of Scots pine inner bark and *A. archangelica*, when viewed as a discrete form of resource utilization within a larger set of activities which constitute the Sami subsistence mode (sensu Krupnik 1993). The specific questions addressed were:

- What role did plants play within the overall diet, focusing especially on Scots pine inner bark and *A. archangelica*? (I, II, III)
- How did the use of plants interplay with seasonal and annual migratory patterns and choice of settlement sites? (I, IV)
- What do we know about practices regarding plant use, such as harvest methods, preparation/cooking and storage? (II, III)

2) Evaluating the human impact of land use from a perspective of plant use. The specific questions addressed were:

- How has traditional harvest of plants effected the plant populations and what conclusions can we draw upon the potential management of resources from this information? (III)
- Was the harvesting of different resources sustainable and, if so, how, with an emphasis on the techniques and knowledge about plant species and ecosystems that were employed? (III, IV)

Based on the answers to these questions I will a) discuss the historical pattern of Sami land use in a landscape ecology context; how did the components and specific resources of the landscape fit into the annual and intra annual movement patterns? and b) discuss how centuries or even millennia of Sami land use have caused domestication of the landscape (cf. Terell et al. 2003) and how we can interpret this process today.

2 Background

2.1 From hunters to pastoralists: the economy of the Sami in history

People have been present in the inland areas of northern Fennoscandia since the melting of the ice during the last glaciations, 8500-9000 B.P. (Bergman et al. 2004b), initially subsisting as hunter-gatherers. During the first half of the 20th century, researchers assumed that the Sami people had migrated into this region from somewhere else, and the focal question was from where? However, today the common view is that a Sami ethnicity developed within the region around 0-900 A.D., as a result of economic differentiation between societies, i.e. between farmers and hunter-gatherers (cf. Hansen & Olsen 2006). Early on, the native Sami people subsisted by hunting wild reindeer alongside fishing and the gathering of wild plants. Eventually the Sami started domesticating wild reindeer using decoy animals (ibid.). At what time this transition first occurred has been a topic of much debate within the research community. Early research suggested that it occurred from the 17th century onwards as a result of the high burden of taxation imposed by the national states (Lundmark 1982). The Sami usually paid tax in the form of dried fish or fur skins (or both), depending on their main mode of subsistence. This practice is believed to have depleted the populations of specific game species to the extent that people could no longer sustain themselves by hunting these animals and were therefore forced to start keeping domesticated reindeer (Lundmark 1982). More recent archaeological investigations have shown that this transition is most likely to have been of much earlier origin, dating back to AD 850-1050 (Bergman et al. 2008, Storli 1994). The timing of the transition has been considered important because it marks a change in social organization, from the common sharing of prey by members of a hunter-gatherer band to the privatization of domesticated animals, allowing individual Sami to gain power due to the possession of private property (Ingold 1980).

A very intensive form of reindeer husbandry prevailed throughout the 19th century; during this period a moderate number, commonly 200, reindeer per family (Lundmark 1982) were herded intensively and milked. The Sami continued hunting and gathering alongside this intensive reindeer herding until modern times, i.e. the early 20th century, when larger herds with up to several thousand head became common. The preferred game species were ermine (*Mustela erminea* L.), marten (*Martes martes* L.), red-squirrel (*Sciurus vulgaris* L.), beaver (*Castor fiber* L.), wolverine (*Gulo gulo* L.) and brown bear (*Ursus arctos* L.) (Linné [1732] 1969), which were hunted along extensive trap-lines in the forest landscape (Josefsson 2009). In the lakes European perch (*Perca fluviatilis* L.), northern pike (*Exos lucius* L.), grayling (*Thymallus thymallus* L.) and whitefish (*Coregonus spp*.), which were caught from the lakes using nets, made important contributions to the daily diet (Fjellström 1985). By cutting a specific type of sedge growing on wet mires, the Sami obtained additional fodder for both the herded reindeer and occasional goats (*Capra spp.*). Construction material, for houses (both permanent wooden houses and moveable tent huts), sledges, and tools and weapons was obtained from the Scots pine forest. Wild plants, including those producing berries, which acted as an important nutritional, energy and medical resource, were collected from different habitats in both forest and mountain regions (more information about specific plants is given below).

Seasonal migrations have been a trademark of this nomadic people, but the degree of nomadism and the main subsistence strategies have varied over time and in between different local communities. The most in-depth information available regarding the historical Sami economy covers the 19th century, particularly the latter half, and inferences further back in time have largely been drawn on the basis of this information (Manker 1947, Ruong 1969). From the late 19th century records, a distinction has been made between *full-nomadism* and *semi-nomadism*, the former term indicating that the entire Sami family undertook constant migrations together with their reindeer herd throughout the year, while the latter implies migration during the summer but a stationary life-style at a fixed settlement site during winter (Ruong 1944, Collinder 1953, Hultblad 1968). These two forms of nomadism have also been coupled to the geographical locations inhabited by of two main groups of Sami that use different subsistence strategies; the *mountain Sami* and the *forest Sami,* the former being considered full nomads and the latter semi-nomads (Hultblad 1968). The mountain Sami moved between grazing their reindeer in the mountain areas during summer to winter grazing in low-land forest, while the forest Sami stayed within the low-land forest all year round. The mountain

Sami commonly had larger herds and are believed to have subsisted mainly on the meat of their domesticated animals, while the forest Sami had far fewer reindeer, which were predominately milked, and their main subsistence came from hunted meat and fish (Rheen [1671] 1897, Læstadius 1928). According to Nickul (1970), the extent to which the Sami diversified their use of natural resources depended on the diversity of the ecosystems which they inhabited. Traditionally, control over natural resources in this region was implemented through division of the land into territories, the so-called taxation lands (Swedish *lappskatteland*). These taxation lands are known from Swedish 16th century cameral records (Hultblad 1968), and the entire Umeå lappmark has been investigated in depth by analysis of a 17th century map (Norstedt et al. 2014), and a small part of the northern Pite Lappmark has been studied by analysis of cameral records (Josefsson et al. 2010b). Much work from the 20th century has classified historical Sami subsistence dichotomously as mountain or forest; however there are several indications that such a division was not always clear-cut, especially further back in time. For example, the missionary priest Graan ([1672] 1899) wrote about the Sami in Pite Lappmark:

> "If a forest Sami only has a few reindeer he will send them with his wife or children to the mountains in summer time, where she, together with the mountain Sami can tend and milk the reindeer. The Sami himself stays in the laplands (reads forest) and pursues his subsistence by fishing. Towards autumn the wife returns from the mountains again"

Furthermore, the priest Jonas Högling described how during the 1740s some Sami in two traditional forest Sami villages, Socksjock and Jokkmokk, actually moved to the mountains in summer-time (Qvigstad & Wiklund 1909). Josefsson (2010b), who analyzed three taxation lands in Pite Lappmark during the period 1700-1900 with regard to the natural distribution of mountain heaths, mountain birch forest and Scots pine forest, remarks that the total area of these specific resources was large enough to sustain the number of people who were residing there throughout the year. He also suggests that people moved seasonally within their taxation lands, implying a geographical pattern similar to that of mountain Sami, but covering much shorter distances on an annual basis. On the basis of the inconsistency within Lule Lappmark (16th and 17th century taxation records) as to whether the Sami were placed in a forest or mountain context, Hultblad (1968) argues that the migration pattern should instead be divided into six categories which better reflect the many intermediate forms which existed historically.

As this thesis covers the period 1550—1900 we can assume that at that time the Sami were still practicing a wide variety of activities and that reindeer were still being herded intensively. I acknowledge that there was an ongoing transition towards larger herds and a greater reliance on herding, especially towards the end of our study period. I adhere to the view of Hultblad (1968) that the Sami subsistence strategy could be viewed as a continuum between the mountain and forest Sami strategies. To conclude, the Sami had to use a wide range of resources to survive in a low-productivity environment like northern Fennoscandia. Moreover, to allocate seasonal and area specific resources appropriately the Sami had to practice flexible and highly organized subsistence strategies.

2.1.1 Plant use

Although fish and meat were the main components of the Sami diet, as for all other circumpolar peoples, it is well known that wild plants were also much used both for food and medicine in historical times (Eidlitz Kuoljok 1969). During the industrialization era many new commercial food products became available to the Sami and their traditional harvesting of plants decreased rapidly (Qvarnström 2006), as did many other traditional customs, at the end of the 19th and beginning of the 20th century. Today traditional knowledge of plant use within the Sami society has declined, in part because oral transfer of knowledge from the elders to the children is not as commonly practiced as before (Huuva 2010). In this chapter I will address the plants that were most commonly used by the Sami historically, as described in the historical sources and more recent publications, to create a frame of reference in which to discuss the two specific plant species covered in this thesis, namely *A. archangelica* and Scots pine (more detailed information about these species is given in chapter 2.1.2 and 2.1.3 respectively).

The use of certain plant species to preserve reindeer milk is described in detail in the historical sources (Drake 1918), indicating the importance of reindeer milk in the past. As the reindeer could not be milked during winter and early summer, the Sami preserved the summer and autumn milk for later consumption (Drake 1918) by adding a number of different herbs, most commonly garden Angelica (*A. archangelica* L.) (Rheen [1671] 1897), meadow sorrel (*Rumex acetosa* L.) (Linné [1732] 1969), alpine sorrel (*Oxyria digyna* L.) and alpine blue sow-thistle (*Lactuca alpina* L.) (Svanberg & Tunón 2000) but also rosebay (*Epilobium angustifolium* L.), wolf's-bane (*Aconitum lycoctonum* L.) and common lady's mantle (*Alchemilla vulgaris* L.) (Drake 1918). The plants were harvested early in the growing season, when they were most tender (Svanberg 2000). After they had been boiled in water the plant parts were cut up finely with a knife and mixed with the milk in large barrels (Svanberg 2000) or in an emptied reindeer stomach (Fjellström 1985). To allow space for the mixture to ferment, the containers were only part-filled; they were buried in the ground, where the milk lasted for years. Depending on which plant species was used the dish had different names. A mixture of milk and sorrel was called *juobmo* (Lule Sami) or *jåamoe* (South Sami) (Aronsson 2000), the use of *A. archangelica* L. resulted in the name *gompa* (Ågren 1976), if Alpine blue sow-thistle was added it was called *järja-gompa* (Svanberg 2000) and with rosebay it was *abrek-kombo* (Fjellström 1985). In historical records the different plants that were mixed with the milk were often referred to only as \`grass´, which complicates interpretation of the practice. One can assume that the wide variation in species used depended on local availability of plant species. *A. archangelica*, alpine sorrel and alpine blue sow-thistle are distributed naturally throughout the Fennoscandian mountain region. *A archangelica*. has a more northerly distribution, with alpine blue sow-thistle occurring further south. This is also reflected in the pattern of use by the Sami, as *gompa* prepared by south Sami usually contained *järja* as well (Svanberg 2000). *Järja* was also consumed raw; the young stalks, which before the plant started flowering, were peeled and the innermost part was eaten (Ågren 1976).

Meadow sorrel, in contrast, is common all over Sweden. Sami who resided in the forest during summer time were therefore more likely to use this species. It is a perennial herb and the Latin name *acetosa* implies that it has a sour taste; this is especially true of the leaves, which contain oxalic acid (Den Virtuella Floran, www.linnaeus.nrm.se/flora/), and if consumed in very large quantities meadow sorrel is considered to be toxic. Historical records state that meadow sorrel grew abundantly on reindeer pastures, especially within milking pens (Swedish renvallar) (Rheen [1671] 1897). Information about the Sami in Enontekis, northern Finland, shows that they sowed *Rumex spp*. within reindeer milking pens during spring to increase the resource available for summer-time when the reindeer were milked there (Paulaharju 1977). This practice has been interpreted as one form of early agriculture (Itkonen 1948). Pollen analysis has confirmed that herbs with a high nutrient demand thrive in reindeer pens, as they are fertilized by reindeer manure, and today old milking pens can still be identified through pollen records, thanks to the high levels of such herbs, especially meadow sorrel, that were present (Aronsson 1991). A record of a legal dispute in the 1820s tells how some farmers were forbidden to entrench the milking pens of a Sami, since these were important habitats for this particular sorrel (Svanberg & Tunón 2000), further confirming the importance of such places historically. One Sami family could have as many as

30-50 milking pens to alternate between (Aronsson 2000), although approximately 8-10 were used in any one summer (Ruong 1944). Special care was taken in pens where sorrel grew abundantly as the plants are damaged by too heavy trampling (ibid). In addition to preserving reindeer milk, meadow sorrel was also boiled into a sort of porridge (Aronsson 2000). There are data on the use of meadow and mountain sorrel throughout the entire circumpolar area, by Chukchi in Siberia, Sami in Fennoscandia, and Inuit on Greenland and Alaska (Eidlitz Kuoljok 1969) as well as Norse settlers on Greenland, the Faroe Islands and Iceland (Svanberg & Ægisson 2012).

Lingonberries (*Vaccinium vitis-ideae* L.), crowberries (*Empetrum nigrum* L.) (Rheen [1671] 1897, von Düben [1873] 1977), blueberries (*Vaccinium myrtillus* L.) (Rheen [1671] 1897) and cloudberries (*Rubus chamamourus* L.) (Drake 1918) were also mixed into the *gompa* to preserve it for consumption in winter-time (Qvarnström 2006) or eaten together with fish (Rheen [1671] 1897). The use of wild berries in Sweden increased in the early 20th century as sugar became cheaper and more readily available to the common people (Svanberg 2012). Sugar was used to preserve the berries by making jam. The extent to which the Sami picked berries in the past is largely unknown, but there are descriptions of how they preserved cloudberries by boiling them, without added water, but with a very small amount of salt (Rheen [1671] 1897, Graan [1672] 1899, Qvarnström 2006). They buried the containers of cloudberry jam in the ground for later consumption; it was supposed to taste `as if they had just been picked´ (Graan [1672] 1899). Bog bilberry (*Vaccinium uligonosum* L.) was considered unpalatable by the Sami (Drake 1918); however berries of rowan (*Sorbus aucuparia* L.) were consumed both fresh and dried (Qvarnström 2006). Amongst the Skolt Sami in Finland, crowberries were the most appreciated berry. They even called this fruit simply `berry´, as though it was the only berry consumed (Itkonen 1948). It has been estimated that approximately 35-40 kg crowberries were picked yearly per Sami family (ibid).

In northern Sweden there are several species of birch (*Betula spp*.) and the Sami either drank the birch sap fresh (Qvarnström 2006) or used it to make gruel (Svanberg et al. 2012). There is a widespread historical tradition of using sap from birch in many European countries, mainly thanks to its high sugar content (Svanberg et al. 2012). Instead of salt, which was difficult to obtain, dried birch bark was used. Many different parts of the birch were also used to cure a wide variety of diseases. For example, the bark could be used as a compress on wounds and swellings (Qvarnström 2006), the birch wood-fungus (*Fomes fomentarius* L.) was burnt and used when bloodletting and to keep insects away (Svanberg & Tunón 2000, Linné [1732] 1969) and birch leaves were used to cure both urethritis and problems in urination (Qvarnström 2006).

Several plant species were used only for medical purposes; these include yarrow (*Achillea millefolium* L.), mezereon (*Daphne mezerum* L.), juniper (*Juniperus communis* L.), tormentil (*Potentilla erecta* L.) (Qvarnström 2006), mountain avens (*Dryas octopetala*) (Linné [1732] 1969) and devil´s dung (*Ferula assa-foetida* L.) (Alm 2004). Tormentil was also used as a coloring agent together with the bark of grey alder (*Alnus incana* L.). Other plants were used for their pleasant smell, for example wood-millet (*Milium effusum*) (Linné [1732] 1969, Ågren 1976), which was carried together with the tobacco. The polypore (*Haplopous odorus* L.) was used by Sami men as a perfume (Linné [1732] 1969). Sedges (*Carex* spp. but predominately *Carex inflata* L. and *Carex vesicaria* L.) were used as insulation in reindeer fur shoes (Linné [1732] 1969, Ågren 1976). After harvest the sedges were dried and combed with an iron comb. Finally the Sami rubbed the plant material between their hands until it was soft. This insulation was used both in winter to avoid the cold and in summer to avoid the heat. Common haircap moss (*Polytrichum commune* Hedw.) was used as bedding (Linné [1732] 1969, Ågren 1976). Genereally the female variant of the moss was used as the male capsules caused skin irritations. This moss usually grows like large mats in the forest, and these were cut into pieces which were used both to lie on and to cover oneself with. White moss (*Sphagnum* spp.) was used as diapers for children, as it can absorb large amounts of water (Linné [1732] 1969, Ågren 1976).

2.1.2 Angelica archangelica

A. archangelica L. is a large herb, which when fully grown can reach up to 1.5-2 meters in height. In the literature it is usually described as a biannual monocarp plant (meaning that it wilts and dies after flowering, which only occurs once, usually in the second growing season) (Fjellström 1997, 2000). Other sources simply state that it is a long-lived monocarp (Jonsell & Karlsson 2010), which I also noted in Paper III. The plant belongs to the *Apiaceae* family and the umbel is light green and the size of a football. The species is native to northern and northeastern Europe, central and northern Siberia, Greenland and Himalaya (Jonsell & Karlsson 2010).

A. archangelica was a highly appreciated by the Sami, who used different parts of the plant throughout its life-cycle for so many applications that it was almost as though they were using several different plant species (Fjellström 2005), a fact which also confused Linné during his travels through Lapland. Apart from being a component of the milk dish *gompa* (described under plant use), the plants were used in numerous other ways. The first year roots (Sami *Urtas*) (Fig. 1a) were harvested early in the spring (Qvarnström 2006, Ågren 1974), when they were considered to be at their most powerful. The roots were dried and cut into small pieces which were prophylactic against colds and stomach problems. It was especially common to chew the root during the winter at markets where the Sami met many people and risked catching infections (Fjellström 2005). There are also descriptions of how the root was boiled in meat soup to add flavor (Huuva, personal com). The first year infertile plant (Lule Sami *Fáddno*) (Fig 1b) was peeled and eaten raw, as one can consume rhubarb.

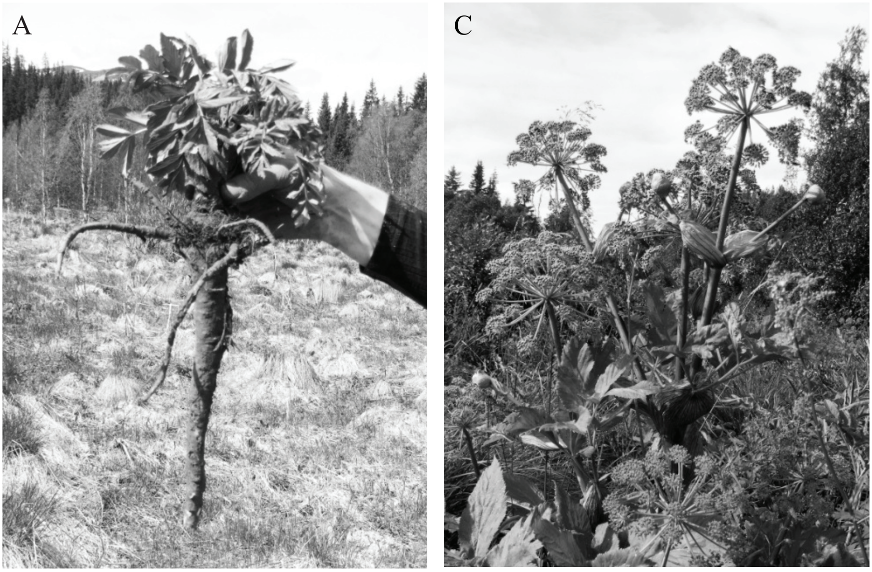

Figure 1) Different life-stages of the A. archangelica L. plants. A) Root harvested in June 2011 at Järnforsen. B) Infertile plant, petioles only, photographed in July 2011 C) Flowering plant with large umbels, photographed in July 2011. All photographs were taken by the author.

When flowering (Lule Sami *Båsskå*) (Fig. 1c), the plant has a very sharp odor and taste. The stalks were harvested in late summer, peeled and dried in the sun or above a fire, and they could then be stored for subsequent consumption in spring and winter. The seeds were most commonly harvested for use in the *gompa*.

A. archangelica was also a well–known and widely used food and medicinal plant in Greenland, the Faroe Islands and Iceland, ever since the first settlements arrived there (Svanberg & Ægisson 2012). Most of the plant was gathered and consumed. The stalks, leaves, seeds and roots were all eaten fresh, fried or boiled. *Heracleum* sp, other large herbs within the Apiaceae family, whose ecology is very similar to that of *A. archangelica*, were harvested and used in very much the same way by native peoples in North America (Kuhnlein & Turner 1986, Johnson-Gottesfeld & Anderson 1988) and Siberia (Manninen 1931). In the Himalayan distribution range, *A. archangelica* is a highly valued medicinal plant (Kala 2000) but it is currently threatened with extinction due to unsustainable commercial harvesting (Vashista et al. 2006, Vashista et al 2007).

2.1.3 Scots pine inner bark

Scots pine (*Pinus sylvestris* L.) is a native tree to Sweden; it was the first conifer tree-species to migrate into what we now term southern Sweden, after the last glaciation around 11 000 to 10 000 years ago (Berglund et al. 1996). It is a pioneer species which thrives in open places. It has a taproot and grows on almost any type of ground, but forms the best stands on dry and nutrient poor soils where it can outcompete the Norway spruce (*Picea abies* L.). Thanks to its elevated crown and branchless stem it is well adapted to survive fires, which were the greatest form of natural disturbance in these northerly ecosystems in the past.

The inner bark of a tree is found just beneath the coarse outer bark. It is a living tissue only a couple of mm in thickness and consists of vascular cambium and secondary phloem (Fig 2a). The function of the inner bark is to transport photosynthates from the needles to the cambial zone, where radial growth of the tree takes place. The use of tree inner bark as food by native peoples is a well known and well documented practice throughout the entire circumpolar region, including regions such as Fennoscandia (Itkonen 1948, Zackrisson et al. 2000, Bergman et al. 2004a, Östlund et al. 2009, Sjögren & Kirchhefer 2012), Eastern Siberia (Middendorff 1875, Argounova-Low 2009) and North America (Gottesfeld 1992, Mobley & Eldridge 1992, Prince 2001, Turner 1988a, Mobley & Lewis 2009, Turner et al. 2009, Josefsson et al.

2012). North American groups further south in New Mexico are also known to have practiced this resource use (Swetnam 1984, Kaye & Swetnam 1999).

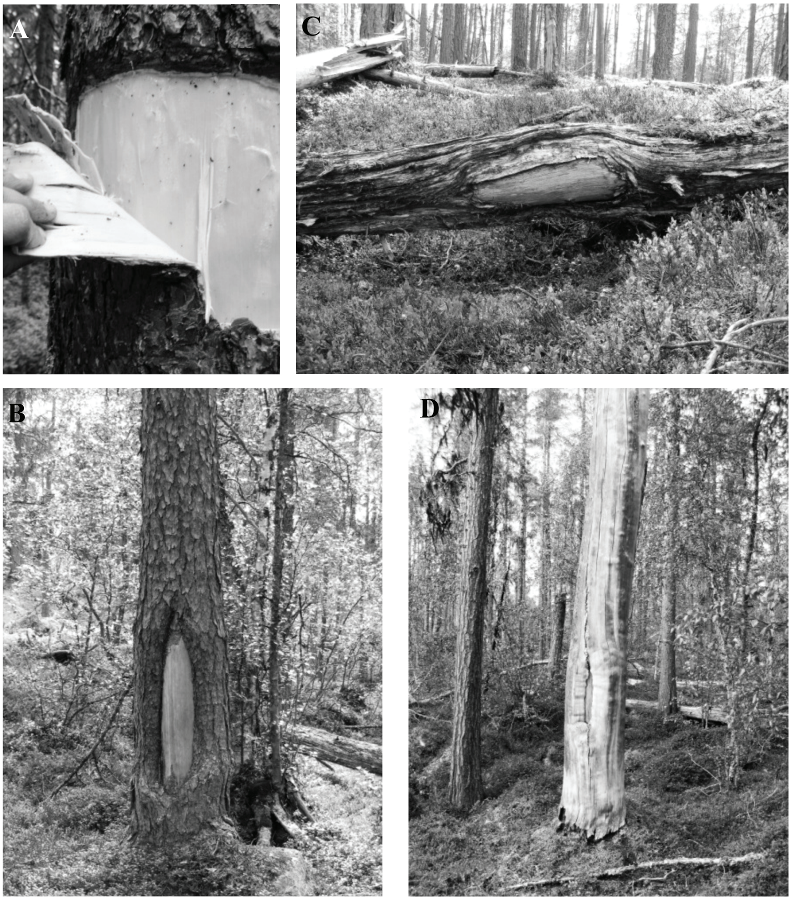

Figure 2. Bark-peelings at different stages after harvest. A) Freshly prepared bark-peeling. The inner bark adheres to the outer bark. B) Bark-peeling on a standing still living tree. C) Bark-peeling on a log which is highly decomposed. As the wood behind the bark-peeling itself is impregnated with resin, the scar surface is usually the last part of the log to decompose. D) A bark-peeling on a standing dead tree. All photographs are taken by the author.

The tree species used for inner bark as a food differ widely between geographic regions or even between different cultural groups of people within the same region, and both coniferous and deciduous species are known to have been used (Kuhnlein & Turner 1991, Keyland 1919). Interpretations of the use of this specific food resource have been wide-ranging and in the circumpolar north it has been described as a famine food, staple food, health food or even a delicacy (Turner et al. 2009).

In Fennoscandia, both farmers and native Sami have used the inner bark of Scots pine, but farmers are known to have also used birch, (*Betula sp*. L), beech (*Fagus sylvatica* L.), lime (*Tilia cordata* L.) and goat willow (*Salix carprea* L.), though to a much lesser extent (Niklasson 2005). Because the way in which the two groups harvest inner bark are very different, it has been suggested that the practices were culturally distinct, though they were taking place during the same period (ibid, Korhonen 2000). The farmers usually felled entire trees before harvesting while the Sami harvested standing living trees (Zackrisson et al. 2000, Bergman et al. 2004a, Östlund et al. 2004). The Sami had a practice of leaving a strip of live cambium, at least three fingers in width, on the back of the trunk to ensure the tree's survival. Very old Scots pine trees with characteristic window shaped scars in their trunks, are therefore still visible today in unlogged forests in northern Sweden (Fig. 2b-d). This allows for very precise dendrochronological dating of the time of harvest, an approach that has been used to understand spatial and temporal patterns of the practice in both North America (Prince 2001, Östlund et al. 2005) and Fennoscandia (Niklasson et al. 1994). The oldest archaeological evidence of the use of Scots pine inner bark have been dated to 2800 B.P, based on a cultural imprint (the window shaped scar, as described above) on a Scots pine tree, which was found in a mire of northernmost Sweden. The oxygen free conditions had preserved the log very well and the wood was dated using the C^{14} method (Östlund et al. 2004). Other studies have suggested that the Neanderthals of Europe were already eating inner bark during the Paleolithic (Sandgathe & Hayden 2003).

Another important difference between the Sami's and the farmer's use of Scots pine was the time of harvest. The Sami harvested the inner bark in spring/early summer and in Sami the month of June is actually called *Biehtsemánno* (Lule Sami, the pine month), a good example of how the overall Sami conception of time is related to seasonal tasks and activities rather than to the linear western time frame (Bergman 2006). Similarly, the native Coeur d´Alene people in North America referred to the season of inner bark harvest as "the bark loose on tree month" (Teit 1930). Farmers, on the other hand, harvested inner bark whenever they needed it, usually in times of famine and the bark bread was strongly coupled to times of hunger (Niklasson 1996). The question of substitutes for bread baking was a much discussed topic among the scholars in Sweden during the second half of the 1700s (Räsänen 2007). This was a period characterized by frequent periods of famine, especially during the decades of war. Carl von Linné (1757) wrote extensively on the subject and gave several suggestions on different plants which could be used for baking bread, such as the roots of Rosebay, Alpine Bistort (*Bistorta vivipara* L.) and Angular Solomon´s seal (*Polygonatum odoratum* (Mill.) Druce), to mention a few examples. Hellens (1782) also covers the use of Scots pine inner bark as a bread substitute, particularly amongst Finnish farmers. He describes how the inner bark should be boiled and leached both before and after drying and roasting, to get rid of the ill-tasting secondary compounds. He also states that the bark bread made from Scots pine inner bark is palatable if consumed with `heavy food´, however very ill-tasting together with a lighter meal. Finally, he notes that in Inari (Finnish Lapland) the bark flour is mixed with `all sorts of food´.

We also know that the Sami used the inner bark to make a kind of wrapping, by folding the inner bark which hardened when dried and formed a rolled up case (Zackrisson et al. 2000). These wrappings were used to store reindeer sinews, which were prevented from rotting due to the antiseptic properties of the inner bark. Such rolled up cases were called *suotna-goulmas* in the Lule Sami dialect (Grundström 1946-54). The sinews were used as thread for sewing and commonly they were chewed to soften them for this purpose. The inner bark apparently gave the sinews a very pleasant taste. It is possible to distinguish between the use of inner bark for food and for making wrappings in the archaeological record, due to the different sizes of the peelings. Bark-peelings taken for food were larger, about 1 meter in length, while the single *suotna-guolmas* were made in two sizes, a smaller and a larger type. The smaller were about 35 cm and the larger about 55 cm in length (Zackrisson et al. 2000).

3 Environmental setting

The fieldwork reported in Papers I-IV was conducted in the western part of Norrbotten and Västerbotten Counties, in the northern boreal zone of Sweden 65-66°N, 17°E (Fig. 3). The region extends along the upper parts of the Pite River and Vindeln River Valleys. The Caledonian mountain range (Swedish; *Skanderna*) extends in a north-south direction and constitutes the national border between Sweden and Norway. The elevation decreases from this mountain range in the west towards the sea level on the Bothnian coast in the east.

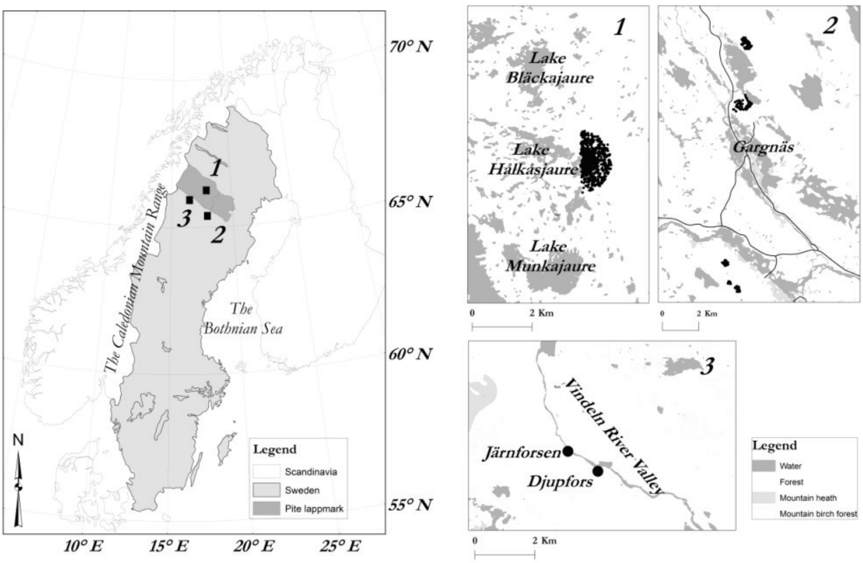

Figure 3. Location and detailed map of Pite Lappmark, showing the locations of study areas used for Paper I, II and III respectively. Black dots in map 1 and 2 represent inventoried trees. Black dots in map 3 represent the entire study areas. © Lantmäteriet i2012/901.

Since the four studies in this thesis were intended to elucidate different aspects of Sami plant use, each study area was selected based on the basis of different criteria. Study area I (Paper I) is situated within the Tjeggelvas Nature Reserve (TNR). The TNR is a large (approximately 330 km^2) forest landscape with no roads and no history of modern logging, one of the last of its kind in Europe. Numerous cultural remains of historical Sami activities are therefore still visible in the landscape. In the study by Josefsson (2010a), the area east of lake Hålkåsjaure, stood out as being particularly rich in bark-peeled trees, and it was therefore chosen for this study. The field-inventory was undertaken in a semi-circular area with a radius of 1 km extending from the shore of the lake eastwards. This corresponded to an area of approximately 150 ha. The landscape is characterized by late successional Scots pine trees with scattered downy birch (*Betula pendula* Erhr.). The terrain is very difficult to traverse, due to the hilly terrain and the many small lakes and mires interspersed within it. Large boulder fields and shrubby under-vegetation of dwarf birch (*Betula nana* L.) further restrict the accessibility of the area. The field layer has low species diversity and is dominated by *Vaccinium* and *Empetrum* species. In moist locations, the bottom layer is characterized by mosses such as *Pleurozium schreberi* (Brid.) Mitt., *Hylocomium splendens* (Hedw.) Schimp and *Dicranum* species. The drier parts are mainly dominated by ground lichens, such as *Cladonia, Cetraria* and *Stereocaulon*.

Figure 4. View from above of the central parts of the Tjeggelvas Nature Reserve; Lake Munkajaure can be seen in the front and Lake Hålkåsjaure in the far back. Photograph taken by the author.

Study area 2 (Paper II) consists of three smaller sites which are situated in and around the village of Gargnäs in Sorsele municipality, Västerbotten County. In a large-scale study on bark-peeled trees from northern Sweden this particular region showed many examples, indicating that inner bark harvesting traditionally took place here. The sites were all selected on the basis of three main criteria. First, the forest stand had to be dominated by Scots pine, second, the mean age of the stand should be about 100 years and third, the trees should have an average diameter at breast height (dbh) of 20 cm (these were the main characteristics of a bark-peeled tree at the time of harvest according to Zackrisson et al. 2000). In terms of species composition, the three stands resemble the study area (area I) in TNR. However, the age and diameter structure is fundamentally different, as these stands have been cut over at least once in the recent past and are thus very homogeneous.

Figure 5. The Djupfors study area in June 2013. The *A. archangelica* has started flowering and form unusually dense stands. Photograph taken by the author.

Study area 3, (Paper III) consists of two sites, Djupfors (5000 m^2) (Fig. 5) and Järnforsen (3600 m^2), which are also situated in Sorsele municipality. The sites are two open fields which are situated immediately adjacent to the Vindeln

River, spaced approximately 1 km apart. The fields are occasionally flooded and they exhibit moist conditions all year round, allowing *A. archangelica* to thrive and form quite dense stands. Other species present are sorrel (*Rumex acetosa* L.) Alpine sorrel (*Oxyria digyna* L.) Wolfsbane (*Aconitum lycoctonum* L.) and sedges (*Carex* spp.), all of which are also highly valued plants by the Sami.

The study area for Paper IV was Pite Lappmark, i.e. the Pite River Valley at the present-day administrative borders of the Arvidsjaur and Arjeplog municipalities. The name *lappmark* implies that historically this area was the land of the Lapps/Sami. By the middle ages, the entire northwestern part of Sweden was already divided into different lappmarks along the large rivers flowing from west to east. This division was first and foremost a way to organize the collection of tax, which had to be paid by the Sami to the Swedish state for rights to use land and water resources (Lundmark 1982). Pite Lappmark is almost 21 000 km^2 in area and it extends from the Norwegian border to the Scots pine basin in the middle of the country. The far northwestern parts are mountainous and consist of a subalpine and an alpine part. The southeastern part is coniferous forest. The position of the tree-line varies within Lappland, but it lies between 600-1000 m.a.s.l. (Carlsson et al. 1999). This position is mainly determined by climate, which affects nutrient cycling, but also locally by anthropogenic factors, such as the historical cutting of firewood by Sami and intensive reindeer grazing. The subalpine area which marks this tree-line is a mixed coniferous-birch forest belt, dominated by mountain birch (*B. pubescens* Erh. ssp. *czerepanovii*), but with occurrences of Scots pine and Norway spruce (*Picea abies* L.) (Lundqvist 1968). Mountain birch is a hybrid between *B. pubescens* and *B. nana* and it occurs as both single- (monocormic) and multiple-stemmed (polycormic) trees (Carlsson et al. 1999). The alpine zone is situated above the tree-line and is characterized by barren mountain heath. The coniferous zone in Pite Lappmark is generally dominated by Scots pine but in the more productive sites Norway spruce dominates. Throughout the drier sites there are scattered occurrences of downy birch trees (*B. pubescens* Ehrh.) and in the wetter locations goat willow (*Salix caprea* L.) and grey alder (*Alnus incana* (L.) Moench) are also present.

To conclude, from a human subsistence perspective the region contains all the different environments important for the Sami subsistence, such as forest for winter grazing, mountain heaths for summer grazing, lakes and streams for fishing and mires from which to obtain fodder for their animals.

4 Methods

In order to determine and understand complex historic people-plant interrelationships, I believe that different methods must be applied. The reason for this is that patterns of plant use can be explained by a nature-culture interaction, i.e. the natural conditions prevailing in a specific environment and human traditions both determined what plant species and what individual plants were harvested, and how, when and in what quantities the harvests were carried out. Combining ecological and historical methods is therefore crucial (Salick 1995). In order to explore the historical events discussed in this thesis, it was necessary for me to use both written and environmental records. Each of these types of record has its strength and weaknesses, but the weaknesses can be overcome by combining several lines of evidence (Whitney 1994).

I approach this work from the initial perspective that people act mainly as a consequence of logical reasoning. I also take into account the archaeological record, for example the spatial and temporal pattern of bark-peeled Scots pine trees, as a clue to how and why these trees were harvested. They are not simply the result of random behavior. I believe that the harvest strategies employed in historical times and the specific times of harvest (as evidenced by historical records) contain important information about the nature and properties of specific resources as well as contributing to an understanding of the role of a food. In order to increase our overall understanding of Sami plant use and the driving forces behind these uses I made use of inventories of existing cultural remains (in this case bark-peeled trees), practical harvest experiments, nutritional analysis and interviews as well as historical records.

As my primary objective for this thesis was to understand the role of plants within the Sami diet, I began the first project (Paper I) by making an inventory of an area that contained a large number of bark-peeled Scots pine trees. By using dendrochronological methods I was able to assign every bark-peeling to a certain time period. Size measurements were also made, to account for outtake of resources over time. However, during this work an interesting spatio-temporal pattern emerged. Some areas and even some trees within an area, were preferred over others. I needed to carry out a nutritional analysis to further understand the benefit obtained by, consuming this resource, and I hypothesized that this nutritional analysis might also be able to shed light on the spatial pattern of harvest which I had observed. I therefore designed a experiment in which Scots pine inner bark would be harvested (in as close a manner to traditional methods as was possible) to enable me to investigate differences in soluble sugars between stands, between trees and at different times. I was also interested in understanding the nature of plant harvesting. Were the Sami opportunistically harvesting whatever resources occurred naturally or did they actually maintain stable populations of plants and/or improve them in any way? Such information is not available from the historical records of plant use. In parallel with the work described in Paper I, I therefore initiated a harvest experiment using *A. archangelica*. The experiment was mainly aimed at investigating survival rates and effects on plant populations after application of traditional management methods (Paper III). The species has a life-cycle characterized by dying after flowering, which when conditions are favorable, takes place in the second growing season. I was intrigued to see whether I could prolong the life span of the plants by means of any of the traditional Sami harvest methods. This experiment was ongoing from 2011 until 2013 to enable me to study the effects of harvest over a period of 3 years. To put my ecological results into perspective I interviewed a knowledgeable Sami woman about Sami traditions related to the harvest and use of *A. archangelica*. Finally, to understand the quantitative impact of past Sami land use on the ecosystem in a larger landscape and time perspective, I used a combination of approaches (Paper IV). As Scots pine is the most abundant tree species in the study region, and the single most important natural plant resources for the people residing here, it was natural to focus on the use of this specific plant. Scots pine has been used in numerous different ways by both Sami and farmers, by early commercial loggers and by the present day forest industry. To put Sami land use into perspective, I contrasted the quantities of Scots pine used by them with those taken by farmers and early commercial loggings in the region. Quantitative data on pre-industrial land use are important tools with which to approach an understanding of what natural forests once looked like and in what ways they differ from current forest conditions.

Below follows a more detailed description of the different methods applied in this thesis, together with their strengths and weaknesses.

4.1 Archaeological survey of cultural remains

For the study in Paper I, an inventory and sampling of bark-peeled trees was carried out along 20 meter wide transects bordering to one another. The inventory was conducted within a semi-circle of radius 1000 meters; corresponding to an area of approximately 150 ha. All bark-peelings found were recorded, the height and width of each open scar were measured to allow for quantitative estimations, and the cardinal direction of the scar was determined in the field. The bark-peelings were identified based on the following criteria: their characteristic rectangular shape and their height on the stem (the lower cut being approximately 1 meter from the base). Moreover, sometimes the knife cuts are still visible on the wood surface in the upper and lower parts of the open scar. The sizes of the open scars vary significantly, and Zackrisson et al. (2000) were able to distinguish between bark peelings for food (size; 96.4 ± 1.17 cm) and bark peelings for making wrappings, (size, double rolled up case 56.9 ± 0.4 cm, single rolled up case, 34.3 ± 0.55 cm). I sampled all bark-peelings that I found within a 500 meter radius of the center-point of the semi-circle. Living or dead standing trees were sampled with an increment corer and cross-sections from downed logs were obtained using a hand saw. Other cultural remains, such as storage platforms (Fig. 9a) and hearths (Fig. 9b) were also inventoried and recorded (see also Paper I), as they provide additional information about settlement patterns and logistics in relation to inner bark harvesting. Culturally modified trees (CMTs) of this kind are very good sources of data since they provide information about the exact timing and place of an activity (for more information on sampling and dating techniques, see dendrochronology), which is very rare with other uses of plants. This type of total inventory is particulary useful if the size of the area of interest is geographically limited. It provides unique opportunities to find the rare objects in the cultural landscape. However, if they are not subsequently compared to patterns in the larger landscape such small-scale case-studies are likely to be misinterpreted and human imprints are usually overestimated in such cases. In our work we already had access to Josefsson's (2010a) large-scale study of 2700 ha of the TNR, which functioned as a reference.

4.2 Dendrochronology

Dendrochronology, or tree-ring dating, is the analysis of tree-ring growth patterns (Stokes & Smiley 1996). All tree species which form annual rings and grow in seasonal climates, or are affected by pronounced wet and dry seasons, can be used as bio-indicators (Speer 2010). Dendrochronology is a well-known and much used method within climatology, ecology and archaeology because the growth of trees can be affected by temperature, rainfall, insect outbreaks and human activities, to name only a few factors. In northern Sweden the growth of Scots pine trees is limited mainly by summer temperatures (Briffa et al. 1992). Trees growing in the same geographic region and under the same climatic conditions will produce similar growth patterns. By matching sequences of tree-rings from many samples of young and very old wood it is possible to construct long chronologies of year-rings (Schweingruber 1988). These so-called Masterchronologies are especially useful within dendroarchaeology when dead wood material needs to be dated.

In the study reported in Paper I, dendrochronological methods were applied to date the timing of each bark-peeling event in the Hålkåsjaure area using tree-ring measurement and cross-dating against Masterchronologies (Schweingruber 1988). The Masterchronologies used were from Lycksele (unpublished), Torneträsk (Grudd et al. 2002) and one local set from Tjeggelvas (unpublished). All samples were measured using a tree-ring measuring station with a resolution of 1/100 mm and the results were analyzed using TSAP win software and statistical methods (LINTAB, Rinntech technologies, www.rinntech.com).

I was able to successfully date about 80% of my samples. The remaining 20% were either samples from downed logs, which were too decayed to obtain samples of sufficient qualities, or trees with clear evidence of reaction wood. Reaction wood can occur as a result of the growth pattern of a tree being determined by external factors other than the overall climate; in my study it was most likely due to unstable ground, such as that found in wet mires, which causes the tree to tilt back and forth during its growth. This creates sections of annual rings which are very narrow on one side of the tree and very wide on the other side. It is hence important to recognize that the temporal data obtained from dendroarchaeological analysis is biased further back in time, as wood decays and disappears from the biological record.

4.3 Harvest experiments

For the studies described in Papers II and III, the data were obtained by conducting field harvests of Scots pine inner bark (II) and *A. archangelica* (III) according to traditional practices. The harvest experiment for Scots pine inner bark was conducted on three consecutive occasions (late, mid and end of June) in early summer 2012, as this was the time at which the Sami traditionally harvested the inner bark (Graan [1672] 1899). In each of the three study areas a total of 15 trees was harvested on each occasion.

Figure 6. The author harvest a Scots pine tree in late June 2012. Photograph taken by Helena Lindén.

Beforehand 15 locations had been randomly assigned to each study area and the tree (dbh >20 cm) standing closest to each position was selected for harvest. For consistency, harvest always took place on the north-east facing part of the stem and the lowest cut was made at breast height. The inner bark samples were immediately frozen in the field using dry ice and then deep frozen (-20°C) when returning to the laboratory. In addition, a full size bark-peeling (40 x 70 cm) was made in study area U on every occasion (Fig. 6). The aim was to estimate time consumption of harvest and to compare the work-load at different times. The *A. archangelica* harvest experiment was conducted in three consecutive years, the summers of 2011, 2012 and finally 2013. Each year the two study fields were visited twice, in early June and mid-July. The harvest experiment was once again designed according to traditional harvest practices and the special life cycle of the plant, as described in the historical sources. The experiment included three treatments:1) harvesting of the entire plant including digging up the roots (Sami *Urtas*), 2) harvesting of infertile plants (Sami *Faddno*) and 3) harvesting of flowering plants (Sami *Båskå*). The first treatment, harvesting of roots, was conducted in early spring, as the roots were said to be tasty and full of power at that time. The second and third treatments were conducted later in the summer when infertile plants could be distinguished from fertile plants. On each occasion about 30 plants were harvested from each treatment; 30 control plants were also marked in each field at these times. Height, width, number of petioles and fresh weights of every plant were measured in the field and the plants were marked so that survival rates could be determined. After transporting them to the laboratory the harvested plants were dried and weighed again. In the following spring, before the fields were completely overgrown, every plant was revisited and survival rates were determined (1= survival, 0 = death). In the middle of the summer treatments 2 and 3 were repeated on those plants which had survived, and all measures were made again.

4.4 Nutritional Analysis and Enzymatic Analysis of Soluble Sugars

In the work presented in Paper II two types of analysis were performed on the inner bark samples. Nutritional analysis was carried out by ALS Scandinavia, who are accredited for nutritional studies on food; the analysis included the main proximates for food, such as water content (Gravimetric, 105°C, accuracy 0.1/100g), ash (Gravimetric, 105°C, accuracy 0.1/100g), protein (Dumas 0.3/100g), fat (Weibull-Stoldt 0.1g/100g), saturated fat (GC-FID ISO 5509, accuracy 0.1g/100g), soluble sugars (HPLC, accuracy 0.1g/100g) and fiber (AOAC 985.29 accuracy 0.3g/100g). Since these analyses required very large sample sizes, only samples from study area U were analyzed, and five samples were pooled to prepare one new sample. This means that nine samples were analyzed, three from each period.

I performed the soluble sugar analysis in the Umeå University Plant Cell Wall Lab using an enzymatic spectrophotometric method. Enzymatic food analysis is an analytical method that can be used to measure, for example, the content of soluble sugars in food or plant tissues (Pettersson 2011). The principle of enzymatic-spectrophotometric analysis is to make the soluble sugars glucose and fructose (sucrose is a combination of the two) measurable by adding enzymes (in this case hexokinase, phosphoglucoisomerase and invertase) which cause reactions linked to the reduction of NAD (Nicotine amide adenine) or NADP (Nicotine amide adenine phosphate), which can be followed spectrophotometrically by observing changes in the optical density (OD). For the reaction formulas and exact concentrations of the different enzymes added see Paper II.

4.5 Interview

In the study described in Paper III, I conducted a semi-structured interview with the knowledgeable Sami elder Greta Huuva about practices and customs related to the harvest of *A. archangelica*. I had prepared open questions, such as *can you describe*…to initiate conversation. The general advantages of a semi-structured interview technique are that it allows the informant to address topics which would not otherwise have been covered, while at the same time giving a structure to the interview (Gillham 2008) I also presented the results of my *A. archangelica* harvest experiment to her and we had a discussion on the outcomes and the reasons behind our results.

4.6 Historical records

In Paper IV, a demographic reconstruction of Pite Lappmark was made based on taxation records from the years 1555, 1600, 1661, 1699 and 1759. These sources are kept at the Swedish national archive and available in scanned form online. Since the taxation records generally only list the heads of the households, the tax-payers, i.e. adult men (commonly married and with their own households), a correction factor has to be applied in order to account for total population numbers. As the record from 1759 includes all family members in Pite Lappmark, we were able to calculate this correction factor as being 4.9. These sources are considered to be the best available demographic record of the Sami population for this time-period. For the years 1810 and 1850 the first population censuses were used (for both Sami and farmer population numbers); these can also be found online.

To obtain information about the first commercial loggings in Pite Lappmark, the statistical yearbooks of the Swedish Forest Service were analyzed and compiled for the years 1870-1910. Such historical records have previously been used to reconstruct pre-industrial forest conditions (Östlund et al. 1997) and they are considered to be good and reliable sources. The logged volume of timber and other forest products for state owned land across the whole of Sweden are listed here. For Pite Lappmark, the time-period which we chose to study corresponds to the earliest account of commercial forestry in the region, due to its relative remoteness.

The state of the forest, i.e. data on standing volume, number of trees and annual volume increment, was obtained from the first National Forest Inventory (NFI) from 1926 (Swedish *Riksskogstaxeringen*). The data for northern Sweden are based on inventories undertaken along 10 meter wide transects which are spaced 10 km apart. These historical data are therefore only reliable for larger regions, such as - in this case - Pite Lappmark, which covers

21 000 km^2. As the forest landscape in 1926 had already been affected by early selective logging of large diameter Scots pine trees, we had to adjust for this fact in order to retrieve the pre-industrial forest state, which could be used for our further calculations. To do so, we used historical data from Dalarna County. The number of trees per hectare in the 1880s in an unlogged forest landscape in Orsa municipality (Linder & Östlund 1998) was compared with the forest conditions in 1923 according to the Swedish NFI for parts of Orsa, Mora and Älvdalen municipalities. The quote between number of trees per hectare for diameter classes 30- 34.99, 35-39.99, 40- 44.99 and > 45 cm DBH in 1889 and 1923 was derived and applied to the forest estimates for our study area.

4.7 Time-period covered by the different sources studied and the used methodology

This thesis addresses the time-period 1550 until 1900. The sources and methods used in Papers I-IV, however, covers different parts of this period. The bark-peelings are snap-shots of the specific years when the trees were harvested. But, to fully understand the context in which they were made, information on the customs associated with the overall use is needed. As the practice ceased rather abruptly in the late 1800s as a result of legislation banning the practice of damaging the valuable timber trees (Zackrisson et al. 2000), such information is restricted to older ethnographic accounts. Regarding the use of *A. archangelica* the situation is somewhat different, as some people still practice harvesting, although the custom drastically diminished in the early 1900s as a result of commercial food products being readily available (Qvarnström 2006). Regarding the use of *A. archangelica* I have therefore turned to both older and more recent ethnographic accounts to retrieve information, and interviewed a knowledgeable Sami woman. But what does her knowledge represent? Traditional ecological knowledge (TEK) has been defined as `a cumulative body of knowledge, practice and belief, evolving by adaptive processes and handed down through generations by cultural transmissions about the relationships of living beings (including humans) with one another and with their environment´ (Berkes 1999). The adaptive processes can be coupled to environmental or subsistence change placing different demands on the people who carries this knowledge. Examples of cultural transmissions can be traditional songs, stories and beliefs. As TEK is constantly evolving it contains components from a wide temporal spectrum and specific pieces of information cannot easily be attributed to a certain time époque.

5 Results and discussion

In the past, people's food habits were more constrained by what was locally available than what is the case with modern diets. The availability of food resources governed the diet of the people and both environmental constraints and human population pressure clearly set both quantitative and qualitative limits on human subsistence. However, culture and traditions also interplayed in shaping the complex combination of resources that were consumed. Some plants were eaten mainly because they tasted good, others because they contained `hard-to-get´ nutrients or vitamins. Certain plant foods were readily available and were appreciated for their predictability (they could therefore be consumed as a daily staple) while some were ripe only during a very short period of the year and still others were only consumed when no other options remained, as famine food (Eidlitz Kuoljok 1969, Minnis 1991). It is also known that several plant species were used interchangeably as both food and medicine (Etkin & Ross 1982) and that some were highly valued for religious or spiritual reasons (Adams & Smith 2011). Different groups living in the same ecosystem are known to have had quite different consumption patterns, purely because of different traditions (Eidlitz Kuoljok 1969, Turner et al. 2011). It has been argued that the more intensively a plant was used for a certain purpose, or the more types of use a plant had, the more culturally significant that plant was to the human culture in question (Turner 1988b). Also, as traditional societies were critically dependent on the diversity of resources, they formulated an array of social constraints on how to interact with the resources, so as not to deplete them (Lertzman 2009). Such constraints could, for example, include rights to access and responsible behavior during harvesting (Darby 2005). Moreover, in human-plant relationships, human intervention is also known to have altered the ecology of specific plants. The degree of intervention ranges from unintentional or intentional management of wild plants, for example by weeding out of competitors, to transplanting individuals for *ex situ* cultivation (Peacock 1998). An understanding of Sami food patterns will clearly improve our knowledge not only about the overall Sami subsistence pattern and economy but also about their impact on the surrounding environment.

5.1 Evaluation of the cultural significance of Scots pine inner bark and *A. archangelica* in Sami subsistence

The traditional Sami diet has been described as lacto-animal, meaning that it was based on fish, meat and milk-products, but with elements of wild greens and a minor contribution made by cereals (Rheen [1671] 1897, Graan [1672] 1899, von Düben [1873] 1977, Fjellström 1985). For many circumpolar peoples, the reindeer made the most important contribution to the diet; this was the case, for example, among the Scandinavian Sami (Drake 1918, Manker 1947, Ruong 1969, Fjellström 1985), the Chukchi and Koryaks, and some Evenks, Nentsy, Khants, Mansi and Komi (Eidlitz Kuoljok 1969). Many studies have recognized that the Sami also gathered plants, but the cultural significance of such activities has largely been overlooked (but see Bergman 2006 on the Sami perception of time). Neglecting of the importance of wild plants in hunting and fishing cultures has been identified as a general problem (Gottesfeld 1994). According to Eidlitz Kuoljok (1969), determining the importance of plant use in a circumpolar context is impossible, due to a large variation in plant use between groups, seasons and even within families. But how important were wild plants for the Sami, a reindeer people in the northern boreal region and subarctic north? Here I will attempt to approach this very fundamental question by examining Sami plant use in a systematic way. I will follow the methodology presented by Turner (1988b) on how to assess the cultural significance of plants. As importance or significance *per se* is very subjective, she suggests that an index be calculated for every species on the basis of three components: Component 1) *Quality of use*, meaning the plant's contribution to survival. In this sense, primary foods are of greater importance than emergency foods or foods used for flavoring etc. However, if a plant food is used for many purposes this obviously increases its value. This particular component has been criticized for being difficult to assess (Stoffle et al. 1990). To assess the *quality of use* for Scots pine inner bark and *A. archangelica* I will investigate the quantities harvested (5.1.1) and the nutritional content of these food sources (5.1.2) in relation to the energy expended (5.1.3) in harvesting them. Component 2) *Intensity of use*, meaning the impact of a plant on the everyday lives of people within the culture. I will address this component by analyzing how the extraction of different natural resources interplayed in mobility and settlement patterns (5.1.4). Component 3) *Exclusivity of use*, meaning the extent to which a particular plant is given precedence over other plant species in filling a particular role. I will address this component based on information about Sami plant use given in historical records (5.1.5). In this final section I will also comment on the distinctiveness of these species (how easily they can be distinguished from other species) and their environmental distribution (sensu Turner 1988b). Taking into account all the components and aspects referred to above, I will discuss the historical cultural significance of Scots pine inner bark and *A. archangelica* in Sami societies (5.1.5).

5.1.1 Quality of use - Quantities harvested

Searching the available ethnobotanical literature I find very little work that has aimed to quantify total amounts of plant resources used in the past, a problem also identified by Deur & Turner (2005) regarding use of plants by the peoples of the American Northwest coast. In general, ethnobotanical information is lacking or is sparse in the historical records, a fact potentially explained by the fact that plant gathering was traditionally women's work whereas the early ethnographers who studied and recorded the subsistence strategies of native peoples were usually men, who were more interested in depicting male activities such as hunting or fishing (Gottesfeld 1993). Also, plant use does not usually leave quantifiable traces in the archaeological record, and this makes such studies difficult. However, in the case of inner bark harvests the traces of use can still be observed in old-growth forests. These cultural imprints are unique as they provide very exact information, about the place, time and sometimes also the magnitude of harvests (Prince 2001, Rautio et al. 2014). A closer examination of an area containing high concentrations of bark-peeled trees (Paper I) showed harvest levels that ranged from only a few bark-peelings per year, up to 51 on a single occasion. This latter value correspond to 16 kg/family/year (FW) or about 0.25-0.5 kg/person/year (FW) (depending on family size). Our quantitative values are clearly lower than those suggested by others, such as 25-30 kg/year (DW) (Bergman et al. 2004a) from Scandinavia and 160-260 kg/year (FW) from Siberia (Middendorf 1875). These numbers correspond to 140-170 bark-peelings and 340-550 bark peelings/family/year, respectively (calculated using densities of inner bark, FW and DW from Paper I, and assuming the average size of one bark-peeling to be 40 cm x 70 cm). Our numbers are closest to those presented by Itkonen (1948), who estimated that a

Sami family in Finland harvested a minimum of 17 kg/year. However, there is no information as to whether this estimate corresponds to FW or DW.

As we were uncertain of whether or not the levels of harvest in Hålkåsjaure were representative of the entire yearly harvest, or represented only a minor proportion, we investigated the landscape data presented by Josefsson (2009) in more detail (Paper IV). We correlated the number of bark-peelings harvested per year (Josefsson et al. 2010a) with demographic data from the same area and time period (Josefsson et al. 2010b). Our regression analysis showed that each person harvested around 4 bark-peelings/year. However, as the explanatory value of our model was quite low (R^2adj = 0.36), we appreciate that factors other than number of people could explain the amounts harvested. Interestingly, the quantification of 4 bark-peelings/person/year is of the same order of magnitude as our suggested number from Hålkåsjaure (51 bark peelings made by 8 or 16 persons = 3.1 or 6.3 bark-peelings/person). This leads to the conclusions that 1) inner bark was not harvested in the large amounts which were previously thought (at least not within this region); 2) harvest levels on a per person level were stable over time 3) harvest strategy differed between years. During some years unusually large amounts were harvested at one single locale and in other years harvesting was spread more widely across the landscape (more on this subject under mobility and settlement patterns). Since the archaeological record of bark-peelings in the landscape is the result of many hundred years of harvest practice (Paper I), it is easy to interpret it as reflecting a resource that was used intensively. However, when the spatial and temporal patterns are analyzed simultaneously, it is clear that it is a very stable, long-term but quantitatively a small resource use.

In the case of *A. archangelica*, there are no previous estimates of the quantities used by the Sami. The field experiment described in Paper III showed that full grown plants weigh around 1 kg/plant (FW). As we harvested 30 such plants from each field we were faced with the problem of drying them quickly enough. It can therefore be assumed that the Sami harvested much lower quantities at any one time, compared to those sampled in this experiment. A total of 15 plants or fewer per harvest occasion is suggested in Paper III. Following his travels in Lule Lappmark Linné ([1732] 1969) describes how the Sami gathered the plant and comments that the young boys and girls harvested the plant in the mountains when they herded the reindeer:

`They carry an armful of stalks back to the camp where they distribute it around for everyone to enjoy´

5.1.2 Quality of use - Nutritional value

The energy content and overall nutrient composition of a traditional food resource provide valuable information about the benefit of consuming that resource. In combination with the quantities consumed these data further our understanding of the specific value and type of food that the resource constituted in the overall diet. However, many present-day national food composition databases lack nutritional information concerning traditional foods (Trichopolou et al. 2007), and such studies has received less attention than other perspectives within the field of ethnobotany (Kuhnlein 2000). Problems in obtaining sufficiently large sample sizes for analysis have been suggested as one reason for this (ibid).

In the studies reported in Paper II the nutritional content and amounts of soluble sugars (glucose, fructose and sucrose) of Scots pine inner bark were analyzed. We obtained the inner bark by traditional harvest methods described in the historical records (for further information see methods section or Paper II). The energy content of Scots pine inner bark was found to be 108 kcal / 100 g FW sample, and this value remained relatively stable over the period studied. In a study on lodge pole pine inner bark, the energy content was determined as 51kcal / 100g FW (Dilbone et al. 2013). As the samples in this study contained much more water, the total energy content of a 100g DW lodgepole pine sample was in fact about 100 kcal higher than that of Scots pine inner bark. Differences could, of course, be attributed to the different species, or to the time of harvest. A study from Finland (also on Scots pine inner bark) shows that energy values fluctuate between under 200 kcal / 100g DW in winter up to 330 kcal /100g DW in June (Korhonen 1986), values very close to our measurements of 286kcal / 100g DW. In relation to other plants consumed by the Sami, these figures represent quite high calorific values (Källman 2006). Due to its high fiber content (57g / 100g DW), this plant food can be classified as a `slow energy releaser´, which is common among carbohydrate sources derived from wild greens. Paleolithic diets are known to give slower and more desirable glycemic responses, compared to highly processed carbohydrate sources (Cordain et al. 2002, Brand-Miller and Holt 1998, Brand et al 1990). In the case of *A. archangelica*, the root seems to be the plant part containing the greatest amount of carbohydrates, approximately 10.4g / 100g DW (Källman 2006). This is slightly higher than for Scots pine inner bark. However, as *A. archangelica* is very aromatic, consumption as a staple food in the way we now consume potatoes or pasta is highly unlikely. The young stalks could have been consumed in larger quantities as they are less aromatic in taste and also require no further processing, but can be eaten raw immediately after harvest (though it has been reported that stalks were sometimes dried in the sun or roasted on the fire to preserve them for later use). Given that in the Paleolithic diet less total energy is derived from carbohydrates and more from protein and fat (Eaton & Eaton 2000), Scots pine inner-bark seems to have been one of the best carbohydrate sources available to the Sami in the past.

We found relatively high contents of calcium, 118.6 mg / 100g FW, in Scots pine inner bark; this is another common property of wild plant foods (Eaton & Eaton 2000). However, as the plant:animal ratio (P:A) within hunter-gatherer diets has been shown to decrease, when northern and southern latitudes are greater than 40° (Cordain et al. 2002), it is unclear to what extent the calcium content of plants in the overall diet contributed to skeletal health amongst the Sami in historical times. Interestingly, ethnographic evidence from North America suggests that hemlock (*Tsuga Canadensis* L. Carrière) inner bark was given to lactating women and infants to suck on during spring famines to improve their health (Eldridge 1982). Scots pine inner bark contains more than 26 phenols (Pan & Lundgren 1996), which are known to have both anti inflammatory effects (Karonen et al. 2004) and antioxidant activity (Kähkönen et al. 1999). Further research into the health benefits of Scots pine inner bark, especially the content of micronutrients and secondary compounds, might increase our understanding of the physiological effects of consuming this plant resource.

5.1.3 Quality of use - Energy expenditure

The optimal foraging theory presented by Winterhalder and Smith (1981) essentially states that foragers will optimize their procurement of food in order to maximize their net energy intake. It follows that the energy consumption required to obtain a food is correlated with its significance as a primary food. By conducting field harvest experiments on Scots pine (Paper II) and *A. archangelica* (Paper III), I gained an understanding of the work required to obtain these resources. Harvesting of Scots pine inner bark was very time consuming, taking about 30-40 minutes per tree (Paper II). This task required about 25-35 hours of intensive work just to obtain the fresh bark (considering harvest of approx 50 trees, paper I). This was harder work than I had imagined, especially when peeling trees with thick outer bark. I also noted a difference in work-load depending on intra seasonal variation. When the inner bark was `ripe´ it did not adhere as much to either the wood or to the outer bark. After harvest the bark was cleaned of outer bark residues, roasted and crushed into small flakes, adding a further investment of time required before it was finally ready for consumption. In the case of *A. archangelica*, the roots were the most difficult and time consuming plant part to harvest. Petioles and flowering stalks could be simply cut or pulled off the plant. Compared to the harvesting of inner bark, *A. archangelica* was very quick and easy to harvest. Instead, problems arose later in the process when I needed to store and dry the large quantities which I had collected. My practical studies can be seen as a first step towards understanding the difficulties encountered during harvesting; however further studies are needed to determine the actual net energy consumption required to collect these food-resources.

5.1.4 Intensity of use - Mobility and settlement patterns

It is well established that the Sami were a nomadic people and their seasonal migrations have largely been explained as following the natural movement patterns of the reindeer. Even the degree of nomadism has been attributed to the type of reindeer herding which they were practicing (Hultblad 1968, Ruong 1945) (more on this topic in the background chapter 2.1). From this perspective it might appear that the other natural resources that they needed were only gathered when and if people came across them on their herding journeys. But in year 1750 the Sami in Enontekis (covering parts of what today constitutes northern Finland and Sweden) explained that the abundance of *Rumex spp.* by the coast was in fact, one important factor why they moved there in summer-time (Paulaharju 1977). Norstedt (unpublished manuscript) argues that settlement patterns in Ume lappmark, which have previously been interpreted exclusively from a reindeer herding perspective, actually also seem to be determined by proximity to good fishing waters, indicating the importance of fishing in Sami subsistence. In the following chapters I will address Sami mobility from the point of view of plant use. I will begin by describing the spatial pattern of Sami land-use in the landscape, followed by mobility on both a small and a large spatial scale, covering within and between resource locales respectively.

Land use matrix

Historical human land use by native people has often been described as heterogeneous, with concentrated clusters of cultural imprints surrounded by matrices of seemingly uninhabited land; this has been reported both from North America (Hammett 1992), and from Fennoscandia (Josefsson 2009, Berg 2010). In agreement with such a heterogeneous pattern, we identified an area intensively used for harvesting of Scots pine inner bark in the TNR (Paper I). An important and intriguing question is of course how many such key-places one family used interchangeably between years? To try and answer this question I inventoried two additional locations in the TNR during the summer of 2014 (Fig. 7). These locations had previously been identified as areas with high concentrations of bark-peeled trees in the large scale inventory by Josefsson et al. (2010a). The first location is an area north of Lake Munkajaure and the second location is an area east of Lake Bläckajaure. To enable comparisons with the results from Hålkåsjaure, I designed the field inventory according to the design in Paper I. That is, inventories of bark-peeled trees were undertaken in semi-circles with the center points located at clusters of archaeological findings at the shoreline of the two lakes. However, as time was restricted I had to make a number of adjustments. First, the semi-circle inventoried only covered a radius of 500 meters (representing study area A in Paper I), second, the inventory of Lake Bläckajaure only encompassed 25% of this area, while a total inventory was undertaken at lake Munakjaure and third, no bark-peelings were sampled at any of the two locations. Our study identified 13 bark-peelings / ha in Munkajaure and only 5.5 bark-peelings / ha in Bläckajaure (unpublished data). Munkajaure position as an intermediate inner bark harvest locale in relation to the mean concentration of bark-peeled trees in the TNR of 3.1 bark-peelings / ha (Josefsson et al. 2010a), and the extremely high concentrations in Hålkåsjaure of 21.9 bark-peelings / ha (Paper I) (Fig. 8). As we have no temporal information from the two new sites it is difficult to interpret when and for how long they were used. A preliminary result is that the trees harvested for bark in Munkajaure was generally older than in Hålkåsjaure, indicating that the area were possibly not used simultaneously as Hålkåsjaure. However, this conclusion needs to be firmly established by further analysis of the data.

Explanations for this type of heterogeneous land use pattern have usually related to differences in the physical landscape, with certain resources occurring only in certain biophysical environments. However, it has been shown that the positions of resource locales in the landscape were also based on socioeconomic factors, such as proximity to other resources or distance to other important structures, such as villages or paths (Trusler & Johnsson 2008). This indicates that native people planned their extraction of resources and chose areas for extraction that fitted into a larger network of activities, resources and facilities.

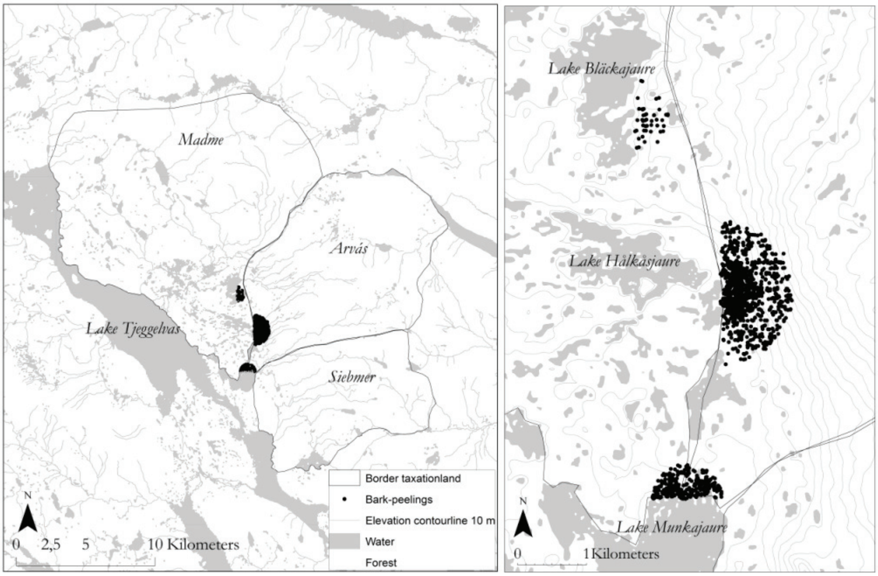

Figure 7. Location map of the inventoried areas; Lake Hålkåsjaure (inventory 1000 m radius), lake Munkajaure (inventory radius 500m) and Lake Bläckajaure (inventory radius 500 m). The borders of the three taxation lands of Madme, Arvás and Siebmer have also been indicated (based on information from Josefsson 2010b). As all three of the inventoried areas lies on the border between Madme and Arvás, interpretations of who actually harvested what are difficult to determine, especially in the case of Munkajaure which lies in both of the taxation lands.

In Paper I, we concluded that the Hålkåsjaure area provides an example of such a pattern of land use. The high concentrations of bark-peeled trees (21.9/ha) in Hålkåsjaure compared to the overall TNR (3.1/ha) was evidence of this. So what can explain the land-use pattern which we found, biophysical or socioeconomic factors? As the composition of Scots pine trees within a certain age or diameter class in this area did not seem to differ from that in the rest of the landscape we hypothesized that potential differences might be found in the quality of the inner bark. From North America it is well known that people actually choose specific trees depending on their taste (Josefsson et al. 2012). In the soluble sugar analysis (Paper II), the combination of glucose, fructose and sucrose showed a very weak correlation, but statistically significant (r = -0.26, P = 0.008) correlation with stand.

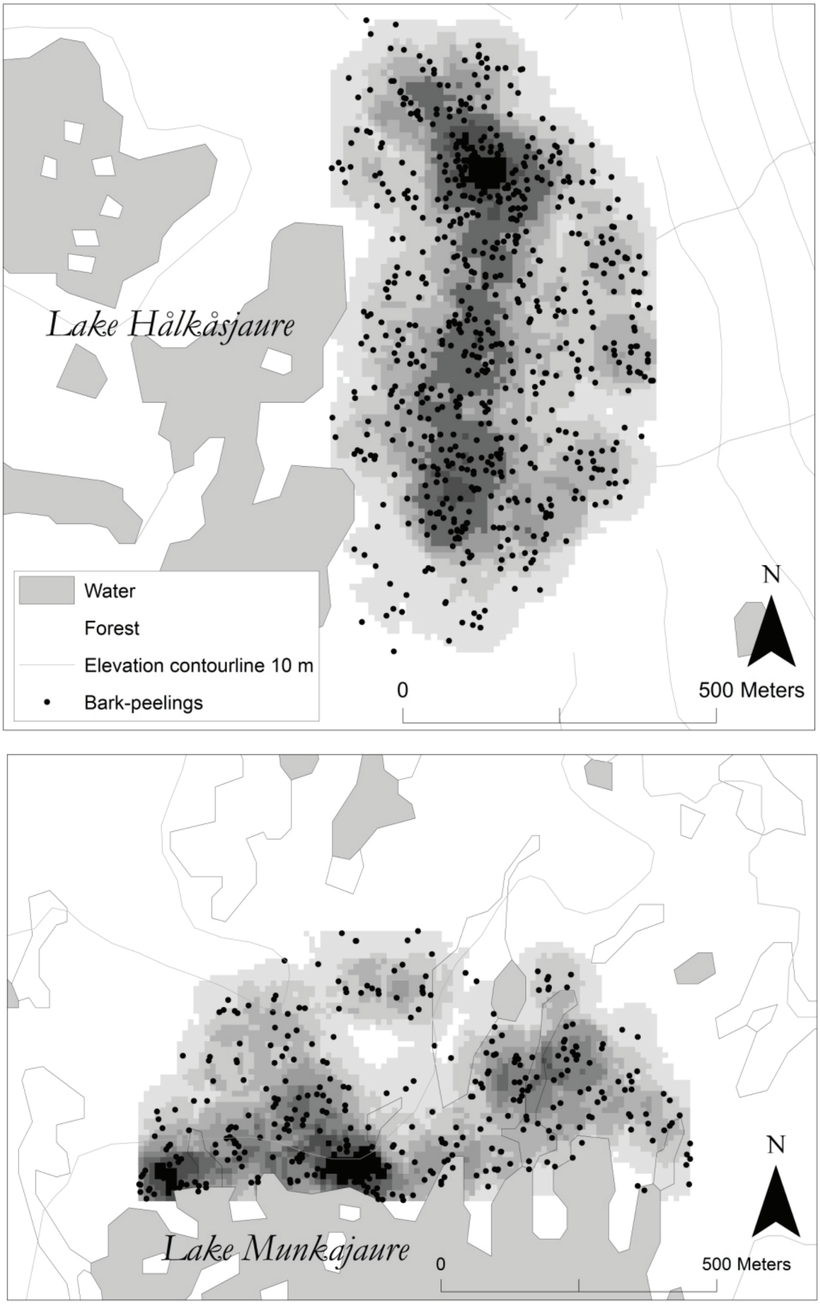

Figure 8. Concentration gradients of bark-peelings in Hålkåsjaure, (21.9 bark-peelings /ha) compared to Munkajaure (13 bark-peelings / ha). Darker colours represent higher concentrations. Bark-peelings in Hålkåsjaure are more evenly spread over the study area, than in Munkajaure. © Lantmäteriet i2012/901.

This indicates that different areas might `taste better than others´, which could be one factor controlling the spatial pattern of resource locales in the landscape. But perhaps more importantly, as an explanation for this patterned land-use, we found other interesting archaeological remains in the area inventoried. Several storage platforms (Fig. 9a), often clustered together with hearths (Fig. 9b) were found, predominantly in close proximity to the lake. We dated the storage platforms to the years 1773, 1776, 1860 and 1868.

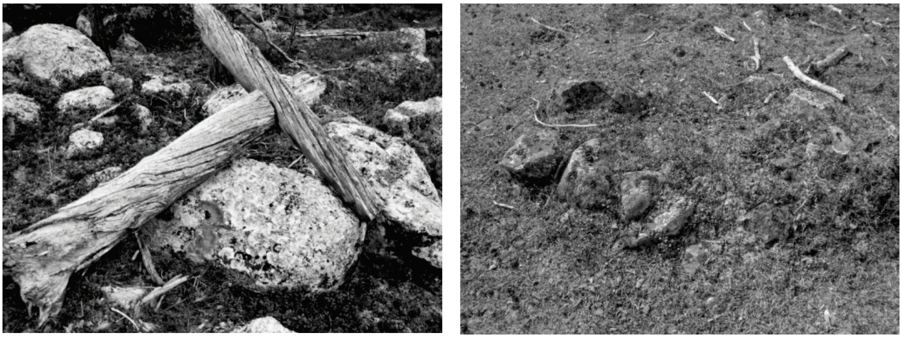

Figure 9. A) A rooted high stump with a crossed construction constitutes the remains of a single storage platform, which has now fallen down. Photograph taken by the author in 2011. *B*) An overgrown hearth, i.e. a stone ring on the ground which was used as a fireplace within the moveable tent huts. These are the best indications of settlement sites today. Photograph taken by Gudrun Norstedt in 2014.

Exactly what was stored on these platforms is difficult to answer, but it most probably included a wide range of items such as food (possible also inner bark), clothes and larger equipment, for example tents, sledges and skis. Storage of food in particular is of crucial importance in seasonal climates, as the availability of harvestable material is restricted to a very small part of the season (Eidlitz Kuoljok 1969). Moreover, the construction of permanent facilities within hunter-gatherer groups has been associated with frequent reoccupation (Smith & McNees 1999), and our bark-peeling record also confirms this (Paper I). Over the very long period of 300 years, bark-peeling events took place in almost every decade (there were only two exceptions). On the basis of these findings I propose that the presence of many storage facilities in Hålkåsjaure was the main reason why people kept returning on such a regular basis. It is well known that autumn and spring camp sites were occupied for the longest time-periods (Manker & Pehrsson 1953), as the reindeer calved in spring and mated in autumn (Ruong 1956). The reindeer were usually set free during these times to carry out these acts (Ruong 1969), and this evidently gave the herders time for other types of activities. These included harvesting inner bark and fishing in spring and hunting small game in autumn. Another important task during these transitional periods was to change over equipment for the coming winter or summer season. In early spring they left their sledges and warm clothing and emptied their food stores (Aronsson 2000, von Düben [1873] 1977), as this was the most crucial time of year from the survival point of view. For logistical reasons the spring and autumn settlement sites were usually situated at the same place in the landscape (von Düben [1873] 1977). This pattern of key storage facilities for use during spring and autumn has also been recognized for the Siberian Nenets (Dwyer and Istomin 2008).

Mobility

An important component in hunter-gatherer research has been to gain an understanding of people's mobility patterns, as these are closely related to the distribution and density of important natural resources and other socioeconomic factors (Kelly 1992, Smith 2003). Mobility is one way in which people can adapt to the environment, for example in order to find more resources. Determining mobility from archaeological remains is very difficult because a high abundance of artifacts can represent frequent reoccupation of a site as well as a sedentary life-style (Binford 1982, Kelly 1992). However, bark-peeled trees provide an excellent biological archive as the presence of people at a specific site can be distinguished with an accuracy of one year. Binford (1980) has distinguished between two main types of mobility pattern; residential and logistical. Residential mobility includes movement of entire groups between settlement sites and logistical mobility covers foraging movements to and from the settlement sites. Such foraging movements can be for the harvesting of wild plants or hunting wild game. Hunter-gatherers have commonly moved in a combination of such mobility patterns (Smith 2003), but the degree to which these specific adaptation strategies have been used depends largely on the main subsistence strategy and the abundance of sought-after resources. On the basis of my findings presented in Paper I, II and IV I will discuss different Sami movement patterns in relation to their overall use of natural resources and reindeer herding activities.

Micro-scale, logistical movement in Hålkåsjaure

As shown in Paper I, the temporal and spatial pattern of bark-peeled trees indicates differences in harvest strategies between years. During certain years a very large number of trees were harvested while in other years only a few were. Notably, peak periods for harvests also displayed a clustered spatial pattern, indicating that people stayed in the Hålkåsjaure area and harvested many trees. In contrast, years with fewer bark-peelings, displayed a very widespread spatial pattern. This we interpreted as indicating a movement through the area. Our findings from Paper II contribute to an understanding of why in certain years people decided to move on. According to our soluble sugar analysis, time has an explanatory effect on amount of sugar ($r = 0.38$, $P=0.000$). If by chance the people reached this particular harvest locale before the pine trees were "ripe", the chances are that they would harvest a few trees and then move further on. Our soluble sugar analysis also reveals interesting information about the micro spatial pattern of peeled Scots pine trees within the resource locale. Some trees had been harvested while others had not, despite the fact that the trees are very similar, being of the same diameter, age and outer bark thickness. The soluble sugar analysis showed large between-tree variations (Paper II). Another important aspect is the difficulties associated with harvesting certain trees. It appears that the point of ripening is different for different trees, possibly because of shading, water availability or site productivity. Combining information about the technical aspects of harvesting with a full nutritional analysis to see whether these factors co-vary would be an interesting aspect to study in the future.

Macro-scale, residential mobility in the larger landscape

We were also interested to know how the Sami used, and moved over, the larger landscape, i.e. between important key places in the landscape. In Paper IV, we calculated the Sami use of different Scots pine resources on a regional scale (21 000 km^2) over time (300 years), not only to assess how much of each resource was used but also to better understand which resources were limiting for the Sami (more on specific quantities and sustainability in chapter 5.2). We analyzed the use of dead Scots pine trees as firewood (Östlund et al. 2013), the felling of slender pines with large amounts of arboreal lichen as reindeer fodder (Berg 2010) and the harvesting of inner bark (Rautio et al. 2013, 2014). The results showed that none of the resources harvested were actually limiting on a regional scale at any point in time. However, the use of firewood stood out as the resource required in the largest quantities. During this work a conceptual model emerged of how different resources related to one another within Sami subsistence. It became evident that certain resources were retrieved over the course of an entire year and probably also harvested in much higher quantities, while others were available only during a short window of time. We termed these patterns *continuous harvest* and *seasonal harvest.* Examples of the former are firewood and grazing grounds for the reindeer. Although the largest quantities of firewood were obtained during winter when the temperature can be below -30°C for weeks at a time (Östlund et al. 2013), the Sami still needed it on a daily basis during summer too, in order to cook. Examples of the latter pattern are harvest of inner bark and other plants, fishing and hunting. Evidently harvest of such resources are restricted by timing of ripening or their spatial occurrence within the landscape. Areas which provided many of the above mentioned resources were of course more attractive and could potentially become *key places* or *harvest locales*, like the Hålkåsjaure area which was visited repeatedly. Furthermore, as we recognized that felling for firewood was the most quantitatively important Scots pine resource use for the Sami, we believe that many more shorter migrations were undertaken during winter, than has previously been recognized (Collinder 1953), so as not to deplete areas completely of certain resources. To conclude, I propose that the residential mobility pattern of the Sami was undertaken not only depending on what type of reindeer herding that was being pursued, but also as according to the availability of many other natural resources.

5.1.5 How culturally significant were Scots pine inner bark and *A. archangelica* in traditional Sami subsistence?

According to my results on the *quality of use* (sensu Turner 1988b) it becomes clear that neither Scots pine inner-bark nor *A. archangelica* functioned as primary foods, with respect to harvest quantities or energy content, in the overall Sami diet. Evidently the Sami's main source of energy was meat and fish. This is in accordance with other studies suggesting that only 15% of the total human energy was derived from carbohydrates in a hunter-gatherer context in the northern boreal zone (Ströhle & Hahn 2011). However, given the regularity of harvest, described in Paper I, inner-bark does not seem to have functioned as a famine food either. Instead, I suggest that Scots pine inner-bark made an important carbohydrate contribution to the diet in spring time when game meat was naturally lean and that it thus functioned as a `seasonal health food´ (Paper II). During this time the high level of consumption of fat-free protein could cause osteoporosis and kidney failure (Speth & Spielmann 1983, Cordain et al. 2000). This also explains why people invested so much energy into this practice, to the extent that it even directed movement patterns, albeit it did not yield a dietary energy input equivalent to the energy expended in harvesting the bark.

Regarding the *intensity of use* (sensu Turner 1988b), my results show that the inner-bark harvest was one of many factors influencing the seasonal migration of the Sami and their choice of settlement sites, especially in spring (Paper I). I also believe that harvesting of *A. archangelica* had the same impact on mobility, although none of my studies have been able to prove this explicitly. In Paper IV we presented a conceptual model of how the interrelated use of natural resources formed the spatial pattern of land use which is still evident in unlogged old-growth forests today. Josefsson (2009) and Berg (2010) have described Sami land use in terms of gradients over the landscape. I propose that the use of wild plants, together with fish and hunted game, were far more important, than what has previously been recognized in shaping this land use pattern and resulting in these gradients.

If we consider the *exclusivity of use* it is apparent that Scots pine inner bark and *A. archangelica* possessed specific qualities which other plants did not. Scots pine inner bark, for example, was an excellent food to preserve for later use. After it had been roasted and crushed into flakes it could be stored for years. Most commonly it was used in fish and meat soups where it had a thickening effect (Bergman et al. 2004a). *A. archangelica* was used as a preservative in milk. As reindeer milk was a highly valued and nutritional food resource, a plant connected with such use must have been extremely important too. The roots of *A. archangelica* were also much used and appreciated for their medicinal properties. Both these species are very easily distinguished from other plant species in the region, the Scots pine of course by its impressive size and *A. archangelica* by its huge flowering umbel. The distribution patterns of the two are very different, as Scots pine occurs in large numbers and is the most common tree species in northern Sweden while *A. archangelica* is restricted to moist and productive sites in the mountainous region. Based on all these factors I consider the cultural significance of Scots pine inner bark and *A. archangelica* to be very high, mainly because of qualitative and functional aspects. Garibaldi and Turner (2004) formulated the concept of cultural key-stone species, defining them as: `culturally salient species that shape in a major way the cultural identity of a people, as reflected in the fundamental role these species have in diet, materials, medicine, and/or spiritual practices´. According to my research on the Sami use of Scots pine and *A. archangelica* I argue that they are the cultural key-stone species of the Sami.

5.2 Human impact of land use - plant populations and regional scale

What was the Sami ecological foot-print in northern Fennoscandia in historical times? The duration – thousands of years – of Sami subsistence in this region, and their many ways of utilizing natural resources (ways that changed over time), make this a difficult question to answer. Nevertheless, in the following chapters I will approach this question by investigating how the Sami related to resources (chapter 5.2.1. Management of Plants) and also, by studying the sustainability of their use of these resources (chapter 5.2.2. Sustainability and Land use). I will also discuss the human impact on these northerly ecosystems over time.

In the last couple of decades, historical processes in general, and early human land use in particular, have received increasing recognition within the field of ecology (Foster et al. 1996, Swetnam et al. 1999). A thorough understanding of anthropogenic impacts on ecosystems is important both for understanding the present state of ecosystems and for predicting future scenarios. In order to conduct informed management of these systems we need to know their history (Gimmi & Bugmann 2013). Areas previously perceived as being pristine or untouched have shown traces of early human land-use (Denevan 1992, Josefsson 2009), activities which in some cases have had lasting legacy effects of ecosystems, even centuries after the land-use has been abandoned (Foster et al. 2003). Such areas can evidently no longer be interpreted as true reference states for `natural ecosystems´, but they can instead provide unique opportunities to better understand environmental impacts by early human land-use. The present day landscape must therefore be understood as a product of multiple events and their cumulative effect over time (Etter et al. 2008). Usually the process of change in land-cover is interpreted as a linear progression from natural to increasingly transformed conditions (Bürgi et al. 2004), but periods of population crisis and regression have sometimes had a temporally and spatially dynamic impact (Dahlström 2006). Data on how human population numbers have fluctuated over time is important information when estimating the overall human use of resources in an area.

A common misinterpretation is that all hunter-gatherers are or were the same (Lee 1968), but the wide range of natural resources used by hunter-gatherers, and the many different ways in which they adapted to these resources or even managed them, created very different landscapes. In addition, different land use practices may overlap in time and impose quite different imprints on the environment. It is therefore very important to know how people in the past interacted with their surrounding environments. Examples of the effects of past human land-use are wide ranging; some groups overexploited resources, while others used them sustainably or even created landscapes of high biodiversity (Hayashida 2005). Deforestation is one common example of overexploitation, which is known from many different parts of the world and at different time-periods (Brown 1997, Kaplan et al. 2009, Karlsson et al. 2009), usually as a result of large-scale extraction of firewood. Unsustainable harvest of wild game species is another quite common example (Smith & Wishnie 2000). But, there are also examples of how traditional societies have intentionally harvested certain resources in a sustainable way (Anderson & Rowney 1999) or by management increased the productivity (Mt. Pleasant & Burt 2010) or biodiversity (cf. Peacock 1998) of a certain system by means of management.

In order to further understand the ecosystem effects of early land use by the Sami in northern Fennoscandia, knowledge on quantities harvested and the management methods used, are needed. The focus of this thesis is not to explicitly look at the ecosystem effects of land-use but to provide better quantitative data on resource use and a working-model of how to retrieve such information. I will begin by addressing the degree to which the Sami intervened with the plants they harvested (chapter 5.2.1 Management of plants). I do so by investigating the effects of traditional Sami harvesting of *A. archangelica* on plant populations. I also want to quantify their use of a specific resource from the perspective of a long time-scale and understand the intensity of use in a spatial perspective (Chapter 5.2.2. Sustainability and land use). I do this by addressing the overall use of Scots pine for firewood, harvesting of inner bark and felling of trees rich in arboreal lichen for reindeer fodder.

5.2.1 Management of plants

Selective harvesting and spreading seeds- practices, timing and sustainability

The traditional view is that the Sami of northern Fennoscandia only harvested certain species and did not manage the plant resources that they used (Eidlitz Kuoljok 1969, Fjellström 1985, Svanberg & Tunón 2000). In recent ethnobotanical work on Sami plant use the importance of specific plants is often emphasized but no attempts have previously been made to understand the intensification of plant production or the potential effects of harvesting on plant populations. I would like to remedy this gap in our understanding on the basis of my results. By personally conducting harvest of *A. archangelica* using traditional Sami methods (as described in the historical records), I tested the general outcomes of such selective harvest. As *A. archangelica* is a monocarpic plant, meaning that it only reproduces once and then wilts and dies back, I hypothesized that harvesting by the Sami could lead to an increase in the life-span of the plant, possibly making it a true perennial.

My results shows that harvesting of the infertile petioles increased the survival rate in comparison to that of control plants (Paper III), which suggests that the life-span of the plant can in fact be prolonged if infertile plants are continuously kept from flowering, for example by harvesting. Peacock (1998) has shown that all wild plant species managed by Northwest coast peoples were perennials and explains this pattern by the ability of long-lived plants to respond to human disturbance or harvest in various ways. In most cases they can regenerate or reproduce by several different methods and as long as the entire plant is not removed it can regrow from underground parts. Turner and Peacock (2005) have even attributed the previous failure to acknowledge incipient agricultural practices among native peoples to the difference in managing long-lived species in comparison to European style agriculture, where annual sowing and harvesting of plants have long been the main method used. They have termed this the "perennial paradox". However, in my study the positive effects of harvesting on survival only lasted for one year. After the second harvest the plants survived to a lower degree than the control plants. In contrast to the perennials studied by Peacock (1998), it seems as though *A. archangelica* cannot reproduce vegetatively. According to my informant, the pattern that I observed can possibly also be explained by the method of harvesting which I used. Every stalk was cut off with a knife, potentially leaving large hollow stems leading down to the roots. These stems could then function as water-pipes, leading rainwater directly down to the roots, which would eventually cause the root to rot. Instead, my informant suggested that the petioles should be carefully pulled off the main stalk, without opening up a passage to the root. She also commented that not all green biomass should be harvested from the plants, as that would remove all the `power´ from them. According to Dragland (2000) on the commercial cultivation of *A. archangelica*, it is possible to make plants that are already flowering grow again the following year solely by removing the flower stalk, preferably as soon as it starts developing. My approach to the harvesting of roots and flowering plants was very destructive, as no plant survived treatment. If the Sami managed *A. archangelica* sustainably in such a way as to achieve true perennial populations, according to my field experiments they must have 1) conducted a very sparing harvest of roots (especially in small populations), as this practice very efficiently removes the plant; 2) conducted harvests of infertile plants very regularly (every year, and at exactly the right time); 3) harvested infertile plants sparingly in term of quantity (i.e. only removing only one or a few petioles from each plant); 4) timed the harvest of the flowering stalk very precisely, as otherwise the plant would wilt and die back.

According to my informant the Sami have spread *A. archangelica* to areas where it did not naturally occur. Such places still exist, for example in Latikberg and Rismyrliden (Ericsson 1984) which are far away from the natural range of the plant (Hultén 1971). Old Sami people still refer to such *A. archangelica* sites as being indicative of the locations of old settlements (Greta Huuva personal communication).

Over-harvesting and extinguishing of local plant populations of both the *A. archangelica* and the closely related species *A. glauca* is a widespread problem in the Himalayas (Vashista et al. 2006, 2007). Although these plants rely on a seed-bank consisting of seeds of different descent, which will germinate when the conditions are right (Ojala 1986) over-harvesting can apparently still eradicate entire populations, as the examples from the Himalayas show. In this context, the Sami's use and possible management and more widespread distribution of a long-lived monocarpic plant, becomes even more intriguing. *A. archangelica* seeds have a very low germination rate (Ojala 1986) and it therefore seems unlikely that people successfully established new populations unless they also actually managed them and kept them alive.

5.2.2 Sustainability and land use

A very interesting question concerns the long term sustainability of the resources used by Sami populations. Of course, this question embraces many different types of resources for example, plants for consumption, fire-wood, fishing, hunted game species etc. Here I will focus only on selected resources which I have studied from a larger landscape perspective and I will compare this resource use with subsequent forest exploitation. In Paper IV we were able to establish that the Sami use of Scots pine resources fell well below any critical threshold level for sustainability at a regional level at any point in time. This included harvesting of the inner bark, felling slender pines with large amounts of arboreal lichen to feed the reindeer and the use of standing dead Scots pine trees as firewood. Our conclusions can largely be explained on the basis of the extremely low population numbers in relation to the extensive areas which they inhabited. It is important to note that the demographic data we have used is specific for Pite Lappmark, meaning that it is spatially correct. In 1555 the population density was approximately 0.018 persons / km^2, i.e. every family had exclusive access to about 270 km^2 of land and water. By 1850, population increases had made this area fall to 100 km^2 / family. Since a large part of every such area was covered by Scots pine forest, the available quantities and re-growth rate of each resource-category were far greater than the amounts used. However, the entire landscape was not utilized with equal intensity, since certain areas were preferred for certain resources, which were intensively harvested there (Rautio et al. 2014, Berg et al. 2011). This conclusion is supported by Östlund et al. (2013) writing on the Sami's use of firewood. Based on experimental studies the authors were able to estimate the volume of firewood needed to heat a tent hut over a year. Furthermore, by analyzing the spatio-temporal availability of dead Scots pine trees of a certain diameter in the landscape they were able to calculate the size of the area needed to support one large family (i.e consisting of two tent huts) over a year as being 60 ha. This corresponds to a radius of about 150 meters from the center of the settlement if nine different settlement sites were used over a year. However, as our results show, certain areas were revisited several times in a decade (Paper I). In such places, creation of firewood by ring barking must have taken place in order to secure this crucial resource. Certain well used areas have also shown long-lasting legacy effects on the ecosystem both above and below ground, more than a century after land use has ceased (Josefsson et al. 2010a, Freschet et al. 2014). To conclude, the spatial and temporal pattern of Sami resource utilization was very complex. Seasonal availability of certain resources and biophysical factors regulating where in the landscape they existed and were abundant, as well as socio-economic factors, all interacted in determining which specific `nodes´ were used more than others. The areas visited during autumn and spring seem to be such nodes, where we might expect a higher degree of human impact. Whether the resource use in such nodes was sustainable remains to be determined, but I suggest that certain areas were depleted of, in particular, fire-wood and reindeer grazing. The complex pattern of mobility from year to year was probably one method of avoiding overexploitation and securing the availability of critical resources over both a short and a long time-scale.

The long-term limited use of the available pine resources by native people and early farmers was superseded at the end of the 19th century by large-scale commercial logging. This exploitation was characterized by selective cutting of very large diameter Scots pine trees and the overall amount of logging consumed more than the total growth in the forest for a few decades. After that, forest felling was successively transformed into clear-cutting of entire forest tracts (Lundmark et al. 2013), a practice which has been ongoing up to the present day. This has of course transformed the entire landscape fundamentally (Linder & Östlund 1998). In Paper IV, we also calculated the quantities of large diameter Scots pine trees felled during the first period of commercial logging in the area, between 1870 and 1910. In only 40 years time, the impact of this activity was far greater than that of land use by the Sami. According to our results these activities very efficiently removed large diameter Scots pine trees from the boreal forest and still today such trees is almost completely devoid from the landscape. Contrasting these different types of use I would describe Sami land use and commercial logging as a *cumulative force* and an *eradication force* respectively. The former was a very small scale localized use which only finally became visible in the archaeological record due to the extremely long repeated use of the same key areas in the landscape over a very long period, whereas the other very efficiently removed entire forest structures from a landscape-level in only a few decades.

Yang et al. (2014), argues that the use of multiple historical sources is clearly advantageous in historical reconstructions of land use and land cover change, as it provides means to better fill gaps of knowledge, verify and increase the accuracy of the data produced. Such an approach is however, still in its exploratory stage, due to problems of coupling various types of sources and data (ibid.). The methodology used in Paper IV is novel in the way historical, ecological and archaeological data have been combined to assess the magnitudes of regional pre-industrial land-uses and the temporal changes in them. The approach is based on quantitative data from small-scale case studies on resource use which have been extrapolated to larger scales by the use of demographic data. In order to understand the extent to which resources were harvested we needed to know what the pre-industrial forest structure looked like. To do so, we have also used the first Swedish National Forest Inventory in a new way. The overall strength of this approach lies in its ability to produce quantitatively precise data on resource use over time. The data is spatially accurate on a regional scale, but it is however not representative of every single location in the landscape. This is evident in my comparisons between Paper I and IV, in this thesis. To summarize, historical reconstructions of past land-use are critically dependent on a combination of larger and smaller scale spatial studies to increase our understanding of early human land-use.

An important question is also how general our results of Sami use of Scots pine resources are for other areas in northern Fennoscandia? This is a very difficult question to answer. However, several other studies covering different parts of this region, such as the study by Zackrisson et al. (2000) for parts of northern Sweden and Finland and Sjögren & Kirchhefer (2012) for part of northern Norway, show similar patterns of bark-peeled trees and hearths over the landscape, to those we have presented (Paper I). These studies lack a larger scale reference, such as the TNR, to which the smaller-scale studies can be compared. The living-conditions for Sami residing in entire northern Fennoscandia during the time-period studied, were however similar. Resources available, such as the Scots pine forests, the mountain heaths and the lakes were similiar and occurred in roughly the same abundances over the entire region. I therefore strongly believe that the patterns observed in Pite Lappmark can be transferred also to other places within northern Fennoscandia.

5.3 The domesticated landscape -a final discussion

In this thesis I have so far focused on the historical use by the Sami of two particular plant resources, the Scots pine and the *A. archangelica*. Can an increased understanding of human practices regarding two single plant species really further our understanding of the overall pattern of Sami subsistence as far back in time as the 1550s, or even earlier? Although, the Sami subsistence was obviously much more complex and also involved a wide range of other plants and natural resources, I argue that the studies on the cultural key-stone species Scots pine and *A. archangelica* provide a window into the Sami past, as they exemplify Sami knowledge of the land and the resources it contains. Terell et al. (2003) argue that wild food production and agriculture are not very different from one another in essence, as both strategies require in-depth ecological knowledge if they are to be conducted successfully. They further propose that societies which have "knowledge of how to put food on the table and a roof over their head" over the long term have in fact domesticated their landscapes. They argue that domestication should be measured by people's actions – rather than by the consequences of those actions. That is, plants or animals (or even places) do not have to be genetically or morphologically altered to be considered domesticated. My studies on Scots pine and *A. archangelica* have shown that the Sami not only knew where in the landscape to find these resources and when the optimal time for harvest was, but also how to extend plant populations to new ranges and how to keep populations viable in the long run. These practices are all evidence that the Sami possessed a considerable depth of knowledge about complex ecological patterns and processes. In that sense the pine forests, the mountain heaths, the mires and the lakes which the Sami used and knew were not just wilderness but in fact domesticated land. This landscape was not inherently different from the farmers' domesticated fields, it was simply that they were different types of land. The diversified Sami economy, with components that included hunting, gathering of certain plant species and managing of others, and reindeer pastoralism, was in fact a very successful long-term strategy. The Sami economy has been dynamic and the relative importance of each component has changed over time, but it has persisted in its essence for millennia. The first farmers moving into these northerly regions also had a wide subsistence base just as the Sami did. The authorities were not pleased that the first "permanent settlers" in the region did not act as true farmers but instead adapted the “primitive” life-ways of the Sami. This is a very strong argument for the superiority of a hunting-gathering lifestyle in these unproductive northerly regions. The best strategy was to alternate between a multitude of options. In agreement with Greaves and Kramer (2014), my studies on the Sami´s use of plants in northern Fennoscandia supports the notion that wild food-procurement represented not simply a period of transition from primitive life in the wilderness but a long-term stable subsistence strategy.

As only fragments of the large and complex picture of Sami subsistence have been presented through my own studies earlier in this thesis, I will now describe a fictional seasonal round of some Sami families in the mid 18th century. I will thus try to visualize how these people lived in, used and moved across a *domesticated landscape* (sensu Terell et al. 2003). By combining observations from my own studies with a large volume of ethnographic data I will visualize the movement and resource extraction across a landscape -the Tjeggelvas nature reserve, with which I am very familiar. In this particular area the Sami presence over time has been well documented through recent research (Rautio et al. 2014, Berg et al. 2011, Josefsson et al. 2010a,b, Josefsson et al. 2009, Östlund et al. 2006). The most important ethnographic work used, includes Rheen ([1671] 1897), Graan ([1672] 1899), Læstadius (1928), Manker (1947), Manker and Pehrson (1953), Ruong (1944, 45, 1969), Collinder (1953). I also adhere to Hultblad’s (1968) view that many Sami subsistence strategies intermediate between the mountain and forest forms existed in the past. Based on previous work from this particular area, I consider that people’s migration patterns at that time are best described by Hultblad’s (1968) type 2 pattern, involving a winter stay in the pine forest region, and autumn, spring and summer in the low mountains with occasional shorter visits to the high mountains.

> *In late spring of the year 1756, the Sami family of Johan Anundsson is on the move northwards to their spring camp on the shores of lake Hålkåsjaure. The elders have a feeling of returning home since they have followed this particular route many times before. The taxation land of Arvás has belonged to their families and their forefathers for a very long time. They follow the tradition of their ancestors and stay within this taxation land year-round, apart from an occasional journey to the church further south. Most years they pass this particular place, their main storage site - Hålkåsjaure. The area is situated right in between the summer and winter lands and is an important node within their migration network. This year the snow is melting rapidly and the reindeer are just about to calve so the family decides to stop at the northern end of the*

lake. It is important not to stress the reindeer cows at this critical time and to keep them under close watch to protect them from predators. The settlement site is situated on a small dry elevation overlooking a small mire. From here the family has a good view of the reindeer herd when they are grazing sedges and the roots of Menyanthes spp. L. *below. They set up camp just beneath a very old pine tree that has eight bark-peelings and other markings from the past. They raise their tent hut over an old hearth (Fig. 8b) which is already there. Down on the mire they have a storage platform which consists of two tall adjacent standing rooted stumps (Fig. 8a), with a platform-like floor on top, they call it luovve. Here they had stored their summer gear, for example fishing hooks and nets, and some dried and roasted inner bark wrapped in birch bark is also stored to provide a complement to fish and meat soups. In underground storage they had left gompa (reindeer milk with A. archangelica, see chapter 2.1.1), a welcome contribution to the evening supper as their staple lately has been lean reindeer meat. A small creek runs down from the Arvasduottar massif, passes the settlement site and continues to lake Hålkåsjaure. From the creek they fetch water for drinking and cooking. During the days they gather fresh Scots pine inner bark. They don´t have to go very far as there are many suitable pine trees nearby. The trees chosen are of medium size and have very light and thin outer bark, making harvesting easy. As soon as they start peeling the pine trees they discover whether or not the inner-bark is ripe. On their travels to Hålkåsjaure, they stopped now and then to check the status of the inner bark, but so far it has been very difficult to harvest. Now they know that Biehtsemánno (Lule Sami: The pine month- June) has begun as the inner bark tastes very sweet and peels off easily. The younger children follow the adults and learn not to kill the trees during harvest as the `father will hurt his back if the pine is girdled´. The older children have been sent out to collect A. archangelica. They follow the creek upstream and find some plants here and there. This is the perfect time to harvest the roots of the plants, since they are now full of power. Once the plant starts producing green leaves and stalks the power will be transferred to those parts. The roots will be dried and used as medicine for ullme (colic symptoms), which is caused by consumption of large amounts of meat and fat. The root also has a strong prophylactic effect and they chew the root in winter time when visiting market places as it will prevent them from catching colds or even the dreaded plague. As the reindeer have been set free for the whole period up to midsummer the Sami family have plenty of time to undertake other crucial tasks, such as gathering plants and fishing. In the lake they catch pike and perch and from the small creeks they get grayling and brown trout. This is a relatively secure resource and not once have they lacked fish in their diet. In fact, it has kept them from starvation many times before, when reindeer have been lost to predators or* *if the hunting of small game has been unsuccessful. In the evenings the plant resources gathered during the day are taken care of. The A. archangelica roots are laid out in the sun to dry and the inner bark is cleaned with a special tool made out of reindeer antler. To make the inner bark taste even better, they prepare a cooking pit. A deep hole in the ground is dug, and later it is filled with rocks. A fire is lit in the pit and they keep it burning for a long time to make the rocks hot enough. They wrap the Scots pine inner bark in birch bark and bury it in the pit by covering it with dirt and let it roast for a day and a night. When they empty the cooking pit the Scots pine inner bark has turned red and now tastes even sweeter.*

When the warmer days come along the reindeer becomes restless, they scatter in the forest landscape and seem to be on the move. They are tormented by the mosquitoes and horse flies and want to seek respite from them on the windy mountain heaths. The Sami family neatly packs away their winter gear on the platforms and they ferment fish which are left behind for later use. They pack their belongings on the backs of the tame reindeer and start walking up the slopes of the Arvasduottar massif until they reach the birch forest. The reindeer calves follow their mothers closely. Once in a while the family stops and takes a snack from a suitable pine tree. On the mountain heaths, where the reindeer can find good grazing, preferably Deschampsia flexuosa, Poa alpina and Festuca ovina, they set up camp. The women immediately start looking for firewood. They need to cook but up here there are not a lot of trees. It is quite hard work to carry or pull the logs back to camp so they don´t want to walk too far. They find a thicket of birch which they cut down. However, they know that they will have to change settlement site a couple of times during summer both to follow the reindeer to new pasture, and to find more firewood. While the reindeer graze the women gather different plants. Alpine sorrel grows on wetter areas at the foot of the high mountains, where it can form dense stands. To make the desired gruel the women pick bushels of it. In the middle of summer A. archangelica is more or less full grown and some of the plants have already started flowering. The flower stalks are carefully cut off and in the camp site they are laid out to dry in the sun. The women know that their kin in the forest land will happily trade for the stalks when they meet again. As A. archangelica only thrives in the mountains the Sami in the low-lands sow the seeds close to their settlements and then tend the A. archangelica plants carefully to keep populations viable. It is important to keep harvesting the plants before they start flowering, since by doing so they can keep an A. archangelica garden for about 8 – 10 years. After this time they renew it with new seeds. Every day the reindeer are milked, a very time-consuming task. The family has as many as 100 female reindeer and about

20 males. The amount of milk is not very large compared to the quantities produced by a cow but it is very high-quality milk, rich in fat and nutrients. They preserve the milk by using mountain sorrel leaves, Angelica seeds and some Alpine blue sow-thistle, if they can find any. At the end of the summer, the mires are filled with cloudberries and the women pick them and preserve them together with reindeer milk or fish. It makes a nice contribution to the diet.

In late summer when the days become shorter and temperatures are lower the Sami family once again pack their belongings to undertake a longer journey, back to lake Hålkåsjaure. They choose the same camp-site as they have left their sledges there. Ahead of them is now a period of almost a month when they will stay put. The reindeer rut, and will be occupied by mating. But before that they still have some time to milk the female reindeer and the milk they now obtain will be stored predominately as cheese. The women continue picking plants which are still available, especially berries and roots and the men are occupied by hunting, mainly smaller prey like ermine, red-squirrel and wolverine which are caught along their extensive trap-lines. The trap-lines are marked with smaller rocks put on top of larger rocks. Some mornings when they wake up, they find that it has been snowing during night. These are perfect conditions as they can see the traces of the animals in the snow. The women make new fur skin clothes for the children as winter is quickly approaching. The slaughtered reindeer have to be taken care of; some of the meat is boiled and eaten but other parts are smoked for later use. Some is even fermented for the lean spring time.

When the first heavy snowfall starts to cover the ground, it is time to move further down in the pine forest. The opposite procedure to that in spring takes place. Winter gear is packed and summer gear is stored away. As the family will not stay in the same camp site next year they move all their belongings to another storage location further to the south along the shore-line of Lake Hålkåsjaure. Here they have multiple storage facilities, which come handy as this summer season has been very fruitful and produced quite large surpluses of many resources. The smallest children are bedded down in the sledges while the older children and parents ski alongside the caravan. This late fall the weather is very unpredictable, as temperatures rise and fall every other day. A hard snow-crust builds up on the surface of the ground. The reindeer are having problems digging down to the ground to reach lichens. One of the elders suggests that they ski down to Lake Munkajaure. He knows that the forest north of the lake has large amounts of arboreal lichen. When they reach the area, they immediately start felling slender pines which they simply leave lying on the ground for the reindeer to graze on. The younger men have never before *experienced such a difficult winter but they make sure that they remember the location as there are many more trees available to be felled at later times, if there is a need. However, this practice is also used during times of travelling when the herd needs to be gathered during the short stops. The women are fully occupied in felling dead pine wood for firewood. They use the standing silver pines as these are full of resin and will burn very well. Inside their tent huts temperatures seldom reach more than plus a few degrees Celsius and the Sami family remain in their clothes both day and night. During this season they undertake many shorter migrations, to find new grazing for the animals as well as to avoid completely depleting an area of firewood. In areas with especially abundant ground lichens the women girdle some trees, to create additional suitable firewood for coming years. And so the long winter season continues, the days are short and sometimes very cold. Some years they visit the church in Arjeplog but due to the very long distance from Tjeggelvas they do not undertake such a journey every year. This year they have a lot of dried pike with them but also fur skins from red-squirrels to pay their taxes. As spring is approaching the Sami move closer to their spring camp, and so one year in Tjeggelvas has come to an end and the next year has just begun.*

(Anna-Maria Rautio 2014)

Conclusions

In this study I have analyzed the specific use of, and practices surrounding, Scots pine inner bark and *A. archangelica* in a historical Sami context, to better understand plant use and the interconnected use of multiple natural resources in northern Fennoscandia. The main conclusions are:

1. Effects of plants on people? – `Scots pine and A. archangelica are two of the Sami cultural key-stone species´.

My studies have shown that Scots pine inner bark was used very regularly over long periods (Paper I) and that Sami migration and settlement patterns were determined partly according to the spatial placement of locales for harvesting Scots pine inner bark within the landscape (Paper I). We have interpreted the locating of inner bark harvest locales as being explained mainly by socioeconomic factors rather than biophysical factors, although the former does not exclude the latter. The harvest of Scots pine inner bark was undertaken during a specific period of time in the year when the inner bark had the highest levels of sugars and starch (Paper II). The Sami practice of harvesting inner bark was also focused on trees of a certain age and diameter, and this is possibly explained by elevated sugar levels or because they were simply easier to harvest (Paper II). Scots pine inner bark (Paper I) and *A. archangelica* L. (Paper III) were not consumed in the large quantities which have previously been suggested. Instead I propose that Scots pine was primarily valued as a health food in spring when game meat was naturally lean (Paper II) and *A. archangelica* L. was used for its medicinal properties as well as for its crucial function in storing the valuable reindeer milk (III). The Scots pine was used for many other purposes in addition to being a food resource; it provided people with firewood and construction material, and the arboreal lichen functioned as fodder for the reindeer; Scots pine heaths with abundant occurrence of ground growing lichens also constitute a crucial natural resource as winter grazing for the reindeer (Paper IV). To summarize, the use of these specific plant species was not quantitatively important but it was qualitatively vital for survival in these northerly regions. An understanding of Sami subsistence in the past therefore needs to include extraction of other resources, apart from those strictly related to reindeer, such as the use of plants.

2. The quantitative impacts of peoples on plants? – Management of plants communities and sustainability on the regional landscape level.

Through experimental harvesting of *A. archangelica* L. I have been able to show that it is possible to manage and maintain stable populations of this monocarpic plant (Paper III). The Sami also spread *A. archangelica* L. to areas outside its natural range, as evidenced by information from my informant as well as ecological evidence of relict populations in the forest region. When these facts are combined, it seems highly likely that the Sami intentionally managed the *A archangelica* L. to maintain long-lived viable populations of the infertile plants, since this was the preferred life-stage for consumption. Furthermore, there are numerous examples regarding harvest practices in relation to both Scots pine inner bark and *A. archangelica* L. which provide evidence that the use of these specific resources was more complex than a simple opportunistic gathering. Much care was taken not to kill the trees when harvesting, and certain trees show evidence of several bark-peeling events, indicating an in-depth ecological understanding of the impact of harvesting. The use of specific tools for harvesting and preparing inner bark is another example of advanced techniques developed to harvest this specific resource efficiently (Paper II). To summarize, the Sami were not simply obtaining resources opportunistically; they deliberately improved certain resources and used others strategically. However, such activities, required a profound knowledge of specific plants and the entire ecosystem which they inhabited. This is in sharp contrast to the traditional view of the primitive hunter-gatherer, who was considered only to opportunistically procure whatever food they found. In this light I also argue that Sami subsistence during the time period studied in this thesis should not be viewed simply as a transition between intensive and extensive reindeer herding. Rather it should be regarded as a period in which there was a very complex and unique mix of many different practices, which varied in intensity and importance between geographical regions and even between family groups in the same region.

The Sami harvest of different Scots pine resources on a regional scale (Pite lappmark, 21 000km^2), was shown to be sustainable throughout the study period (1550-1850) (Paper IV). However, as we know that certain areas were preferred over others for certain resources, localized impacts could have been larger. For example, the inner bark harvest in Hålkåsjaure, far exceeded that averaged across the entire landscape (Paper I). Likewise the felling of lichen-rich trees was conducted in specific years when the resource was needed (Berg et al. 2011), and the legacy effects of vegetation pattern and ground nutritional status at old settlement sites have been shown to be significant and long-lasting (Freschet et al. 2014). Cutting of firewood has been interpreted as a localized action (Östlund et al. 2013). The increase in the Sami population from the mid 16th century until the mid 19th century was very rapid, albeit starting from very low initial numbers. This means that the land area available exclusively to each Sami family also drastically decreased, from 270 km^2 / family to 100 km^2 / family during the time period studied. Moreover, these numbers do not take into account farmers' land use requirements from the 1750s onwards. Although the average land area used by one Sami family in the 1850s was still large, it may not have been large enough to allow them to continue to pursue a highly complex subsistence strategy involving many different resources. In particular, hunting and fishing as subsistence practices might have required areas that were so large that it was not possible for them to be undertaken from the 1850s onwards. Further research into this topic might reveal whether the demographic change may have driven an increasing dependence upon reindeer subsistence in the Sami economy from the early 19th century and onwards.

3. Northern Fennoscandia was already a domesticated landscape in the 1500s, probably even earlier.

The overall traditional Sami subsistence and the complex pattern of different natural resources used are evidence that the far north of Fennoscandia was already a domesticated landscape in the 1500s, probably long before that. People moved over large areas, but they made well informed decisions on what resources to obtain at what times. They were not simply opportunistically searching for food in new `unknown´ areas, but instead they followed well established migratory patterns which led through areas that had been visited many times before. This is one reason why they could survive in such a harsh climate and low-productivity environment. Although missionaries, tradesmen and travelers clearly felt that they were entering the wilderness, as described in their travelogues from the 1600s onwards, this was home to the Sami and an area which they had not only adapted to during thousands of years but also managed in different ways. I have interpreted the traditional pattern of Sami land use as a cumulative force, only visible in the landscape as a result of many hundreds of years of repeated occupation, whereas early commercial forestry acted on the landscape as an eradication force. The latter very efficiently removed important structures from the forest in only a few decades.

4. Interdisciplinary research- challenges and benefits

Historical plant use by the Sami is an exciting and very complex topic. I believe that an array of methods within a theoretical framework is the most effective way to study this topic. Field studies on culturally modified trees and other archaeological remains provide a broad understanding of the landscape inhabited. Dendrochronological analysis deepens that understanding by providing explicit data on temporal and spatial patterns of past land-use. Experimental field studies give information about the biological responses to certain human harvest techniques and the small-scale ecological impacts of early human plant use. Laboratory analysis of the nutritional content of harvested plants increase our understanding of the roles these resources played within the diet as well as explaining the spatial pattern of harvest which has been observed in the landscape. Historical records and ethnographic accounts contribute a broader context to the specific events studied in this thesis. Each of my investigations were planned and carried out against this background in order to obtain a clearer overall understanding of historical Sami subsistence. Therefore and in summary I suggest that a combination of methods from different fields are used to understand how the plants were used, why they were used and finally to understand historical Sami subsistence at different spatial scales.

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Personal communication
Greta Huuva, Jokkmokk 2014-04-10

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