Reindeer herding as a high-level buffering mechanism: the role of climate change in a multi-causal model of the emergence of reindeer herding among the Sami of northern Sweden

Abigail Louise Flint

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Summary

This thesis takes a critical examination of current theories of the emergence of reindeer herding, during the sixteenth and seventeenth century, amongst Sami communities in northern Sweden. This period coincides with the latter part of the Little Ice Age, a period of extremely variable climate in northern Europe, which has not been addressed in current theories of the emergence of herding. Using a bottom-up approach, gathering evidence of the nature of the environmental change and its impact on reindeer, human populations, and subsistence activities, it is suggested this had a profound effect on subsistence strategies. These impacts are considered in context to provide a multi-causal model of cultural change during this period. The evidence suggests that reindeer herding did not represent a radical and large-scale cultural change, and that Sami subsistence strategies do not fit neatly into categories of hunting or herding. The intensification of reliance on domestic reindeer emerged, from the preceding mixed economy, as a high-level buffering mechanism to cope with increased local environmental variability and a disruption in the wild reindeer population, and was facilitated by interactions with the Swedish state through trade and taxation.

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Chapter 1. Introduction to the Sami and the problem of the transition to pastoralism

Introduction

Previous studies suggest that, during the late sixteenth and early seventeenth centuries, there was a significant change in the subsistence strategy taken by indigenous Sami communities in northern Sweden. Previously the Sami had employed a mixed strategy of, amongst other activities, hunting, fishing, keeping small numbers of domestic animals, and trading with other Sami and non-Sami groups. Around this period, many authors argue that a significant proportion of Sami in northern Sweden developed a specialised form of reindeer pastoralism, involving a highly mobile lifestyle and an increased reliance on reindeer products. This thesis aims to explore in detail the nature of reindeer herding among the Sami of northern Sweden during this period and to enrich the understanding of the factors which may have had an impact on this perceived transition. There is a particular focus on the way in which the variable climatic conditions of this period, encompassing part of the Little Ice Age, may have affected the subsistence strategies employed by the Sami.

Before further exploring the scope of this thesis, it is perhaps necessary to provide some general background information on the Sami culture. This is not an exhaustive description of Sami culture but it aims to provide some context for the study that follows. Those aspects of Sami culture most pertinent to the thesis are expanded on in appropriate chapters.

The contemporary Sami

The term Sami[1] refers to a number of indigenous groups of northernmost Scandinavia and the Kola Peninsula. In Sweden the Sami have officially been recognised as an indigenous people by the Swedish Government since 1977. The traditional area inhabited by the Sami is known as Sapmí (figure 1); although this is not formally recognised by the nation states it crosses (Sametinget, 2006). Although collectively known by the single term Sami

[1] There are many ways of spelling Sami which appear in the literature, throughout this thesis (apart from in direct quotes) the spelling 'Sami' has been adopted, following the example of the Sami Parliament in Sweden's website www.sametinget.se (last accessed 29/03/2006)

(literally meaning 'we the people') Sami culture is not homogenous and differs geographically in terms of lifestyle and language dialect. Sami society has undergone many transformations, both historically and more recently, in response to local environmental and socio-economic conditions. These internal and external pressures have no doubt influenced the variability of the Sami culture (Hansen, 1995: 131). However, there are sufficient commonalities between Sami groups for their broad culture to claim collective ethnicity.

The size of the Sami population is difficult to estimate as different sources have conflicting classification techniques and rarely state how they obtained their figures. At present in Sweden there is no formal criterion or definition of 'Sami-ness' apart from in relation to eligibility to vote in Sami Parliament elections; the identifying characteristics of Sami ethnicity are the use of the Sami language as the 'home language' by either the individual, their parent or grandparent, and self-ascription (Sara, 2002: 16; Beach, 1988: 4). Using this mixture of subjective and objective criteria is thought to result in an under-estimation of the real Sami population. Although, in recent years, the sense of pride and interest in ethnic identity has risen in the Sami community, this has not always been so. Historically, and especially during the last 300-400 years, they have been under pressure, both external and internal, to assimilate within the majority Nordic populations. Many Sami now leave their traditional family enterprises to work in Nordic industries, universities or other professions where they are much less likely to use Sami language or perpetuate elements of Sami culture (Jones, 1982: 5). In 1988 Hugh Beach estimated the total Sami population at 60,000, with 40,000 in Norway, 15,000 in Sweden, 4,000 in Finland, and a further 1,500 to 2,000 in the former Soviet Union. The Sami parliament gives a much larger estimate of 70-80,000 Sami split between Norway (40-50,000), Sweden (17-20,000), Finland (6-10,000) and Russia (*c.*2000) (Sametinget, 2006) These figures correspond with estimates given in recent research articles such as Danell's (2000) article on the present state of Swedish Sami reindeer herders. Using an estimate of the Swedish population as 9,024,000[2], Sami make up 0.2% of the overall population. However, the Swedish Sami Parliament estimates that the distribution of Sami means that the

[2] Estimated population from 2005 as given in the Encyclopaedia Britannica Online http://search.eb.com/ (last accessed 29/03/2006)

proportion of the population who are Sami rises to 10% in northern Sweden (Sametinget, 2006).

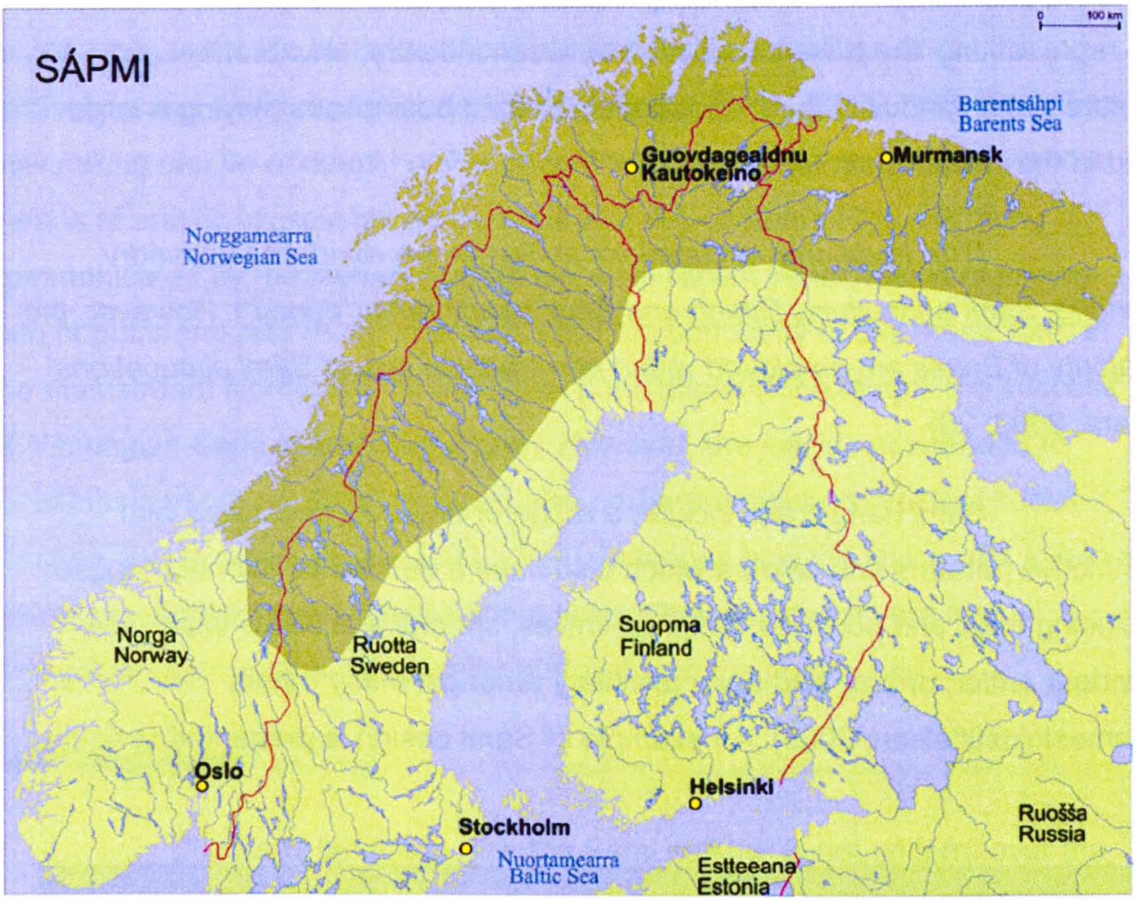

Figure 1. Map of Sapmí, after the Encyclopaedia of Sami Culture (SENC) hosted by the University of Helsinki.

Each of the Scandinavian countries has a formally elected Sami Parliament, although these are not identical in form or function. In Sweden this is the Sametinget, founded in 1993. There is also a collaborative Sami Council, founded in 1956, which incorporates Sami representatives from all countries within Sapmí (Sara, 2002: 17). Much of the political activity of the parliament and council has been to reinforce Sami identity and unity as an indigenous people not divided by the borders of nation states (*ibid.*: 24). The Sami have a common Sami national song, a flag (inaugurated in 1986) and a number of official flag-flying days that mark special occasions or events in Sami history (Saami Council, 2010).

Traditionally, Sami economic activity has been closely linked to the environment and particularly reindeer. However, only an estimated 10%-15% of Sami actually work within the reindeer herding industry and this is principally focussed in the inland areas of Sapmí (Sara, 2002: 26; Sametinget, 2006).

Whilst reindeer herding has symbolic value for all Sami, and is an occupation that non-Sami cannot undertake in Sweden, the contemporary Sami economy is considerably diverse. The Sametinget (2006) describes many Sami businesses as representing 'the close connection between industry, environment and culture', with various cultural and tourism-related businesses playing a large part in the current Sami economy.

'The traditional occupations in Sapmí are reindeer husbandry, hunting, Sami agriculture, fishing and Sami handicrafts ("duodji"). However, the majority of Samis are employed within non-tradition bound Sami occupations' (Sara, 2002: 26)

Sami handicrafts include a range of artefacts decorated with distinctive patterns and colours which also have a defined functional purpose, including bags and pouches, clothing, knives, spoons and bowls inlaid with reindeer antler, drums, and silver jewellery amongst many others (Sameslojdstiftelsen, 2009). An example of Sami design is presented in figure 2.

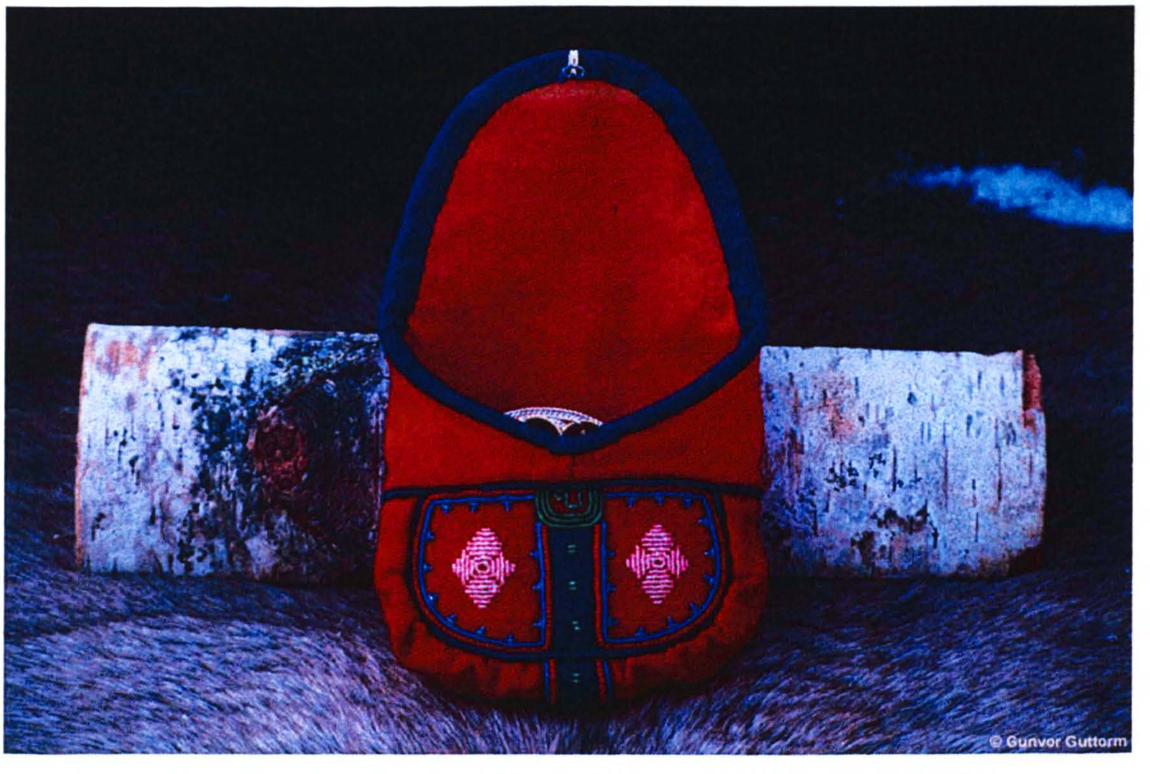

Figure 2. A small South Sami handbag, made by Lena Persson, Såahka (Undersåker) district. Image by Gunvor Guttorm, available from the Encyclopaedia of Sami Culture (SENC) hosted by the University of Helsinki.

The Sami also have a strong indigenous poetic/musical tradition incorporating a number of lyrical forms including *joiking*[3]. Usually unaccompanied, *joiks* are highly contextual and personal; often concerning topics such as the life histories of people and families, feelings about the landscape and environment or particular animals. Gaski (2000: 193) describes how *joiking* can be a 'deeply philosophical text', a way of remembering, and a means of artistic expression, sometimes with the content of the *joik* being communicated by the melody (*luohti*) alone. In recent years, fusion of *joiking* with popular and jazz music has increased the popularity of this music form in the mainstream Nordic and international populations (for example the success of Norwegian Sami singer Mari Boine). However, the *joik* is not intended to function simply as an art form: it can also perform a highly contextual social function. For example, Gaski (2000: 204) describes how the giving of a *joik* to a young person both gives that person a link to their community but also recognises their unique individuality and status in the community.

Sami languages

The Sami language, like the Sami culture, is not uniform over the whole of Sapmí. There are three main languages or dialects in Sweden (North, Luleå and South Sami), the most common being North Sami, which is spoken by *c*.80% of Sami speakers (Sammallahti, 1982: 103). The Sami languages belong to the Finno-Ugric language group, with more similarities with Balto-Finnic languages than Germanic ones, such as Swedish and Norwegian. The Sametinget estimates that 35-40,000 Sami in Sapmi currently speak a Sami language, although the regularity and the extent to which they speak it is unclear. The languages are more commonly used in family and close social contexts, and are unlikely to be used in formal dealings or with public institutions (Sara, 2002: 4). However, Sami languages did achieve official formal status in 1999/2000 (*ibid.*: 7) and, although they have been historically excluded from being taught, are now accepted with teaching in Sami (albeit at a limited scale) at all levels of the education system and Sami broadcasts for radio and television programming (Sametinget, 2006; Sara, 2002: 7-8). In addition, the

[3] Examples of *joiks* are available to listen to on the Encyclopaedia of Sami Culture website at http://www.helsinki.fi/~sugl_smi/senc/en/audiovideo.htm (last accessed 7/12/2006).

Sami Parliament established a Sami language council in 1992 to facilitate the promotion of Sami language matters (Sara, 2002: 13).

Sami worldview

'For the Saami, this world and the supernatural generally constituted a continuum rather than a Western type of dichotomy between the secular and the sacred.' (Pulkkinen, 2003-2004)

It is difficult to separate aspects of traditional Sami culture as they are all interrelated. Elina Helander summarises a number of key concepts in the Sami philosophy or world view as 'animism, tolerance, respect, collective thinking and the belief in the interconnectedness of all life forms' (Helander and Kailo, 1996: 171). Other authors have stressed that this 'interconnectedness' goes beyond living things to incorporate inanimate aspects of the environment. In particular the landscape is seen as invested with social, cultural and symbolic meaning, as well as being of physical and economic importance. This strong connection with the environment is reflected in the traditional belief system of the Sami.

The traditional religion of the Sami is characterised in the literature as animistic, polytheistic, cultic and shamanistic. The shaman (*noajdde*) played a key role in Sami culture: acting as communication channel between this world and others (especially the world of the dead; Rydving, 1993: 70). The *noajdde* performed sacrifices, divinations (using shamanic drums) and communicated with spirit guardians and ancestors. The picture of this traditional religion is patchy, as Sami have been strongly influenced by the introduction of Christianity into the region by Swedish missionaries and settlers since the fourteenth century (Lundkvist, 1985: 95), and practising the traditional religion was prohibited by the state in 1685 (Kvist and Wheelersburg, 1997: 4). The earliest sources on Sami pre-Christian religion originate from the sixteenth and seventeenth centuries and are mainly recorded as a result of conflict between Christian and indigenous belief systems. Indeed, many of the records come from court reports or from the records of Christian missionaries (Mebius, 1965: 351; Pulkkinen, 2003-2004) and are therefore likely to give biased or inaccurate representations. The picture created from these sources is a religion closely connected to the landscape and environment. There are numerous descriptions of ritual sites within the landscape where Sami would make offerings to particular deities, or ritually deposit metal items, or reindeer and bear remains. Both the reindeer and the bear figure strongly in the traditional belief system, with specific rules about the way in which they were hunted, slaughtered and their remains disposed of. See, for example, the account of the bear hunt given in Elgström and Manker's (1984) *Björnfesten*. Before the widespread adoption of Christianity there was some blurring between the traditional and new belief system (Pukkinen, 2003-2004), although some traditional practices continued as late as the twentieth century, including reindeer sacrificial offerings to Sami deities and continued respect for ritual sites in the landscape (Kjellström, 1987: 25-27). Furthermore, the way that some contemporary Sami describe their relationship with the environment indicates that elements of the traditional belief system are still incorporated in the Sami worldview, and are important factors in the way that indigenous knowledge is produced and disseminated (see, for example, the discussion between Helander and Kailo, 1996).

The *siida* system

The Sami *siida* pastoral system is used to describe the social/cultural institution through which reindeer herders mediate the relationship between the reindeer and the pasture. Each *siida* is usually made up of an extended family group who are connected with a particular area of land comprising year-round areas of pasture for reindeer (Bjørklund, 1990: 76). Overall, it is used to describe a group of people who move and live together tending the reindeer herds. In practice, the *siida* composition varies during the year as the herds are divided and regrouped according to, amongst other factors, seasonal variability in pasture conditions and climate.

'The siida is in other words an alliance recruited through cognatic and affinal relations, based upon mutual herding strategies among its members. This principle of organization provides each reindeer owner with potential access to pasture and herding partners' (Bjørklund, 1990: 81).

The *siida* system was officially recognised and incorporated into the Swedish administration during the 1970s. Since then there has been considerable conflict between herders and the government over how reindeer herding should develop. The Nordic states have traditionally viewed the *siida* system as potentially leading to overgrazing of pasture and uneven distribution of reindeer wealth. However, Bjørklund (1990, 79-80) contests this, arguing that as the *siida* system is not strictly speaking a system of common land ownership, but a means of regulating and negotiating access to pasture. Overgrazing is not a natural feature or result of managing the land this way. Although different in function and organisation, the Sami villages currently used to divide and govern Sapmí have their roots in the concept of the *siida* system (Rochon, 1993: 28). There are currently 51 Sami villages, each containing several reindeer herding associations (Swedish Institute, 2006: 2).

Socio-political context

In order to get a full picture of the situation of Sami in northern Sweden it is also necessary to consider the socio-political context of the Swedish state during the period of transition. This is necessarily brief, but is dealt with in more detail within the context of the transition to herding elsewhere (Kvist, 1992; Wheelersburg and Kvist, 1996; Lundmark, 1989; Zorgdrager, 1999). The period of the transition to herding was a period of increasing colonisation of the north by the Swedish state, involving administrative, fiscal and religious control. Between the thirteenth and fifteenth centuries the state had divided Swedish Sapmí into '*Lappmarks*' and later into smaller Sami villages known as '*Lappbyar*' (Kvist and Wheelersburg, 1997: 4). By 1553 each of these villages had specific Sami who were responsible for paying tax for their extended family (referred to as '*Skattelapps*'). By the late sixteenth century the Sami had probably been taxed in some way by the state for almost 300 years: first through *birkarls* in the thirteenth century and later through crown officials and sheriffs. Taxation was not simply a source of income but also a means of administrative control over the area (Wheelersburg, 1991: 338-339).

The religious aspects of colonisation began during the fourteenth century, when Christian missionaries established themselves in the region (Lundkvist, 1985: 95). By 1603 each *Lappmark* had to have a church and market and, in 1617, these northern parishes were organised under the control of a mother parish in one of the coastal towns (Kvist and Wheelersburg, 1997: 4). The full extent of religious colonisation was evident by 1685, when practising the traditional Sami religion was made illegal by the state (*ibid.*)

The Sami had a long involvement in trade with neighbouring populations through the Dano-Norwegian, Swedish, and Russian trade systems. Trade was focussed mainly in towns and at regular markets but also via travelling tradesmen (Roberts, 1958: 25; Hansen, 1984: 52-56). The establishment of state-controlled markets in Sami areas in the early seventeenth century was clearly an attempt to exert more control over this trade.

The drivers for colonisation efforts may be linked to the broader socio-political context of Sweden during this period. The variable climate of the Little Ice Age had had a serious impact on Swedish agriculture and there were many reports of poor harvests in the south of Sweden between 1523 and 1781 (Roberts, 1979: 43), accompanied by numerous epidemics of plague (Roberts, 1958: 7). Sweden was also involved in considerable conflict and empire-building abroad: between 1600 and 1660, Sweden was at war every year. This continued conflict was very expensive and part of the funding to support these efforts came from taxation (Roberts, 1979: 47-52). Therefore the state would have looking at how to gain more income from all areas of the country. There were also industrial reasons for colonisation: for example, the establishment of iron, silver and copper mines during the early seventeenth century (Söderberg, 1984: 6). Colonisation of the north of Sweden was actively incentivised by the state through, for example, giving tax respites to Swedish farmers who settled there (Roberts, 1958: 17)

A holistic approach to cultural change

As outlined in the introductory paragraph of this chapter, the scope of this thesis is to contribute to and enrich the understanding of why some sections of the Sami in northern Sweden developed a subsistence strategy based principally on reindeer pastoralism during the late sixteenth and early seventeenth century, and the extent of and nature of that transition.

The transition to herding is essentially a cultural change. The concept of culture used in this thesis aligns closely with Geertz's (1973: 187) semiotic concept of culture as something through which people attempt to co-create meanings for their experiences and understandings of the world, rather than a discrete physical phenomenon. As such, this culture is not a static or 'super-organic' entity but is dynamic, acted through the lived experiences of individuals and groups of individuals (*ibid.*: 188). The approach taken in this thesis is not purposefully aligned with any particular theoretical standpoint but is based on three key principles:

- A clear focus on developing and enriching understanding rather than necessarily reaching a definitive solution.
- The approach will build from the bottom-up; assembling detailed and contextualised information on various aspects of the transition to herding in northern Sweden to try and provide a more nuanced understanding of the issue.
- The nature of the issue requires the approach to be multidisciplinary in nature, taking a holistic view of cultural change.

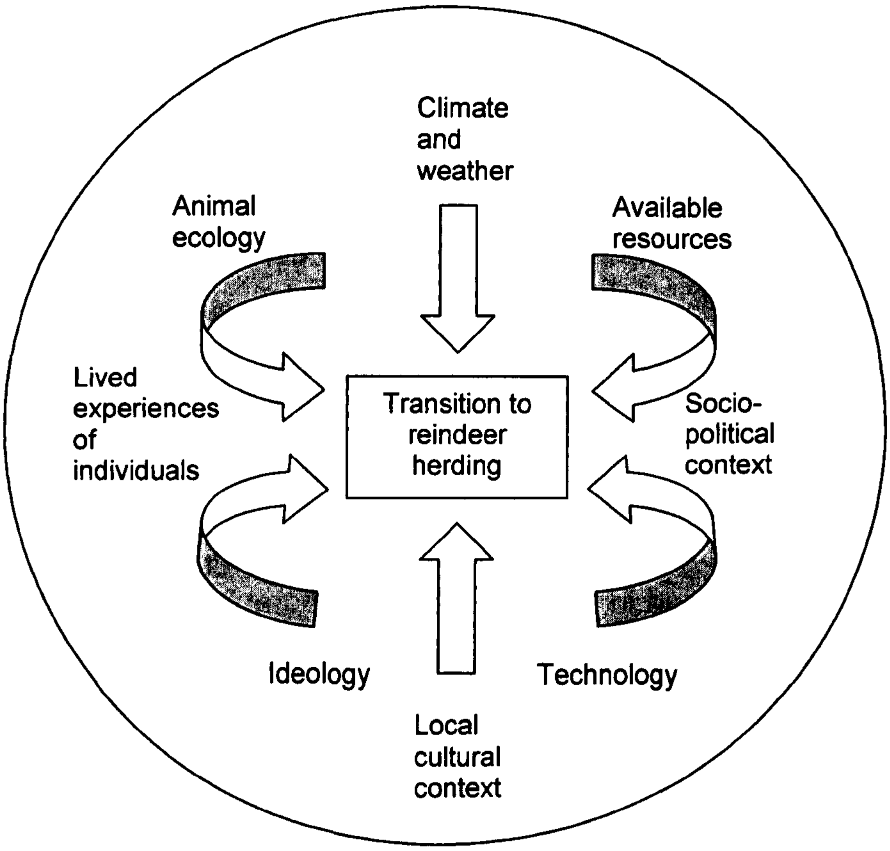

Figure 3. Representation of factors that may have played a role in the transition to reindeer herding in northern Sweden

Traditionally the transition to reindeer herding has been approached from, and studied within, a particular discipline: for example, history (Wheelersburg and Kvist, 1996), ecology (Krupnik, 1993), and anthropology (Ingold, 1988). These studies have made a significant and substantial contribution to the understanding of the transition but have not provided a holistic picture of the cultural changes. By focussing on a particular aspect of the transition to herding, these studies have privileged certain factors as having a prime role at the expense of others. For example, the specific focus on the impact of economic and social policy in Kvist and Wheelersburg's research has left the impact of environmental change as incidental to the transition. In their 1996 article on the transition to herding, climate is briefly discussed, and a single proxy record is described as showing that climate was 'a neutral or at best "conducive" factor for reindeer pastoralism' (Wheelersburg and Kvist, 1996: 160). Although Kvist and Wheelersburg do not present the relationship between these factors and the transition to herding as a simple linear relationship, it still does not acknowledge the complexity inherent in these kinds of cultural transformations.

This thesis aims to focus in on a particular aspect of that context which has not been thoroughly addressed to date: the role of the environment in the transition to reindeer herding. This is not an argument for environmental determinism; it is not intended to imply that environmental change *caused* the transition to herding. A key principle in the approach taken in this thesis is that it is inappropriate to look for a single causal factor, as this misrepresents the complexity of the cultural changes involved in the transition. Each of the factors that may have played a part in the transition to herding is inextricably linked and related, and behind each of these lies a complex web of underlying factors associated with particular contexts. For example, climate change will have produced tangible impacts on the socio-political context, which in turn will have influenced the decisions individuals made in response to environmental change. A multidisciplinary approach, taking into account all factors that may have played a role in the transition to herding, can contribute to creating a richer understanding of the problem. However, this would be a considerably larger piece of work than the scope of this thesis. What this thesis aims to do, therefore, is to examine the environmental context in which the transition to herding took place, and consider how this may have affected the transition. This is not an attempt to undermine the considerable work of previous authors on the transition to herding, but to add another dimension to the debate. It is a recognition that the role of the environment, and particularly the role of climate and weather, in the transition to herding has been largely overlooked in previous work. However, this may have had direct and indirect impacts on the subsistence and mobility patterns of Sami populations, and on the ecology and behaviour of animals they exploited. It is hoped that, by adding this dimension to the debate, we can reach a more holistic understanding of the transition to herding.

This thesis aims to present a situated understanding of the transition to herding, which is of critical importance if we are to avoid an environmentally deterministic view. It is also a key reason as to why caution must be exercised when generalising from one context to another: for example, the way in which Krupnik (1993) draws from Siberian and Russian examples when debating the transition to herding in Scandinavia. It is likely that the transition to herding was patchy and complex: with considerable temporal and spatial variability, not to mention cultural differences between community groups and individuals. The ways in which these societies and individuals respond to environmental change is connected with so many other contextual factors that transferring any conclusions must be done with caution.

'...the consequences of a climatic event, once documented, are not direct functions of its physical characteristics. The consequences, rather, vary with the ways in which the society has organized its relations to its resource base, its relations with other societies, and the relations among its members.' (Meyer et al, 1998: 237 quoted in Head, 2000: 73).

Head (2000: 7) stresses the importance of taking a *contingent* approach: looking at the 'historical particularity of sets of circumstances'. This is particularly appropriate to bear in mind for this thesis. The Sami are not, and were not in the past, a homogeneous group and there was considerable variation in the cultural, social and environmental context of specific communities. In considering the transition to herding, it is important to remember that the development of a specialised reindeer pastoralism was not an inevitable event. Not all Sami chose to become reindeer herders; many options were open including settled agriculture and animal husbandry, fishing, hunting and trapping, and a wealth of combinations of these. What is of interest to this thesis is what particular contextual factors led to this decision being made. All of this argues for a more situated consideration of the transition to herding. Therefore, the focus of the thesis is limited, as far as possible, to a specific geographical area (northern Sweden) and a particular time period (the late sixteenth to mid seventeenth centuries).

'"Big-picture" overviews often (unintentionally) reinforce the idea that certain historical outcomes - the development of agriculture, the destruction of indigenous societies, land degradation - were inevitable. Not only does this reify categories, for example "hunter-gatherer", that we should critically examine, it implies that the future is a foregone conclusion. In contrast, examining the details of variable forces, processes and circumstances converged at different times and places in the past provides a more nuanced understanding' (Head, 2000: 7)

In order to provide this dimension, information will be drawn from research in a variety of disciplines and fields, including climatology and paleoclimatology, ecology and paleoecology, history, anthropology, environmental sciences, and archaeology. Hopefully this combination will bring new insights and understandings to the study of the transition.

The relevance of the thesis

The outcomes of the thesis will add to the understanding of the transition to herding in northern Sweden, through the combination and consideration of a range of evidence from multiple disciplines. This approach is also of relevance to those studying and developing models for understanding other cultural transitions. In particular, the importance of taking a holistic and contextual approach toward understanding change, rather than the application of standard models or focussing on the role of single factors. Furthermore, because the thesis will focus on a period of high temporal climatic variability, it is also relevant to modern concerns about how anthropogenic climate change may affect human populations. Through examining how environmental change may have affected populations in the past we can enrich our understandings of the complexity of how climate change may affect present day and future populations. This is particularly pertinent for Arctic environments where the impact of anthropogenically forced climate change may be more severe. The use of global circulation models (GCM) to predict climate change has suggested that anthropogenic climatic forcing, primarily through the release of greenhouse gases (CO^2), will result in an increase in global temperatures of 1.9 – 5.2°C by the middle of this century (Parsons *et al.*, 1995: 61). In Arctic regions, the effect of this warming is considered to be exaggerated giving a typical warming of 1-5°C in summer and 2-4°C in winter (Heal *et al.*, 1998: 26).

The situated nature of the study lends weight to the argument that, although often presented as a global issue, the impact of climate change may be locally variable and involve a range of complex feedback mechanisms and therefore needs to be considered holistically at the local level. For example, some researchers have argued that some, or even all, of the predicted global warming may be counteracted by various cooling forces; both natural feedback mechanisms and through anthropogenic interference with the climate. The enrichment of CO^2 in the atmosphere and increased temperature may actually increase productivity, by plants on the land and algae and therefore phytoplankton in the oceans. Both of these processes absorb CO^2 and produce the by-product dimethyl sulfide (DMS). DMS is thought to increase cloud albedo and reflect of solar radiation back into space (Idso, 1998: 75). This may not, however, be an immediate response. Using evidence from global temperature regulation after a volcanic eruption 55,000,000 years ago it has been predicted that it would take 60,000 years for plankton to absorb sufficient CO^2 to counteract global warming (Pearce, 2000: 171). Cloud albedo may also be increased by the increased water vapour content and the decrease in droplet size[4] within the clouds which are both consequences of an increase in global temperature (Idso, 1998: 74-75). Again, this assumption may not be true as it is unclear whether the increased water vapour in clouds would be a negative mechanism (via cloud albedo) or a positive mechanism (via water vapour-greenhouse feedback) (Schneider, 1994: 345). The release of certain aerosols through burning fossil fuels has been shown to increase reflection of solar radiation into space, and thus offset some of the CO^2 induced global warming. However, the distribution of both CO^2 and aerosols in the atmosphere varies geographically. For example, the Gross National Pollution Map showed in 1977 that aerosols were concentrated primarily over the north-eastern part of the United States and extended into the Atlantic, Eurasia, Europe and China for hundreds of kilometres (*ibid.*: 34). Therefore the effect of offsetting will vary regionally and cannot be described as acting on a global scale. Even if cooling mechanisms can offset global warming to the extent that the global mean temperature remains the same, it may result in smaller scale fluctuations. The combination of the effects of CO^2 and aerosols is predicted to cause summer cooling and winter warming in the northern hemisphere. Although this would result in a similar or unchanged annual mean temperature it would reduce seasonality and have a profound effect on ecosystems in the north (Sinha and Harries, 1997: 2355). On a more general scale, the predicted temperature changes over the ocean may be slightly different to those over the land (Prabhakara *et al.*, 1998: 1930); therefore this must be considered when extrapolating the impact of temperature change on terrestrial ecosystems from globally averaged temperature estimations.

Structure of the thesis

An introduction to the cultural and socio-political context of the transition to herding has been provided in this chapter. This is a necessarily concise introduction, and aspects of Sami culture relevant to the thesis are elaborated on in later chapters. The structure of the remainder of the thesis is purposefully bottom-up, with each chapter presenting synthesis and analysis of the literature and research pertaining to each of the building blocks, that will then be combined to provide a more holistic understanding of the transition. As such, each chapter will address a number of questions pertinent to developing this bottom-up approach.

Chapter two focuses on the nature of subsistence activities around the focal period of study and attempts to provide answers to the following questions:

- What do terms such as hunting and herding connote and how do they apply to Sami subsistence activities?

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[4] Increased DMS release causes more cloud concentration nuclei (CCN) which decreases the size of existing clouds droplets creating higher albedo effect.(Idso, 1998: 75).

- What were the prevailing subsistence activities prior to and following the period of transition (drawing on archaeological, historical and anthropological studies)?
- What current theories about the transition to reindeer herding in northern Sweden have been proposed? And,
- Where are the gaps in these theories (with a particular focus on environmental and climate change during this period)?

Chapter three deepens the focus on archaeological material and explores what more this can divulge about the nature of the transition to herding:

- What does the archaeological evidence tell us about the spatial and temporal nature of the transition?
- Considering previous research on settlement patterns, archaeozoological material, changes in technology and ideology, and environmental analysis, does the archaeological evidence support the notion that this was a radical cultural transformation?

Having gained a more nuanced understanding of the nature of the transition to herding from the current research position, the next three chapters begin to assemble the bottom-up understanding of the contribution environmental and climate change may have played in that transition. First, establishing the nature of this environmental change, how this may have affected the physiology and behaviour of the key resource – reindeer. Then, going on to explore how the combination of environmental change, and consequent impacts on reindeer, may have had direct and indirect impacts on Sami communities and subsistence activities.

Chapter four provides the first building block by synthesising some of the previous research around the Little Ice Age (LIA) climate, focussing specifically on northern Sweden during the sixteenth and seventeenth centuries:

- What were the probable causes of the LIA?

- What do climate proxies and documentary sources indicate about the nature of the LIA climate? And,
- Are the connotations of the term LIA (that it was a largely cold period) correct?

Chapter five introduces the key resource that is the topic of this thesis, reindeer. Background information on the evolutionary origins of reindeer, migration and distribution within northern Fennoscandia is presented, along with an overview of selected aspects of reindeer ecology. This provides the foundation for the following chapter, which goes on to explore the impact of environmental change on reindeer behaviour and ecology: drawing from both scientific research and understandings from written accounts of the indigenous perspective, addressing the following questions:

- What do scientific investigations indicate are the physiological and behavioural impacts of environmental change on reindeer?
- What does the term 'local knowledge' mean? How can this be used? And, how does it compare to the western scientific paradigm?
- How do written accounts of local knowledge describe the impact of weather and climate change on reindeer? And,
- Taken together, how do local knowledge and scientific research inform the understanding of how reindeer may have responded to the environmental conditions during the LIA?

Chapter seven begins to draw the thesis together, and refocuses attention on the communities experiencing the transition; building on the preceding chapters and considering :

- What were the direct impacts of the LIA climate on indigenous Sami communities?
- What were indirect impacts of the LIA climate on indigenous Sami communities, with a particular focus on indirect impacts on subsistence activities?

The thesis is drawn together in the final chapter, which takes an overview of the findings from the previous chapters, and uses these to create a picture of the interaction between environmental conditions and Sami subsistence activities during the sixteenth and seventeenth centuries in northern Sweden. This synthesis is used, alongside a specific theoretical lens, to inform the discussion of the larger questions pertinent to the thesis:

- What was the scale of Sami reindeer herding during the sixteenth and seventeenth centuries?
- How might Sami subsistence choices have been made, at the individual and community level?
- How did the environmental conditions during the LIA affect Sami subsistence choices?

Through this discussion, a number of conclusions are drawn about the role of environmental change in the transition to herding, and a strong case made for greater consideration of environmental factors when studying historic/prehistoric cultural change. Finally, the interplay between environmental and other factors within the transition to herding is discussed, reflecting on the aim of the thesis to provide a more holistic understanding of this transition. The limitations of the thesis are considered, along with remaining questions and suggestions of possible areas for future research.

Chapter 2. The transition from hunting to herding

It is clear from many sources that Sami subsistence strategies underwent a substantial change in emphasis during the late medieval period, especially between the fifteenth and eighteenth centuries. This is typified by many authors as a shift from a largely egalitarian hunting society to a socially stratified pastoral society, with products of this system being used for household subsistence, tax payments and trade with non-Sami groups. In order to establish exactly what changes in economic strategy took place during this period, and to understand fully these changes, it is necessary to provide some background information. Firstly, the kinds of economic strategies described in the literature (*i.e.* 'hunting', 'pastoralism', and 'ranching') need to be defined so that is clear what is understood and implied by these terms. These definitions need to take into account not only the external characteristics of a particular subsistence strategy, but also the underlying social relations between people and the resources they exploit. Secondly, it is necessary to establish exactly what type of economic strategy was employed by the Sami directly before and after the period in question. This involves looking at reconstructions utilising ethnographic, anthropological, archaeological and historical evidence. Finally, a synthesis of how and, if possible, when the change in subsistence strategy took place will be provided together with an overview of some of the current theories as to the complex reasons why this change came about. As this thesis focuses on the impact of climatic change on Sami societies during this period, particular attention will be paid to the extent to which climate change has been explored as a factor in this transition.

Hunting

Before a definition of hunting societies is presented, it is necessary to point out that this is a brief overview of the work on categorising hunting societies and the problems associated with this issue. Rather than providing an exhaustive survey the intention is to outline some of the defining characteristics of hunting societies, especially those criteria which set them apart from herding or pastoral societies.

It is extremely difficult to describe what typifies a hunting society, as there is so much variation encompassed within this broad term. In fact, the difficulty in ascribing parameters to this group has led Burch to assert that 'there is too much variety in the class of hunter-gatherer societies to make it a useful category for theoretical purposes' (Burch, 1994: 454). Traditionally, the term has been used by Europeans to describe populations which they encountered who were not engaged in agriculture or pastoralism, were not sedentary and gained most subsistence needs through hunting, fishing and gathering (Bird-David, 1988: 17). Clearly this will include a wide range of societies. An important point deriving from this definition is that hunting societies do not get all of their subsistence requirements solely from hunting. In fact, these societies employ a wide range of resource-exploitation techniques including gathering, small-scale agriculture or animal husbandry, and fishing, alongside hunting and trapping activities. It is also important to remember that many hunting societies did not live in isolation; on the contrary, many groups, particularly in extreme environments, such as Arctic maritime hunters in Eurasia, supplement their own activities with exchange for food and skins with herding groups (Krupnik, 1993: 120). Similarly, some south Asian and African groups have been involved in contact and trade since antiquity (Bird-David, 1988: 18). Therefore, some of the subsistence requirements of hunting societies may have been met by products from outside their own economic activities. As well as practising a wide variety of economic activities, recent and extant hunting groups have exploited diverse habitats, ranging from tropical rainforests, interior deserts and coastal areas to polar regions (Service, 1966: 3).

Within this broad range of groups it is possible to identify a number of characteristics which, while not universal, do apply to the majority of hunting societies studied. Firstly, most tend to live in small groups of high mobility. They may be associated with a specific geographical range but they do not exercise exclusive rights to resources. This flexibility allows a variety of resources to be exploited over a wide area and, to some extent, prevents the over-exploitation of a specific resource. Because of the need to be highly mobile, levels of personal possession in hunting societies tend to be low: as Sahlins (1972: 12) states 'mobility and property are in contradiction'. Economic activity is organised at the household level and much of the social organisation of production is carried out through family relationships (Service, 1966: 8). There are high levels of sharing and pooling of resources in hunting societies, and exchange is generally governed by principles of reciprocity and gift-giving rather than formal trade relationships. However, the exact nature of these reciprocal exchanges is highly situational. Larger-scale social organisation tends to be egalitarian without a specific leader, and control of individual behaviour within the group is enforced by the community as a whole through the prevailing social ideology and culturally prescribed norms of behaviour. When a particular objective requires a certain level of authority, this is usually done by consulting an 'advisor' who is considered by the community to be an expert on the matter in hand (*ibid.*: 49-53).

Again, it is reiterated that these broad generalisations are just that, and exceptions exist which do not fit this description. Because of this, Ingold (1988: 3) has argued for the classification of hunting societies according to the nature of their relations of production rather than by external features of their cultures. For hunters the relationship with resources is one of predator and prey. This separates hunting systems from other systems of food production, as these typically involve the protection of the living animal in some way before slaughter (Clutton-Brock, 1989: 117). There is common access to the means of production, with no private ownership or rights to land or prey, and the produce is usually shared amongst members of the group, with sharing particularly prevalent during periods of famine or abundance (Lundmark, 1989:30; Ingold, 1988:147). However, some societies use property symbols on weapons identifying the hunter who caught the animal; in this situation the animal does becomes personal property after its death (Storli, 1996: 83). One of the main features in the relationship between hunters and their resources is that it is not purely economic, but social. In many northern indigenous communities the perception of the world does not separate the spheres of nature and human society. As such, hunted animals are seen as active participants in a social relationship with the hunters. This is often seen by the hunter as a partnership where the animal consents to be killed, and the hunter is obliged to respect the animal as his part of the exchange. This is a simplification of a very complex concept but goes some way to explaining the different relationship hunters have with their prey when compared with, for example, farming communities where animals are seen principally as passive and subordinate in the economic relationship, being merely possessions of the farmer.

If we use the above definition of hunting, based on a predatory relationship with animals and common access to resources and land, we find it includes a number of groups exploring a broad range of economic activities including fishing, gathering and, in the northern context, the keeping of small numbers of tame animals for draught and decoy-hunting purposes. Inger Storli (1996: 82) has argued that this equates to what has been described in the literature as 'Arctic reindeer herding'.

Regardless of the complex nature of many hunting societies, and thus the inherent problems in defining them, societies based solely or partly on hunting have been extremely successful in the history of humankind. Indeed, Lee and DeVore (1979: 3) described hunting as 'the most successful and persistent adaptation man has ever achieved'. This is evident from the fact that many hunting groups do not take up alternative economic strategies even when they are known to them. For example, the Hadza people from the area around Lake Eyasi, in Tanzania, rejected agriculture even though many neighbouring societies practiced it. Their main reason for doing so was that they considered it to involve much more work than their present hunting lifestyle (Sahlins, 1972: 27).

Pastoralism

1.Nomadic Flat-land Pastoralists with Large Stock		2.Transhumant Mountain Pastoralists with Small Stock
(a)Mounted	(b)Pedestrian	
(i)Independent of agriculture	(i)Independent of agriculture	(i)Independent of agriculture
(ii)Integrated with agriculture	(ii)Integrated with agriculture	(ii)Integrated with agriculture
(iii)Practice secondary agriculture	(iii)Practice secondary agriculture	(iii)Practice secondary agriculture

Table 1. Pastoral taxonomy after Goldschmidt, 1979: 17-19.

Pastoralism generally involves the taming and keeping of herd animals for a number of purposes, including milk, meat, transport, labour, and supply of other raw materials such as skin, hair and bone. The term has been split into categories by Goldschmidt (1979: 19; table 1), with reindeer pastoralism included within his second category. The problem with placing reindeer pastoralism in this taxonomy is that, being a general taxonomy, it misses a lot of the variety within that category. Reindeer pastoralism is unlike many other forms of pastoralism as it occurs outside the limits of agriculture, the animals are still behaviourally and morphologically wild, and are usually kept within their natural range (Ingold, 1988: 84). Therefore, it may be more pertinent to use a specially designed taxonomy of classes of extant and recent reindeer pastoralists; using the ways in which the animals are exploited to categorise the type of reindeer pastoralism (table 2).

	Labour	Milking	Hunting Decoys	Controlled by dogs	Riding
Sami type	x Traction	x	x	x	-
Western Siberian /Samoyed type	x Carriage	-	x	x	-
Tungus	x Pack carrying	x	-	-	x Saddle without stirrups
Northeastern	x	-	x	-	-
Sayan	x Pack carrying	x	-	-	x Saddle with stirrups

Table 2. Vashtein's five classes of reindeer pastoralists summarised in Aronsson, 1991: 8-9.

As pastoralism requires the taming of animals, it comes under the broad umbrella term of domestication. As with the term 'hunting', domestication and pastoralism are value-laden terms and there are similar problems with their definitions. The first problem with the term 'domestication' is that it describes both a specific event (when an animal was initially domesticated) and the ongoing process of domestication as a whole (Ducos, 1989: 28). Often, authors are not clear about which way they are using the term. Defining when initial domestication of animals took place is extremely difficult, as it often took place in prehistory, or in cultures with no longstanding written traditions. The method usually applied in archaeology to establish a date of domestication is analysis of skeletal morphology, but this may not be possible in all cases. For instance, at the initial stages of domestication the differences between wild and domestic animals are likely to be negligible. Even in later periods the differences may lie well within the range of natural variability. Ducos (1989: 29) points out that many non-hunting relationships with animals exist where there are no morphological differences between the tame and wild animals. He goes on to state that the 'idea that domestic animals are distinguishable from wild ones in all periods is scientifically unsound' (*ibid.*).

Bökönyi (1989: 22) asserts that 'the essence of domestication is the capture and taming of animals of a species with particular behavioural characteristics, their removal from their natural living area and breeding community, and their maintenance under controlled breeding conditions for mutual benefits'. The behavioural characteristics of the animal selected are of great importance. In order to be easily controlled and be kept in large numbers, the animals must be gregarious, docile in nature, and of a manageable size (Ingold, 1988: 97). The second part of Bökönyi's definition is not so straightforward. If we consider the way in which reindeer have been exploited by recent pastoral groups, it cannot actually be viewed as domestication under this strict definition. For example, in mountainous areas Sami traditionally used the natural range of reindeer for their migration routes and pastures, and these animals were therefore not removed from their 'natural living area'. Similarly the amount of control over breeding conditions varies widely. Some Russian Evenk pen their reindeer during the rutting season to exert full control, whereas the Siberian Sel'kups accept that wild and domestic reindeer will mate. It is probable that control over the herd composition is exerted through selective slaughter rather than control of reproduction (*ibid.*: 77, 98-99). Bökönyi describes the 'mutual benefits' experienced by both parties in the pastoral relationship as a special kind of symbiosis. The benefit to the human party in this symbiosis is obvious, they are provided with a guaranteed source of labour and a resource harvestable at any time (Baskin, 2000: 24). Resources may be harvested parasitically whilst the animal is alive (for milk and wool) or in a predatory way, by slaughter for meat, skin and other raw materials (Ingold, 1988: 31). However, this benefit has to be weighed against the investment in first taming the animal. The initial taming of a reindeer involves close and regular physical contact with the animal, and therefore these animals are unlikely to be slaughtered except in extreme circumstances. In some Russian groups it has been noted that, even in times of crisis, a switch to temporarily exploiting other resources is preferable to slaughtering tame animals (Krupnik, 1993: 118). It can thus be asserted that, in populations which exploit reindeer for meat (carnivorous pastoralists), the majority of the animals are not likely to have received such an investment. These animals cannot be considered to be domesticated in the strictest sense of the word, but rather are associated with human groups through control and protection. So the main benefit for the majority of animals involved in carnivorous pastoralism is the protection of the herd. Humans will prevent other predators taking animals and try to minimise the impact of other harmful exterior influences, through practices such as lighting smudge fires to deter insects and inoculating animals against diseases. Since, on the surface, both parties appear to benefit from this relationship, it is not surprising that it has been considered symbiotic. It must be remembered, however, that the animal did not voluntarily enter into this relationship; domestication exists because humans wished it to (Ducos, 1989: 29). Furthermore, the level of protection during the animals' lifetime does not disguise the fact that ultimately they will be consumed by the pastoralist.

As with the definition of hunting societies, Ingold proposes a definition of pastoralism set within the context of the relations of production between herders and their animals. In contrast to hunting, although the land may remain a common resource for the community, animals are considered private property to be protected. As such, animals become incorporated as part-members of human groups or households and in some societies this association can be highly sentimental. Some Evenk groups, for example, have names for all their tame reindeer and in many societies animals are included in laws and rituals regarding norms of acceptable behaviour within human groups (Ingold, 1988: 97). However, the notion of animals as property means that they will remain only subordinate part-members rather than equals in human society. Treating animals as property means an emphasis on accumulation, and the social system in pastoral societies tends to be stratified rather than egalitarian, although social mobility is high. The amount of trade and exchange that herders participate in is largely determined by their subsistence needs. For example, some Russian herders have long-standing trade relations with other non-herding groups, which provide valuable alternative sources of foods (Krupnik, 1993: 122).

Bjørklund (1990: 76) prefers to see the relationship between herders and their animals as one of a mediator (rather than simply protector), with the herder mediating between the animals and the land, ensuring access to pasture. He points out that the concept of land as a common resource is over-simplistic. Using the Sami *siida* system as an example he demonstrates that, although the land is not considered to be the private property of anyone in the community, rights over access are regulated by the cultural distributive *siida* system. This system ensures flexibility of access and a buffer against possible over-exploitation (*ibid.*: 83). A common theme in the literature regarding pastoral societies is the idea of the 'tragedy of the commons'. The main tenet of this idea is that the notions of common access to land and private ownership of animals are in opposition, and make pastoral economies inherently unstable (Lundmark, 1989: 30). Eventually, personal interest in accumulation leads to over-exploitation and consequent loss of pastures. However, when considering Sami reindeer pastoralism, there is no historical evidence to suggest this has ever happened. In fact, the Sami *siida* system has regulated pasture use in the past, preventing overgrazing. The pastoral system as a whole seems to have permanent centrifugal dynamics, with herds and herders dividing and regrouping throughout the year, as the type of economic activity being undertaken and the quality/amount of pasture available allows. In periods when the animals exert stress on pastures, the system is flexible enough for herders to seek alternative pastures elsewhere in the *siida* territory or through relationships with neighbouring *siidas* (Bjørklund, 1990: 79-83). In this way the pastoral system suggests an underlying interest in the good of the social group as a whole, without hindering individual interests.

The range of extant pastoral societies, and the range of interpretations of the relationships between humans and animals within these societies, preclude any definitive boundaries being established. In fact, reindeer pastoralism may be considered to be towards the middle of a continuum of resource utilisation with hunting at one end, and specialised reindeer herding for a market economy (or 'ranching') at the other end. The overlap with the previous category of hunting is obvious, and it is difficult to ascertain at exactly what point a hunting society with a small number of domestic animals (so-called 'Arctic reindeer pastoralism') becomes a pastoral society that still meets some subsistence requirements from hunting. Herd size may be a good indicator of the proportion of time spent on pastoral activity. It is generally true that the larger the herd the more time must be spent maintaining the herd and the less time spent on other subsistence activities (Krupnik, 1993: 92). However, there are upper and lower limits to herd size; too large and the herd will need to move constantly in order to obtain sufficient pasture, too small and the internal cohesion of the herd, and its genetic viability, is compromised (Ingold, 1988: 90).

Halstead (1996:21) argues that there is a terminological problem when discussing pastoralism in that some authors use it to refer to early mixed economies with an emphasis on livestock, whilst others use it to refer to only large-scale pastoralism. The problem when considering these arguments with respect to reindeer pastoralism is that it is difficult to see an emphasis on livestock, as the same animal is being exploited in both hunting and herding economies. Similarly, the fact that domestic reindeer have probably been present in small numbers for several hundred years (for traction, decoy hunting *etc.*), may mean that the transition to herding in northern Sweden is more a question of scale than a dramatic shift in subsistence activity. This confusion, over what exactly constitutes a pastoral herd, has led to controversial classifications of the subsistence strategies employed by the Sami in northern Sweden prior to the accepted date for the transition to reindeer herding.

Ranching

Ranching is a more recent development in northern Scandinavian reindeer economies, principally developing during the twentieth century. Ingold describes ranching as having some common elements with both hunting and pastoralism. For example the relation between humans and animals is predatory, as in hunting, while the social division of access to live animals is more like pastoralism (1980, 235). However, ranching differs from both these in two important ways: firstly the involvement in a market economy based on livestock; and, secondly the fact that individual herding units have (usually exclusive) control over units of land or territory (*ibid.*: 236). Although animals are kept in herds, there is less contact between the rancher and the animals: with contact focussed on gathering for marking and slaughtering. The location of slaughter is also different, with ranching economies in Norway transporting live animals to state run (and few Sami run) abattoirs rather than slaughtering animals in the open (Vorren, 1960: 185). Slaughter is selective, but the purpose of selection is different. In pastoral economies slaughter is principally for consumption, and the aim is to maintain the number of animals. In ranching economies slaughter may be for consumption but is also for commercial sale, therefore the selection of animals focuses on maintaining the quality and productivity of the herd (Ingold, 1980: 239). The overall number of animals on pasture may be lower than in pastoral economies, as the rancher is not able to use mobility as a buffering mechanism against catastrophe (*ibid.*: 246).

Ingold considers the modern reindeer economy in northern Finland (and most of northern Scandinavia) to be one of emerging or proto-ranching. This developed as a fusion of colonial and indigenous economies, and has been facilitated by the introduction of modern technology such as motorised snow scooters, helicopters, and radio communications (Ingold, 1980: 250-255). These have enabled profound economic and social changes within Sami lifestyle. They have reduced the time spent undertaking herding activities, allowed more sedentary settlement patterns with dwellings able to be located away from the animals, and provided opportunities to engage in other commercial activities (*e.g.* summer fishing and berry collecting; Wheelersburg, 1987: 114). Ranching often involves employees paid to carry out reindeer management tasks. For example, in Ingold's example from northern Finland these were paid through an association of reindeer owners who kept their animals in a particular shared territory. It is this collaborative ownership and/or access to pasture that Ingold argues prevents the economy being full blown ranching. With the lack of exclusive rights/control over territory there is (albeit limited) scope for hunting and pastoralism to continue alongside ranching (*ibid.*: 260). In Norway the transition between traditional herding and ranching took place during the Second World War. The economy is administered through a system of foremen and under-foremen in each reindeer districts who, along with the Sami Bailiff, make decisions about access to pasture, registration of earmarks, and complaints and conflicts between reindeer owners and their neighbours (Vorren, 1960: 182).

Sami subsistence activity prior to AD 1600

A relatively common picture of Sami subsistence prior to AD 1600 described in the literature is one of a mixed economy, with most food being provided by hunting, fishing and gathering, and the keeping of a small number of domestic animals (Kvist & Wheelersburg, 1997: 3; Lundmark, 1982: 174). The nature of this mix of domesticated and wild resources will have depended on individual circumstances, and this is highlighted by the difference between coastal and inland groups. Coastal groups concentrated on fishing, hunting and trapping whereas the inland populations focussed on hunting, fishing, and keeping small reindeer herds for transport, labour, decoy-hunting and milking (Manker, 1964: 6; Wheelersburg, 1991: 338). The date from which the Sami used reindeer for providing milk is unclear. Some authors have claimed that the use of Scandinavian loan-words for milking terminology means that this is a relatively recent development (Collinder, 1949: 88). However, closer analysis of the loan-words has led to the suggestion that they derive from Old Norse terminology, and could date back to the pre-Viking period (AD 850 – AD 1050) or even earlier, before *c.* AD 700 (Storli, 1996: 97,103). All of these speculations imply that the use of reindeer for providing milk could have been in place before the accepted transition to pastoralism in the seventeenth century.

A ninth century (AD 892) account, provided for King Alfred the Great of England, by the Norwegian chief Ottar (or Othere), details taxes paid by Sami and also notes that small numbers of domestic reindeer were kept. Ottar claims to own 600 reindeer himself, of which six are trained as decoys for hunting purposes (Vorren and Manker, 1962: 13). However, the status of this herd of 600 'unbought/unsold' reindeer is ambiguous. Even if the number of animals described by Ottar is accurate, the ownership of the reindeer is unclear. Ottar would have been in a position to demand tax from the Sami, and it is not clear whether the 600 reindeer were in a single herd belonging to Ottar or the collective animals of Sami that he had tax rights over (Lundmark, 1982: 40).

A number of literary sources are available from the early sixteenth century: ranging from reports from sheriffs and priests who had direct dealings with the Sami to more removed accounts. Following Lundmark (1982: 57) these sources must be considered with the caveat that they were created by non-Sami for non-Sami and therefore may not be the most accurate representations of Sami life at this time. Olaus Magnus's sixteenth century monograph, *Description of the Northern Peoples,* is an important contemporary source of information about the Sami. Magnus was the Archbishop of Uppsala at the time of writing this work, and compiled it mainly from written sources. He uses the term '*Scrifinnia*' to refer to the Sami, due to use of skis lined with reindeer fur by some Sami (Magnus, 1998: **1**: 22). The *Scrifinnia* relied solely on meat for subsistence, exploiting animals, birds and fish, the most important of these being reindeer. Although Magnus includes several erroneous facts in his descriptions (for example, describing reindeer as having an extra third horn), he recognises the importance of these animals as a source of many products including milk, skin, sinew (for sewing), hair (for stuffing pillows and saddles), hooves (for medicinal remedies), bones (for tools), and meat (Magnus, 1998: **3**: 872). He also provides one of the earliest descriptions of keeping tame reindeer: indicating both tame and wild reindeer herds were important, with the tame animals being kept in pens to protect them against predation. Magnus estimates herd size as anywhere between ten and five hundred reindeer (*ibid.*: 869). Although the accuracy of these claims cannot be verified, this does provide an insight into the timescale of the domestication of reindeer. The fact that tame reindeer may have been penned as early as AD 1555 indicates that the transition to herding from hunting was a long and gradual process. The scale of the herds kept varies widely in Magnus's description: from 10 to 40, right up to 500. Keeping ten reindeer is an acceptable number for a hunting household (Odner, 1992: 32), but 500 would be considered a large pastoral herd. Lundmark interprets the higher figure as not relating to Sami but to the reindeer herds controlled by the Birkarls, as this corresponds with an earlier account in Magnus's *Carta Marina*, and goes some way to address the fact Magnus provides conflicting accounts of the relative importance of game, fish, wild and domestic reindeer to Sami (Lundmark, 1982: 59). However, it is possible that the conflicting descriptions of subsistence activities could relate to seasonal or local variations within the broader Sami culture and the numbers are worth further exploration. One possibility is that Magnus may have got his facts wrong - as noted above some erroneous material was presented in the monograph. The second possibility is that pastoralism was fully developed in some areas at this time, with some households specialising to such an extent that they had built up considerable herds. The third explanation lies somewhere in the middle; the figure of 500 animals may represent the combined herding interests of a number of households, or perhaps the whole *siida*. As previously described, the Sami pastoral system involves the aggregation and division of many herds within the *siida* at different times of year. If this is what Magnus is describing then, although the social organisation of herding is present at this time, the number of reindeer owned by each household is still low. For example, using Odner's (1992: 93) estimation of *siida* size from his analysis of pre-AD1600 size of hunting groups in the north Varanger area, it can be hypothesised that a *siida* consisted of between 20 and 50 households or families. Taking Magnus' figure for a collective herd of 500 would mean between ten and 25 animals for each household. However, Mulk (1997: 24) suggests *siidas* in the Swedish Sami area may have been smaller, consisting of between eight and twelve families. In this case the number of animals per household would have been considerably higher, at between 40 and 60 reindeer per family. Definite conclusions cannot be drawn from this one literary source, but it does provide the potential for different shades of early reindeer herding existing at this time.

From the mid-sixteenth century, Letters from King Gustav Vasa contain some references to herding and reindeer herding products, but most references to the Sami indicate the importance of fishing and hunting, and the use of domestic reindeer mainly for transport and skins (Lundmark, 1982: 60)

Records of taxes paid by the Sami to nation states, and other fiscal documents can also hold valuable information about the resources they were exploiting at the time. However, these records are sporadic and discontinuous in earlier historic periods. Lundmark (1982: 50) asserts that from early tax records (*c.* AD 800) it is not tenable that Sami were reindeer pastoralists during this period. By the early medieval period the Sami had been providing pelts for the Scandinavian fur trade for hundreds of years and certainly since the ninth century AD (Wheelersburg, 1991: 343). Adult and calf reindeer skins were an important part of this trade, as evident from English custom records from Hull (AD 1305-6) detailing the import of 170 reindeer skins from Norway (Fjellström, 1982: 95). Fjellström argues that the income generated by this trade led to an influx of silver into Sami areas, a hypothesis which may be verified by the occurrence of silver sacrificial sites dating from this period (*c.* AD 1000-1350; Storli, 1996: 111). This income may have encouraged Sami to increase domestic herds to ensure a regular supply of skins and this has been used to argue that reindeer pastoralism was 'in full swing' by the end of the fourteenth century (Fjellström, 1982: 96). In contrast, later tax records have been used to show the exact opposite, that the Sami economy remained a mix of hunting, fishing and the keeping of small herds until the early seventeenth century. Prior to AD 1550, taxes were predominately paid in the furs of small mammals, especially marten but including beaver and otter too. By AD 1569, fish was an important method of tax payment but it is not until after 1602 that reindeer became an important species in tax records (Wheelersburg, 1991: 341-343). However, it is not clear how much these tax records reflect the normal economy of the Sami and how much they represent the needs of the nation state. The payment method was decided by the tax collector (*i.e.* the government) and not the person paying the tax, although it is unlikely a government would tax people in a currency they were unable to pay in. It is possible that the change in tax payment method to reindeer in 1602 may mask an attempt by the state to intervene in what it saw as an already successful fur trade. However, Wheelersburg (*ibid.*: 344) maintains that around *c.* AD 1600 the herds of reindeer owned by Sami were not large enough for extensive pastoralism to be a viable subsistence strategy. This coincides with other interpretations of Swedish sources stating that reindeer were almost exclusively used for transport, with food and raw materials coming largely from wild reindeer in the sixteenth century (Krupnik, 1993: 162).

Based on archaeological material from the North Varanger area in Norway, Tanner has argued that remains of herding dogs and a possible reindeer *pulka*[5] point to early herding activity occurring in the seventh to eleventh centuries AD (Storli, 1996: 84). Knut Odner has used archaeological material from the same area to suggest that, from around *c.* AD 1200 until the

[5] A distinctive reindeer sled used by the Sami (see figure 7 in chapter 3).

late seventeenth century, pastoral activity in this area was limited to small household herds kept for transport, decoy, and milking purposes (Odner, 1992: 17).

This shows the variety of opinion concerning the extent of reindeer herding practised prior to AD1600. The main problems encountered with these theories may be summarised as follows. Firstly, many authors have their own interpretation of what the terms 'pastoralism' and 'herding' entail but rarely make them explicit, and so problems of definition arise. Secondly, theories are often developed whilst working in specific areas or with a specific body of material. Obviously, this type of particularity is essential when working with such heterogeneous groups, as the Sami undoubtedly were during this period. However, this makes it difficult to make generalisations about subsistence patterns. Finally, many authors have their own models of the transition to pastoralism for the Sami, as to when, how and why it occurred. As such, ambiguous information may be interpreted within the framework of individual models, and refuted or used accordingly. For example, Ottar's account of 600 'unbought/unsold' reindeer with small numbers of domestic reindeer trained as decoys has been interpreted by Wheelersburg and Kvist (1996: 153) as indicating a largely hunting society who kept small numbers of tame reindeer for transport and decoy purposes. In contrast Manker has used this as evidence of a shift from hunting and trapping to pastoralism in the Early Viking period (as described in Storli, 1993: 17).

To summarise, the evidence and current state of research on Sami economy prior to AD 1600 provides a varied picture. There is considerable evidence of the continuation of hunting, fishing and gathering as principal modes of subsistence but there is also convincing evidence for the keeping of domestic animals. In many cases, and certainly for the earlier periods, this is restricted to small numbers of animals (possibly up to 10) kept mainly for labour, transport, decoy-hunting and, possibly from *c.* AD 700-900, milking. However, from the latter part of this period there is evidence, albeit ambiguous, for the increased importance of herding and decreased importance of hunting as subsistence strategies. For example, analysis of Olaus Magnus's account of herds of 500 reindeer may indicate that households in some areas may have kept between 10 and 60 reindeer: whilst this is not enough to provide all subsistence needs it would have made a significant contribution to household economy. Furthermore, some archaeological remains (explored in more detail in the following chapter), such as *stalo* sites, have been interpreted as belonging to early pastoralists. Therefore, whilst the period before AD 1600 was predominately one of hunting and mixed economies exploiting small domestic herds, it may be tentatively suggested that more intensive pastoralism existed towards the end of this period. Obviously, the level of pastoral intensification could be influenced by a number of external and internal factors and it is those which will be explored later in this chapter.

Sami subsistence activity after AD 1600

There is a general consensus in the literature that the Sami economy underwent a dramatic change during the early seventeenth century, which resulted in a certain percentage of the Sami population concentrating exclusively on reindeer pastoralism (see for example, Vorren, 1960:173; Krupnik, 1993: 164; Lundmark, 1982: 174; Mulk, 1997: 28; Wheelersburg, 1991: 343). Evidence for this change is drawn from taxation records, detailing the predominance of reindeer as a taxation payment and the first mention of the occupation of '*renväktare*' (reindeer herder) (Kvist and Wheelersburg, 1997: 153). Other historical sources provide detailed information, such as the first mention of the Sami system of earmarking reindeer. This system involves the cutting of a series of notches into the animals' ears, which correspond to a particular reindeer herder. It is used in preference to branding, which would decrease the value of the skin, or fur cutting or dyeing, which would only act as a temporary marker (Ingold, 1988: 116). The use of earmarks is associated with an increase in herd numbers and therefore an inability to maintain intimate knowledge about every animal in the herd. It creates a permanent and easily visible mark of ownership, which functions well in a system of individually owned animals and collective use of pasture. On a deeper level, earmarks may maintain the order within a group of herders who use a pasture area and contribute to the creation of social relations (Näkkäläjärvi, 1996: 89). By 1620, there is evidence for increased expansion and diversity within reindeer herding with wealthy herders able to accumulate substantial quantities of silver. Reindeer wealth is also apparent in the fact that one third of the reindeer herding Sami in the Uma district had sufficient animals to pay their taxes solely in reindeer at this time (Kvist and Wheelersburg, 1997: 154). However, not all Sami found reindeer herding a viable option. In the north Varanger area Odner has highlighted the fact that a substantial proportion of Sami lived almost sedentary lives in coastal settlements, where fishing and small-scale animal husbandry were the main subsistence activities (Odner, 1992). Similarly, some Sami had settled as agriculturalists earlier, during the first millennium AD (Mulk, 1997: 18). Even today, although reindeer herding is strongly associated with Sami identity, only between 10% and 15% of the Sami population actually obtain their main source of income from reindeer herding.

Within the development of reindeer herding after AD 1600, three distinct types have been characterised, each exploiting a different ecological niche (table 3). The type of reindeer herding which existed in northernmost Sweden during the late medieval period was that of the Mountain Sami, and this will be explored further. The differences between mountain reindeer pastoralism and forest and Skolt/Kola pastoralism have also been described using the terms 'half nomadism', and 'full nomadism' referring to the scale of migrations undertaken by each group (Collinder, 1949: 85).

Skolt/Kola Sami reindeer pastoralism	Annual movements between a central winter camp to peripheral pastures and fishing grounds.
Swedish Forest Sami reindeer pastoralism	Circulation between a number of permanent camps in the forest area during spring, summer and autumn. Migration down to the Gulf of Bothnia coast in the winter.
Scandinavian Mountain Sami reindeer pastoralism	Nomadism between winter pastures in the forest and summer pastures in the mountains or on the Arctic Ocean coast.

Table 3. The categorisation of types of traditional Sami reindeer pastoralism in Scandinavia, (data from Manker, 1964: 6)

The following section provides a general description of the annual reindeer herding cycle of the mountain pastoralists drawing from relatively recent ethnographic work with Sami communities (Manker, 1964; Vokov, 1996; Paine, 1994a). Some of the issues concerning the use of ethnographic data are explored in chapter six, but it should be stated that this in no way implies that these societies have been static and unchanging since the medieval period. In fact Sami have undergone profound changes, both from internal and external pressures affecting their socio-economic, political and cultural spheres.

However, the special ecological niche that reindeer herding exploits has, in contrast, remained relatively static. In recent times, reindeer were still being herded along migration trails which had been used for centuries. The continued use of pastures means that settlements may also be in places which have been periodically occupied for centuries. It is just this long association with particular reindeer herding areas, and other aspects of the landscape, which have been used to reinforce political claims in issues such as land rights. Similarly, the symbolic meaning of the landscape to the Sami is often used as a means of expressing identity; for example, ancestral associations and narratives are often connected to particular locations, and traditionally sacred sites are still treated as significant (Mulk, 1997: 13).

In more recent times the way in which herders tend to their animals has been altered radically through the introduction of new technology. Modern transportation technology, such as the snowmobile, helicopter and off-road motorcycles, means that reindeer are seldom used for transportation (Manker, 1964: 4) and herders may travel longer distances in shorter times; enabling a more settled life. Other technology, such as CB radios, has meant that herders may share information about the location of a herd, local conditions and emergencies much more easily. Finally, the introduction of centralised state- and Sami-run abattoirs have changed the way in which animals are supplied to the market (Vorren, 1960: 185). Contemporary reindeer herding in Sweden is a fully modernised industry and is thoroughly integrated with external commercial markets.

The sources used to create the following description of mountain Sami annual activities are therefore older sources, prior to the development of ranching and the impact of modern technology. The exception to this is Robert Paine's (1994a) work, which covers the period when new technology was being introduced; during the 1950s and 1960s. However, this text is still an extremely informative source book and was probably the first comprehensive account of participation in pastoral processes from Norway (Mathiesen, 1995: 525). Because Paine was able to work as a herder for the majority of his research, he was able to develop some understanding of how to care for and think about the reindeer as a herder would (Ingold, 1997: 73). As such, it remains an important text.

The annual cycle of the mountain Sami reindeer pastoralist is punctuated by regular migrations between areas used at particular times of year. This pattern has led the Sami to be described as a people of eight seasons. During the four main seasons Sami camp where specific herding activities are undertaken, and during the in-between seasons they migrate between these areas. The scale of these migrations can be quite large, with distances of up to 250-300 miles being travelled each way.

In early spring the reindeer are moved to pastures where the female reindeer will calve. The timing of this migration varies according to environmental conditions, but it usually takes place before the beginning of May, when the ground is still suitable for travel by sled and to maximise the period reindeer can graze on accessible forage. During spring the reindeer graze on the calving pastures, an area which may also function as the autumn rutting ground on the migration back to the mountains. The same areas are used annually and are generally found on the boundary between the forest and the mountain foothills. Male reindeer are often separated during spring, as their presence can make the calves nervous and any disturbance can lead to females abandoning their young. Calves that are born on the way to, or from, the calving areas may be abandoned, as it is more important to get the majority of herds to the good quality spring and summer pastures.

In early summer, typically during June, herders take animals through mountain valleys into summer pastures on the coast or in the mountains. The low-lying coastal pastures provide early spring vegetation and salt-licks, whereas the higher mountain pastures offer cool temperatures and relief from insect harassment. The calves and females are often herded separately to the males, as the new calves need regular rests and help in crossing difficult terrain (for example, fast flowing mountain streams). During the summer, it is typical for a group of herders to combine their herds, although these will be gathered and separated in corrals from time to time to enable owners to earmark new calves. The quality of summer pastures is incredibly important for providing reindeer with the bodily reserves to survive the winter, and is widely believed to decide the survival chances for the calves. During the summer, herders also collect wild berries and fish to supplement their diets and, in more recent periods, have derived an income from selling handicrafts to tourists.

During late summer, usually late July or August, the animals are moved back towards the mountains in good time for the rut (September-October). After the autumn rut, grazing is maximised so that the animals are as healthy as possible before the long winter period. There may be some gathering and separation of animals, to divide into individual herds and allow selection for slaughter. Old and sick animals tend to be slaughtered first, as these are considered to contribute less to the herd. Reindeer meat and skins are considered to be of a good quality in autumn, therefore this is often when animals are slaughtered for domestic requirements. Meat is either boiled fresh or dried and smoked, to be used later in the year,

In late autumn, the reindeer are herded to the winter pastures, sometimes using herding dogs. Conditions here are very important, as early snow can make migrations easier (as skis and sleds can be used). Herders spend significant time watching the herd and protecting animals from predators (especially wolves) during this period. In winter, all of the families/households in the *siida* congregate together in the winter village. Paine (1994a) explains that although using a large common area, the herds of each group are kept separate during this period, and visits are paid between camps to allow the collection of stray animals that were not separated in the autumn. Although reindeer grazing in the forest must still be tended to, winter provides opportunities for considerable social interaction. As all members of the community are together, church festivals and markets were often organised to take place in winter. Within households, handicrafts are produced, stories are exchanged, and friends are entertained. Some reindeer are slaughtered during winter and the meat is dried and prepared as food for the following spring. For dried meat the fattest animals are chosen, concurring with Speth's (1983: 146-148) assertion that fat is of cultural and biological importance in human diet and that 'a diet based entirely on <u>lean</u> meat would quickly lead to nutritional disorders, and eventually to death' (*ibid.*: 150).

There are older accounts of aspects of Sami lifestyle that complement this general picture, but these are often asides in works concerned with other issues. In 1732, Carl Linnaeus travelled through Lapland for the Swedish Academy of Sciences, and later published the journal kept throughout his travels. Most of the journal is concerned with plant species found on the journey, and personal observations about his surroundings. However, there are some details of the Sami people that he encounters. He accepts Sami hospitality in bad weather in Lycksele Lappmark, and buys cheese from a Sami woman there (Linnaeus, 1971: 145). He describes the way reindeer are slaughtered by the Sami as different from contemporary slaughter methods for other animals. The reindeer are stuck in the shoulder with a spear, so that the blood is collected in the thorax cavity for utilisation (*ibid.*: 110). However, it is not clear is whether this method differs from Sami slaughter of other animals or from Swedish farmers' methods of slaughter, and whether or not this technique was in widespread use. If it is a different culling technique used by the Sami, it may imply differential treatment of reindeer; perhaps reflecting the special significance of reindeer to the Sami. Nonetheless, it can still be suggested that this technique was used to ensure as little wastage of the carcass as possible.

Other pieces of information about the Sami can be drawn from diaries and notes written by Scandinavian missionaries, and settlers living in Sapmí. These firsthand accounts of people living with Sami communities, and previous research on the subject, were used by Schefferus to compile his book, *The History of Lapland,* in 1674. The timing of this publication, and the thoroughness of the author, makes this an invaluable source of information on Sami lifestyle in the seventeenth century. Schefferus was commissioned to write the book by the Swedish crown, in order to counter claims that paganism and barbarianism were rife in its northern counties and, as such, the work of the Swedish Crown in 'civilising' the Sami is stressed throughout. However, when compared with descriptions provided by earlier authors (*e.g.* Magnus), Schefferus provides a more sympathetic account of Sami life.

Schefferus's account is important because he describes the variety of economic activities undertaken by the Sami and the mixed nature of this economy. His chapters on the animals hunted and fished shows a wide range of resources being used; wild reindeer, elk, and smaller fur-bearing animals are hunted; salmon, pike, perch and trout are fished, and birds such as the *loom* (loon) and white partridge (ptarmigan) are trapped (Schefferus, 1971: 133-14).

This diet of meat was supplemented with a variety of wild fruits, including blackberries (*Rubus fruticosus*), currants (*Ribes*), *hiortron* (cloudberries – *Rubus chaemomorus*), *halton* (raspberries – *Rubus idaeus*), and dewberries (*Rubus cæsius*)[6]: '...The inhabitants delight to eat them with their flesh and salt meats' (*ibid.*: 141). These fruits were also preserved with salt so that they could be stored until winter. A number of herbs were also used, the most important being *Angelica* sp., and ground, dried and baked pine bark was used as a seasoning.

As well as hunting wild reindeer, Schefferus notes that the tame herds kept by the Sami were of a considerable number: '...the beast is naturally wild, and such still abound in Lapland but now multitudes are tamed for domestick service' (*ibid.*: 131). He describes two groups of Sami defined by the environments they exploit: the *Fiæll Lapper* (mountain Sami) and *Graan Lapper* (forest Sami). The mountain Sami live, with their herds, in the woods in winter and in the mountains in the summer, whereas the forest Sami move between permanent places within the forest as local resources are available (*ibid.*: 81). This corresponds well with the distinctions previously noted in this section. He describes the mountain Sami as living mainly from the products of their reindeer (meat, milk and cheese), whereas the forest Sami subsist mainly on fish, supplemented with hunted birds and mammals (*ibid.*: 92): perhaps indicating variable levels of the importance of herding within the economy. The size of Sami herds at this time is not clear, but some indication is given in his estimation of the proportion of male to female animals. He asserts that many Sami keep 100 does to every 20 bulls, suggesting herds of up to 120 animals. Furthermore, the fact that herders may lend out up to 10 or 20 animals to other men for long periods of time indicates that they had a substantial number of animals, so as not to miss these (*ibid.*: 15, 132). He describes how Sami children are given animals when they are born, and throughout childhood, so that they have accumulated a herd of their own by adulthood. Each animal marked with the owner's specific earmark. In addition to tame reindeer, Schefferus notes some Sami bought oxen, sheep, and goats from Nordic neighbours. However, these animals were usually kept over the summer as a source of milk and then slaughtered for their hides and meat before winter. It is

[6] Linnaean names from Oxford English Dictionary http://dictionary.oed.com/ .

unlikely that these animals would have been able to overwinter with the reindeer herds (*ibid.*: 129), particularly on migrations.

By the time that Schefferus wrote his monograph, the method of taxing the Sami had moved from being predominately in reindeer and fish, as it was in the 1602 and 1606 edicts, to being in cash, reindeer, reindeer skins or (for poorer Sami) fish and other skins. The inclusion of money as a method through which to pay tax indicates significant trading with outside groups. This is further indicated by the establishment of two fixed markets a year, by an edict in 1602 (*ibid.*: 71). Although these markets and fairs may have already existed, their regulation by the state suggests that substantial and valuable trading took place there.

Throughout the period after AD 1600, there was considerable variety in the degree of dependence on reindeer and therefore varying herd sizes and use of supplementary foodstuffs. Hunting continued throughout this period, and subsistence could further be supplemented with traded goods obtained from Scandinavian neighbours. The fact that supplementary foods were utilised is suggested as accounting for population growth in some Sami areas following the adoption of specialised reindeer herding. According to Ingold (1988: 81), as reindeer herding offers no new ecological material, and is less productive than hunting, a straight switch from hunting to herding would involve a decrease in the population supportable from these resources. For a population increase to occur, the Sami must have supplemented their diet through other subsistence activity and trade. A similar increase in population is seen after intensification of herding amongst Russian groups (Krupnik, 1993: 178).

In summary, this period represents a continuation of the use of hunting and fishing seen in previous periods, but these activities now take on less importance to some sections of the Sami population, who have increased their reliance on tame, herded reindeer. Although still essentially a mixed economy at the start of this period, it developed into a specialised herding economy. As with subsistence activities before AD 1600, this was not uniform across the communities. Local factors would have meant the degree of dependence varied. However, it is clear from many of the sources that the lifestyle of more communities was tied up with the maintenance of large herds of reindeer, way beyond the level of a domestic herd owned by a hunting society for labour purposes.

Current theories of the rise of reindeer *pastoralism in northern Sweden*

The rise of reindeer pastoralism in northern Scandinavia has been explored by researchers from archaeology, anthropology and history since the early twentieth century. It is beyond the scope of this thesis to provide a detailed background of these early studies and history of the debate; for a summary of this see Aronsson (1991, chapter 2.) In the following section selected theories are presented which reflect the current research position. A brief outline and critique of each author's theory will be presented. As this thesis is concerned with issues of environmental impact on Sami communities at this time, particular attention will be placed on the perceived role of climate in these theories.

Lennart Lundmark

Lundmark (1989: 29) views the transition to reindeer pastoralism as 'an area where archaeology, anthropology, ethnology and history meet'. As such, his approach is based on the analysis of documentary historical sources coupled with reference to anthropological concepts. His model is based primarily on taxation records from the Lule Lappmark from the sixteenth and seventeenth centuries. During this period, the Swedish state increased its interest in the north and the Sami people, under the instruction of the kings Gustav Vasa and Karl IX. In the mid-sixteenth century the state took over the control of taxation from the Birkarls, and in the face of increasing demand from external markets took over the control of the fur trade (Lundmark, 1982: 175). By the late-sixteenth century the tax was considerable, with each family paying 40 squirrel pelts or one marten skin and 7-10kg of dried pike. Furs were also traded for commodities such as butter and flour, providing a valuable supplementary food source for the Sami and allowing population growth. For example, records from the mid-sixteenth century show 100 families living in Lule Lappmark whilst, by AD 1610, this had grown to 200 families (Lundmark, 1989: 34). During the early-seventeenth century, the taxation payment method was altered to 55kg of dried pike and one reindeer calf; half of the fish payment could be substituted by one live male reindeer. The desire to be paid in live reindeer may represent the need of the state to provide provisions for the Swedish army, in the context of increased military activity at this time. The live reindeer obtained by the state were kept in Lapland, with herders being paid in butter and flour for tending them (*ibid.*: 35). It is thought that the fact that the state took only male reindeer may have changed the composition of Sami herds, leaving a higher proportion of female animals. This may have provided a gender structure which facilitated the transition to pastoralism (Lundmark, 1982: 175). However, the problem still exists that herding was seen as a less productive exploitation strategy than hunting, and the transition was unlikely to have taken place whilst large wild stocks of reindeer existed. Lundmark believes that a decrease in wild reindeer at this time may have encouraged the adoption of pastoralism. This decrease is attributed to over-exploitation by the Sami, encouraged by the state's demand for fur and reindeer, and also by the corrosion of traditional societal rules concerning the environment by other types of Swedish intrusion into Sami life (Lundmark, 1989: 36). These wild herds would have become too small to viably support a hunting population and Lundmark suggests a crisis occurred, in 1610, which encouraged a reliance on domestic herds and a switch to nomadism (Lundmark, 1982: 175). In fact, under these conditions the transition may have taken place over a short period; calculations based on an increased ratio of females to males in the herd suggest a herd of 40 could grow to 100 animals in 11 years if conditions were suitable (giving a herd size capable of supporting a family; Lundmark, 1989: 35). During the seventeenth century, rights to land for pasture became linked to taxation payments, meaning an interdependence between taxation and herding was established, encouraging further herd growth. Therefore, Lundmark's theory proposes that the transition to pastoralism was initiated by increased levels of taxation of the Sami, a change in terms of taxation payment method, and the intervention of the Swedish state in other aspects of Sami life. This intervention accelerated the depletion of wild reindeer stocks, meaning that a return to a hunting way of life was no longer possible.

Tim Ingold

Ingold's theory of the rise of reindeer pastoralism is a general theory and is not based on any specific geographic locality. His argument is more concerned with large-scale anthropological concepts and the nature of change between hunting and pastoral societies. As previously stated, the transition to herding does not provide any new subsistence material and is less productive than hunting; weaker animals are protected and considerable time is involved in controlling and tending to herds (Ingold, 1988: 87). The principle notion behind this theory is that hunting and herding involve different relations of production. Hunting is based on undivided access to the means of production and principles of generalised reciprocity, whereas pastoralism is based on divided access to the means of production (live animals are property) and reciprocity based on 'shares'; with rights to 'shares' linked to kinship, past debts and provision of labour (*ibid.*: 161-173). Before the transition to pastoralism, the Sami had been involved in external trade networks and had kept small numbers of domestic animals for transport, decoy hunting and as a buffer against times of shortage. Therefore, although the hunting relations of production were dominant, ideas of property and exchange were present. In these conditions the keeping of small domestic herds would continue until something occurred to disrupt the supply of wild animals. If the wild herds were temporarily displaced by environmental factors, dependence upon domestic animals would be increased, accompanied by encouragement to accumulate larger herds. This increase in herd size would be accompanied by a dominance of relations of production associated with pastoralism; values such as wealth, property and poverty would be accepted. These larger herds would further displace wild animals, again increasing dependence on the pastoral herds. Thus, the transition to herding can be seen as an 'alternation on two co-existent sets of relations of production, one of which rises to dominance under the impact of a temporary ecological disequilibrium, and consequently displaces the other' (*ibid.*: 90). Because success in pastoralism would not be equal for all herders, there would also be social stratification. Full development of extensive carnivorous pastoralism was only possible in the barren tundra and mountain areas, and the marginal forest area where other resources were limited. In the taiga, the ability to switch to alternative resources as an additional buffer to shortage meant that the transition to such extensive pastoralism was unnecessary (*ibid.*: 119). Ingold's theory thus sees the transition to pastoralism occurring in closed systems due to a disruption of normal subsistence strategies; in this theory the role of external social agents of change is not given precedence.

Igor Krupnik

Krupnik's research on the transition to reindeer pastoralism is based primarily on Russian and Siberian groups, such as the Nenets, Nganasan and Kola Sami, but is included here as his theory has implications for the transition to pastoralism in general and therefore for the situation in northern Sweden. Krupnik's theory is concerned with ecological adaptations and conditions, and is therefore more focussed on the nature of Arctic environments and economies than the prevailing social climate. He argues that the best conditions for reindeer are cold stable winters, moderate precipitation and cool damp summers, therefore the cool stable phases in the Russian climate at AD1500/1600 and 1700/1800 provided favourable ecological conditions for reindeer growth and reproduction. However, in order for the transition to take place the social conditions must also be conducive to change. The nature of conducive social conditions varies according to the local situation; for example, the rise of pastoralism in Sel'kup groups is largely attributed to over-hunting of local resources due to market demands of the Russian state. Therefore, the impact of these varying social conditions are difficult to integrate into large-scale theories (Krupnik, 1993: 165). Because of this, climate is viewed by Krupnik to be the universal trigger for the transition. These favourable climatic conditions are thought to have worked in two ways. Firstly, since they also provide favourable conditions for wild reindeer, people would gain experience of dealing with larger herds in general. Secondly, if large wild herds provided a readily accessible source of meat then domestic herds could be left to grow without the need to slaughter (*ibid.*: 168). As larger herds were accumulated, people found increasingly more time taken up with herding activities and also created a larger surplus to enable trade with external groups for other types of supplementary foods. With the development of large-scale reindeer pastoralism, wild herds were gradually displaced from the pastures increasing reliance on domestic herds (*ibid.*: 181). In summary, the mixed economy present on the Russian/Siberian tundra switched to an increased dependence on domestic reindeer through a combination of environmental and socio-economic factors. Ecological conditions favoured reindeer growth and social factors, such as trade with other groups and the Russian expansion, encouraged the accumulation of animals. Trade may have also acted as an impetus for social change, encouraging wealth and status to be measured in terms of reindeer wealth. However, Krupnik does point out the difficulty in combining social and environmental factors in the discussion; the historical documentation of these economies is quite poor and the climatic data are not complete for every area. This transition may have occurred rapidly, perhaps taking only 150 to 200 years for large-scale reindeer pastoralism to be established.

Anatoly Khazanov

Khazanov's (1984) text *Nomads and the Oustide World* deals with general issues of the nature and origin of pastoral nomadism across the world. As such, it does not specifically focus on the emergence of pastoral nomadism in the Sami, but does have relevant material on pastoralism in Northern Eurasia. He asserts that nomadic reindeer herding in Northern Eurasia is the most geographically isolated, 'most homogenous', and 'the only fully monospecialised form of nomadism' (Khazanov, 1984: 41). His 'Northern Eurasian Type' constitutes three subtypes: Lapp (Sami), Komi-Nentsy, and Chukchi-Koriaks (*ibid.*). Although the economy is seen as monospecialised, it is also connected to other alternative economies. For example, he asserts that the Sami supplemented their diet through trade with agriculturalists and the use of gathered plants, such as *Angelica archangelica* (*ibid.*: 44). This interaction and trade with outside groups is seen as an inevitable consequence of nomadism, in that it can only be an 'incomplete' adaptation to the environment (*ibid.*: 84). Nomadic reindeer pastoralism is viewed as an adaptation to conditions in a particular ecological enclave, rather than a niche. These enclaves are defined as connected with the spatial division of particular ecological zones (*ibid.*: 43).

He considers there to be three components to the transition to nomadic pastoralism: the economic and technological conditions prior to the transition; the trigger or stimulus for change; and, the social and political context (*ibid.*: 117). The origin of Sami reindeer herding is unclear. He accepts that this started in the sixteenth and seventeenth centuries and continued into the nineteenth century. However, it is not clear whether this was an indigenous development or whether it was influenced by contact with pastoralists from the east (*ibid.*: 114). Nomadic pastoralism in the east has its origins in the European and Kazakh Steppes in the second to first millennia BC (*ibid,*: 94, 112).

Wherever the technological knowledge of pastoralism came from, a number of factors influenced its adoption by the Sami, including: pressure from agricultural societies from the south; the importance of reindeer products for trade; and, possibly climatic conditions (*ibid.*: 114). Earlier in the text, Khazanov argues that both long and short term climatic oscillations will have had profound impacts on animals exploited by pastoral nomads and therefore may have played a role in cultural and economic change. However, he asserts that climate alone cannot be sufficient explanation for change: it needs to be accompanied by suitable 'economic and cultural preconditions' (*ibid.*: 88). The adoption of nomadic reindeer pastoralism, combined with the pressure from the south, led to the reduction in size of wild reindeer populations and completed the large-scale transition to pastoralism.

'The ecological character of the tundra is such that reindeer-herding occupies the dominant position there. Increase in the number of domestic deer leads to a decline in the number of wild ones and to corresponding difficulties for hunting groups' (Khazanov, 1984: 42).

Knut Odner

Odner has developed a robust situated theory of social change and organisation for the Varanger area, northern Norway, for the period AD 1200-1900. This was produced through examination of archaeological material from this region and the application of anthropological and socio-economic theory. Odner asserted that, until the sixteenth and seventeenth centuries the Sami were reliant on wild reindeer, fish and small game to provide subsistence requirements, but also kept small numbers of domestic reindeer. These reindeer were principally kept for transport and labour provision, use as hunting decoys, and for milking (Odner, 1995: 29). During the sixteenth and seventeenth centuries, the wild reindeer population declined, and a differentiation and specialisation of Sami economic activity took place. Unlike researchers who have focussed on social means of change, Odner does not believe that stress from mercantile trade and taxation caused this population decline; taxes were predominantly paid in fish, and other furs were more highly prized than reindeer (*ibid.*: 39). Instead, he states that the decline in wild reindeer was part of normal 'ecocycles' in reindeer populations. At this time the

Sami had considerable contact with neighbouring Scandinavian pastoralists, and were therefore aware of techniques of animal husbandry. For the coastal Sami, the decline in wild reindeer led to a specialisation in fishing and animal husbandry, whilst for the mountain Sami it involved increased reliance on domestic reindeer herds. By the time the wild reindeer 'ecocycle' was due to re-establish wild reindeer, the large domestic herds would have displaced them from the pasture; the niche had been filled (*ibid.*: 41). Odner considered Ingold's theory concerning changing relations of production between hunters and herders, and asserts that, in the case of the Varanger Sami, there was no drastic shift from hunting to herding values. The Sami were aware of concepts of property and monetised relations through involvement in mercantile trade. Furthermore, they were aware of alternative uses for reindeer through their own experience with small domestic herds (*ibid.*: 99). To summarise, Odner describes the transition to herding as a specialisation of an known subsistence activity (through contact with Scandinavian pastoralists and keeping of small domestic herds), caused initially by a decline in wild reindeer due to natural population cycles. It must be noted that Odner developed this theory with specific reference to the Varanger Sami, and it is not meant to be an explanation for the transition to herding throughout Scandinavia. However, elements of his hypothesis may be relevant to the broader picture.

Robert Wheelersburg and Roger Kvist

Kvist and Wheelersburg argue for a social impetus for the transition to pastoralism, mainly through the analysis of taxation records and other historical documentation. The authors have produced articles on this topic both individually and jointly. Wheelersburg has examined historical records from Västerbotten from the sixteenth and seventeenth centuries, in order to establish the nature of resource utilisation at this time. As with Lundmark's study of the Lule Lappmark records, he stresses the fact that, in the late sixteenth century, tax was paid in small animal furs and dried fish, with a switch to payment in dried fish and live reindeer in 1602. He goes on to assert that '...taxation was not only a source of revenue for the crown, but a way to increase the internal administration and to establish the external borders of Lapland' (Wheelersburg, 1991: 339). Thus, taxation was also a form of social control over the Sami. The change in the method of tax payment is seen as a major driving force behind the transition in subsistence. The earlier taxation in furs enabled the Sami to obtain other foodstuffs via exchange and support a higher population level. However, over-exploitation led to a decline in the numbers of fur-bearing species. This, in conjunction with the change in taxation method in 1602, led to increased exploitation and thus depletion of wild reindeer herds and the growth of domestic herds. This specialised form of reindeer pastoralism developed between AD1601-14 and was fully adopted by 1620 (*ibid.*: 344). Thus a complex network of social factors takes the form of the catalyst for change in Wheelersburg's argument.

'*In response to a combination of increased government control, trade (especially the European export market), land use competition with Scandinavian settlers, and internal social dynamics..., which altered the natural population dynamics and production systems of the Saami, allowing modern reindeer pastoralism to develop.*' (*ibid.*)

In a joint authored paper, Wheelersburg and Kvist (1996) offer a critique of the open and closed models of the rise of reindeer pastoralism offered by Krupnik and Ingold, and propose their own theory as to how the transition took place. This focuses mainly on socio-political factors and, draws on centre-periphery theory, particularly the role of the expansion of the Swedish state into Sami areas (*ibid.*: 161). This is described as a gradual process of intensification. Prior to direct state involvement the Sami participated, and often acted as middlemen, in internal and external trade networks covering northern Scandinavia; the Dano-Norwegian, the Swedish and the Russian (*ibid.*: 154). However, by 1553 the Swedish crown employed their own representatives to administer trade and tax in the region. In 1602 this became more structured with the establishment of annual fairs in each of the Sami districts, with their own storage buildings, churches, and scales (*ibid.*). Wheelersburg and Kvist attribute this interest in the north as a response to the demands of the newly emerging Swedish empire. Cash needed to be raised to pay foreign mercenaries and consumables needed to be supplied for armed forces, therefore trade and taxation were increased and the mode of taxation chosen to suit the empire's needs. Sami adapted to these requirements through expanding their domestic herds of reindeer to a fully pastoral level (*ibid.*: 156). Although the switch to herding initially allowed an increase in the Sami population, as more Sami adopted what they perceived to be a more reliable subsistence method, differential success of herders soon led to economic stratification; with some herders building up considerable wealth both in animals and silver. Out-migration of impoverished herders to coastal areas resulted in the settling of population at pre-herding levels. These impoverished herders found it hard to re-start a pastoral subsistence and therefore this switch was to a large extent irreversible (*ibid.*: 158-159). Therefore, they believe the rise of reindeer pastoralism to be;

'...a response to increased governmental control, trade (especially the European export market), land use competition with Swedish/Finnish settlers, and internal social dynamics that altered natural man-animal population rates' (Wheelersburg and Kvist, 1996: 157).

Summary

Each of the theories summarised above considers slightly different aspects of the transition to reindeer herding. For Ingold, the transition is part of an internal process of change concerning the relationships of production between animals and people. Odner also sees the transition as an internal process. However, here the change is a specialisation of an existing relationship with animals rather than a change in values. It is hard to ascertain exactly how this change in values would be manifest in the archaeological and historical records and it is unlikely it would be easily identified. Nor can it be assumed that the adoption of an alternative subsistence strategy indicates the underlying cultural values have changed. There are many examples, from recent ethnographic literature, of the incorporation of innovations or technology actually allowing the continuation of values rather than changing them. For example, the use of computers by Inuit has actually contributed to the protection and development of the native language, *Inuktitut* (Therrien, 1999: 30). Similarly, the use of snowmobiles by the Inuit may actually have allowed the continuation of traditional subsistence activities, and perpetuation of values, within a new situation of 'southern' residence and economy. Apart from the snowmobile, the hunting technology used by Inuit has changed little from that used with dog-sled teams and in many ways western technology is adapted to be more appropriate for Inuit life. This may not have been possible with a more traditional technology (Wenzel, 1991: 166). Within northern Sweden some authors have suggested that the use of snowmobiles and motorbikes by Sami reindeer herders lessens contact with nature, and may isolate some sections of the community, especially women, from herding activities (Andersson, 1995: 33). However, other research, and information from members of Sami communities, indicates that culture is dynamic and flexible and the incorporation and modification of technology from other cultures is a continuous part of cultural processes.

'No Saami has said they will stop using the old values, it is a case of being in a new practical situation' (Sami informant quoted in Rochon, 1993: 53).

Both Ingold and Odner propose that the preceding dominant subsistence strategy was disrupted by a decline or displacement of the population of wild reindeer. However, neither state explicitly how this took place or for what reason. Lundmark focuses explicitly on socio-political reasons for change and does not consider the role of climate or environmental change in the transition. For example, the decline in wild reindeer, which he argues prevents a return to hunting, is attributed to social forces acting in a seemingly neutral, and static, natural environment; the possibility of the decline being caused by climatic or other environmental change is not considered. Furthermore, if these disruptions were part of natural 'ecocycles' as Odner suggests, why did the Sami choose to change subsistence rather than draw upon existing local cultural knowledge as to how to buffer such changes? Krupnik (1993: 142) describes how regular cycles in reindeer populations were known to indigenous groups. In these situations it is likely that they would have strategies for coping with these regular cycles: for example, temporarily exploiting other resources or relocating. A possible explanation may be that the fluctuations during this period were outside the variability of known cycles and, therefore, outside the experience provided through collective local knowledge.

Krupnik, Khazanov and Wheelersburg and Kvist all explicitly discuss climate as a possible impetus for the transition for reindeer herding. For Krupnik, the ecological (including climate) conditions are of paramount importance and, when combined with a 'conducive' socio-political situation, can result in the adoption of a pastoral system. Similarly, Khazanov argues that although climate may play a role in the transition it needs to be accompanied by appropriate economic and cultural conditions. As both Khazanov and Krupnik focus on the broad issues of pastoral nomadism over wide areas the subtleties of individual situation, such as the Sami, are not fully explored. Furthermore, whilst Khazanov acknowledges the impact of climate as a possible factor in the transition to pastoralism, he does not elucidate how climatic variability may have affected the potential pastoralists and their animals. The strength of Wheelersburg and Kvist's model (and Lundmark's and Odner's theories) is that they are situated accounts: focussing on the particularities of the transition in specific areas. Wheelersburg and Kvist offer a valuable critique to Krupnik, although they acknowledge it is based on material unavailable to him. They analyse a small number of local proxy records of climate for Scandinavia and propose that, far from being the stable cold period that Krupnik asserts would be perfect for reindeer herding, the period around the transition to reindeer herding in northern Scandinavia was unstable and variable both in summer and winter (Wheelersburg and Kvist, 1996: 152). They criticise Krupnik for overstating the impact of climate at the expense of socio-economic factors, which they believe had a far greater impact (*ibid.*: 160). Although they describe the variable climate around the time of the transition as creating poor reindeer pasturage they go on to state that:

'A reconstruction of local climatic history...indicated that weather was a neutral or at best a conducive factor for reindeer pastoralism' (Wheelersburg and Kvist, 1996: 160)

One of the reasons underlying this apparent contradiction may be that Wheelersburg and Kvist view the socio-economic and climatic factors that affect human populations as *competing* for influence (Wheelersburg and Kvist, 1996: 148). This rationale creates a number of problems. Firstly, the aim becomes not to explore what factors may have influenced change but which was the most important influence; a kind of academic one-upmanship. This is dangerous as it results in what may be superficially seen as causal relationships, when the real situation is considerably more complex. Secondly, the environment and the socio-political system do not exist as closed entities but are complex and dynamic systems which may act to exacerbate or diminish the impacts of one another.

These theories provide great insight into the transition to herding across a range of locations and from the perspective of a range of disciplines. They also raise a number of questions which are useful to consider through this thesis. The role climate played in this transition has not been sufficiently considered, therefore, is it possible to provide a comprehensive reconstruction of the climate during this period? And, more importantly, how did the environmental conditions affect both reindeer and the human populations exploiting them? Was it conducive or an inhibiting factor in the transition to herding? Do the environmental conditions provide a potential explanation for the reported decline in wild reindeer numbers? And, what might that mean for the Sami relying on those resources? Is there evidence for a change in production relations between animals and humans, or a change in values, as indicated by Ingold and Odner?

The following chapter attempts to explore this final question in some detail: focussing specifically on the archaeological evidence for the nature and scale of the transition to herding.

Chapter 3. Archaeological material

Both history and archaeology have been used to support theories about the transition to reindeer herding in northern Sweden. This chapter focuses on the archaeological material available from northern Sweden, which may provide evidence for the transition to herding, and attempts to establish whether there are changes in societal organisation, technology or other aspects of cultural behaviour associated with the transition. Although there is substantial material which may be used to infer Sami subsistence from many areas in northern Scandinavia (see, for example, the considerable research from the Varanger Fjord area of Norway; Odner, 1992; Vorren, 1998; Hambleton and Rowley-Conwy, 1997), this review of archaeological material focuses on northern Sweden: in particular the area referred to as Norrland, incorporating the historical provinces of Gästrickland, Hälsingland, Medelpad, Ångermanland, Västerbotten, Norbotten, Jämtland, and Lappland. The types of archaeological information that may yield information on subsistence strategy will be considered in turn and include:

- **Settlement patterns**. Is there a shift in settlement structure, organisation, and patterns connected with the change from hunting to herding?
- **Changes in faunal species exploited**. Is there any evidence to indicate domestication of reindeer, or a change in resource use?
- **Ideological changes**. Can the material from sacrificial and ritual deposits be used to illustrate ideological changes which may be associated with a change in subsistence strategy?
- **Technological changes**. By looking at artefacts from the period, are there any changes in technology or assemblages that may indicate a change in subsistence strategy?
- **Environmental archaeology.** Can environmental evidence, such as soil and pollen analysis, be used to indicate particular subsistence strategies?

The historical setting for a Sami archaeology

Sami archaeology in Sweden is a relatively recent and highly politicised field. Throughout its history, the study of Sami archaeological remains has been dominated by political discourse: from evolutionary Darwinism, to nationalism, and, more recently, discourses concerning ethnicity. At present, there is only one mainstream University department of Sami Studies (the Department of Archaeology and Sami Studies at Umeå University)[7], although other universities do run courses on Sami languages (for example, Uppsala and Luleå Universities). Much of the previous research on Sami archaeology has focussed on the question of Sami origins, itself an extremely contentious and political issue. Many Sami find the need to prove their origins - and thus their authenticity as an indigenous people - offensive, since there is no question that the Sami were living in northern Fennoscandia when Nordic populations colonised the region. Much of the study of Sami origins has been politically driven, and often relates to issues such as who owns the historical and natural resources of the area.

The earliest historical reference to the Sami comes from the concluding section of Tacitus's *Germania* (AD 98). He refers to a group of people called '*Fenni*' who have a particularly spartan lifestyle having '...no arms, no horses, no fixed homes; herds for their food, skins for their clothing, earth for their bed' (Tacitus, 1946: 331). The name '*Fenni*' is probably related to the old Nordic name for the Sami ('*Finner*'), which is still occasionally used in Norwegian and is evident in place names (such as the province of Finnmark in northern Norway; Beach, 1988: 4). Because of the adoption of this Nordic word in his description, it is probable that Tacitus never actually encountered any '*Fenni*', but heard of their existence through Germanic Scandinavians (Bosi, 1960: 44). As such, this early reference is neither informative nor particularly reliable. The '*Fenni*' are mentioned again in the geography of Ptolemy in the second century AD, by Procopius and Jordanes in the sixth century AD, Diaconus in the eighth century AD, Ottar in the ninth century, Adam of Bremen in the eleventh century and Saxo Gramatticus around AD 1200. These authors refer to the way in which the '*Fenni*' (or '*Finnoi*') were able to travel across snow

[7] Information available from the department's website at http://www.umu.se/samiska/kopia%20av%20index.htm

on long pieces of wood; as such their name is often accompanied by the prefix '*Skrithi*' (Manker,1964: 4). Ottar's ninth century account describes the keeping of small numbers of tamed reindeer by the Sami.

Later texts such as Schefferus's *Lapponia* (1673) stress the importance of reindeer as a dominant Sami resource, supplying daily subsistence, clothing, and transport requirements (Blunt, 1971: 61). Schefferus considered the Sami to be closely related to the Finns, who possibly represented an ancient population of Finns who had moved to the present area to avoid heavy taxation. This may be evident from one interpretation of the word '*Lapp*' as deriving from the meaning 'someone who is expelled'. Schefferus's informants suggest a variety of dates for the establishment of a Sami presence in northern Scandinavia, but Schefferus suggests the time of Saxo Gramatticus, around AD 1200 (Pulkkinen, 2000: 217).

In the later seventeenth and eighteenth centuries a number of different theories for Sami origins were put forward. For example, Olaf Rudbeck Sr (1630-1702) considered Sweden to be the cradle of civilisation and, as such, the Sami represented the true descendants of the ancient Hebrews and Greeks. In the early nineteenth century a Swedish priest, Anders Fjellner (1795-1876), suggested that Sami might have come from as far away as the Himalayas and had travelled up through Denmark into Sweden (Pulkkinen, 2000: 218-226).

In the late nineteenth and early twentieth centuries, exploration and expeditions into Arctic areas became more common and a number of descriptive travelogues of these journeys were published. Most of the information in these travelogues relates to the authors' own personal experiences and opinions, but there are occasional references to Sami lifestyle. As these accounts were written for a western audience, they are often framed by exoticism. The English author, Frank Hedges Butler (1917), was actually guided by the famous Sami writer Johan Turi, but his comments about Sami lifestyle are limited and the book has a lengthy introduction on Sami culture that is largely from other published sources. More informative accounts are from individuals, who actually worked or lived with Sami communities. Nordström (1930) describes her experiences of a spring migration with a Sami group, and teaching in a Sami summer school on Lake Tarfallajauri, with particular empathy. Although no date is given for the year that she taught, she does mention war and therefore we can assume it was sometime during the First World War. Because she lived as a Sami during this time, she was able to highlight some of the socio-political problems that existed between Sami and the nation states in which they lived. She was turned away from a hotel in Kiruna because they did not rent rooms to Sami (Nordström, 1930: 129), and was shocked by the fact that the Sami had to pay taxes to Norwegian sheriffs in case their reindeer damaged crops and to allow them to take their herds over the Norwegian/Swedish border (*ibid.*: 229). One of the most interesting insights in this book is the fact that many traditional Sami beliefs persisted long after the time of conversion to Christianity. A young Sami woman admits to *joiking* in private although Christianity forbade it, and a man claims to have seen the Uldas, a fairy folk from traditional Sami folklore (*ibid.*: 192, 205).

The study of Sami origins is not restricted to historical and archaeological material. In the late nineteenth and early twentieth centuries, the popularity of social Darwinism led to biological theories of origins concerned mainly with racial characteristics. These studies initially suggested that the Sami were related to the Mongoloid races of Asia or 'primitive' European people with bracycephalic skulls, showing most similarities with Alpine types (Coon, 1939: 300). As racial studies became less popular in the later twentieth century, more importance was placed on other biological characteristics such as blood groups and DNA. Blood groups are most useful for distinguishing ethnic groups through a process of elimination, rather then ascribing membership to a particular group: by excluding certain ethnic groups which do not share the particular blood group. However, if one particular ethnic group has a dominant blood group then these studies may be used to suggest possible membership. In view of this, it is often difficult to assign ethnic affiliations from blood groups alone. In the case of the Sami, blood group analysis suggests inclusion within the Europid group along with other Nordic populations (Baker, 1974: 625). A major problem with using blood types and DNA analysis for identifying ethnic inclusion is that most societies rarely live in complete isolation. The Sami have had a long and complex history of interaction with their neighbours and it is probable that there has been considerable gene exchange over this period (Vorren and Manker, 1962: 143).

More recently, the genetic relationship between different populations in Europe has been explored. Lahermo *et al.* (1999; 1996) have used a number of indicators, including autosomal markers and mitochondrial (mt) DNA polymorphism, to establish the genetic structure of the Finno-Ugric language group. DNA samples were taken from 502 unrelated males from 11 Finno-Ugric groups and five additional Eurasian groups, and used to examine, among other factors, Y-chromosomal polymorphism. Three reference population samples were also used in the comparison (Lahermo *et al.*, 1999: 448). Two founding lineages were identified in both Finns and Sami, which have survived up to the present day (*ibid.*: 453). Of the five most commonly occurring lineages in Sami samples, four were shared with Karelians and two with the Finns. The analysis suggested that Inari Sami and Finns showed more genetic admixture and were more likely to share a common source than the Finns and the Skolt Sami. The small number of lineages present in the samples overall was thought to be an indication of the previously low level of colonisation of Finland (*ibid.*: 455). Analysis of mtDNA marker loci of Finns and Sami has shown that Sami may be more closely related to Finns than to other European groups (Lahermo *et al.*, 1996: 1309). However, Finns are probably more closely related to other European populations than they are to the Sami. A number of conclusions can be drawn from these studies. Firstly, the Sami are genetically distinct from other European populations and are not especially closely related to their geographic or linguistic neighbours. Although there is evidence for some admixture with neighbours, this is surprisingly low. This could imply an early isolation from other European populations. Comparison between the Sami and other circumpolar populations suggests an equally ancient isolation from these groups (*ibid.*: 1320).

Linguistic studies have also contributed to the debate around Sami ethnicity. Sami languages are thought to belong to the Finno-Ugric language group, with a suggested Uralic origin for all languages in this group (Odner, 1985: 2). Whilst humans are thought to have followed the retreating ice sheets into Fennoscandia around 13,000-7,000 BC, the speakers of Indo-European languages are believed to have first entered Europe after 6,000 BC. This has led some researchers to suggest that the Uralic was the primary language group of ancient Europe, and that Sami languages represent the last traces of the existence of that group (Zachrisson, 1997: 374). This would certainly imply that the Sami are the oldest inhabitants of Scandinavia. However, not all authors are in agreement. The large number of loan words in Sami could support the hypothesis that the language is relatively young and was only adopted by the Sami people around 2000 BC (Collinder, 1949: 36). The use of loan words to date a language, however, is extremely problematic. For instance, the use of a loan word rather than a Sami word for stone tools does not imply that the language is younger than tool use. Many reasons for the adoption of a foreign word exist, especially in the context of increased contact with other groups and the need to be able to communicate clearly with those groups. Throughout their history, Sami have had a lively interaction with their neighbours, and it is not unexpected that words have been incorporated from their neighbours' languages. Similarly, the lack of a word for a particular object in recent Sami language does not mean that the word never existed. Since the first Sami dictionary was published in 1768 many terms have become obsolete in the present language, and it is possible that many more words went out of use before this dictionary was put together (Sammallahti, 1982: 105).

Hætta (1996: 13) emphasises that the representation of the prehistory and history of northern Scandinavia (and therefore the Sami) is biased, because of those who have studied it. He points out that, whilst it is acceptable to call ancient rock carvings 'Norwegian' (even though they may have existed long before the present country of Norway), it would be unheard of to refer to them as Sami, even though they also lie in the territory referred to as Sapmí. The earliest published Sami account of their culture is from the early twentieth century, when Johan Turi published his *Book of Lapland*. Turi published his text, with the encouragement of Emilie Demant Hatt, because he believed that much of the persecution of Sami was due to a lack of real knowledge about their culture. Addressing Sami origins, Turi dismissed the idea that Sami were late immigrants to Scandinavia. 'No one has ever heard that the Lapps came to this land from any other place' (Turi, 1931: 20). The book is concerned mainly with the author's own personal knowledge of Sami from the Jukkasjarvi area, and covers subjects such as religion, legends, social relationships and reindeer knowledge. Throughout the book the long and close association of Sami and reindeer is stressed. In another text, Turi records the tradition that the Sami were created for this association with reindeer, saying: 'It has probably happened so that the reindeer is created before man or the Lapp. And man has been created for that purpose, of course, to go after the reindeer and follow them where they go and labour with them all his time and support himself by them' (Turi & Turi, 1921: 227).

Older sources detailing Sami narratives exist, but these are generally paraphrased and recounted by southern observers. For example, the Swedish missionary Pehr Högstrom, describes how Ibmel, the god of the gods, created both the ancestors of the Swedes and the Sami.

'Saami and Swedes were one people from the beginning, brothers: but a violent storm grew and one of them got afraid and tried to hide under a board. His offspring became Swedes, and God turned the board into a house. But the other one, who was more fearless and did not want to flee, became the ancestor of the Saami, who still live under the open sky' (quoted in Zachrisson, 1997: 371).

Later Sami authors have stressed their people's long occupation of northern areas. A long period of occupation is described in Heikan Jussa's story (Kohva, 1997: 19), in which the Sami are descendants of reindeer herding peoples from Europe who were pushed further north by 'white faces' following the last ice age. The imagery used in this book also denotes the close association Sami feel for their country, tying their origins to aspects of the natural environment. 'We are children of the sun, created from rock, winds of freedom and thunder' (Kohva, 1997: 22). While these accounts of Sami origins may differ in many ways, one thing they all have in common is the long occupation of northern Scandinavia by Sami.

Questions of rights to land, water and resources are important issues to the Sami and the nation states in which they live, and archaeology can be an extremely potent ethno-political tool in this context. By claiming ancient artefacts and archaeological features as Sami, one is effectively saying that 'the Sami were here first'. By questioning Sami origins, the focus turns to the Sami as outsiders who have come from an external land. In this situation, the burden of proof rests with the archaeologists, who must provide concrete evidence that a particular feature or artefact is unambiguously Sami in cultural affiliation. This research also tends to have a historical bias, in that the majority of past and present researchers are non-Sami (Urbańczyk, 1992: 56). No research can be carried out within a vacuum and therefore archaeological theory, research and interpretation will be affected by the prevailing political conditions and largely driven by the politically dominant group. For example, Swedish archaeology developed during the seventeenth century as a means to provide proof for the nation's past greatness. Clearly the ethnic pluralism of Sweden, and therefore Sami archaeology, had little place in this archaeology (Zachrisson, 1993: 171). Finally, because of the desire of many Sami scholars to redress the balance and create a 'Sami archaeology', there is a perception of a 'backlash' in that these scholars will be perceived to be biased through their ethnicity and are therefore not to be trusted (Magga, 1996: 79). It is clear that, to understand the progress of Sami archaeology, we need to bear in mind their marginal position with respect to the dominant Scandinavian centres of power, and their political influence throughout history.

Archaeological evidence

Earliest human occupation of Sapmí

The extent of ice cover during the last glaciation, and the pattern of the retreat of the ice sheets, meant that Scandinavia was one of the last parts of Europe to be colonised by humans. Although one cannot rule out Eemian (Oxygen Isotope Stage 5e) or earlier colonisation of this area, there is scant evidence to support this. Recent research in Mamontoyava Kurya, in the European Russian Arctic, has yielded stone and mammoth tusk tools dated to between 34,400 and 37,400 BP, indicating a human presence in the Arctic during the last Ice Age (Pavlov *et al.*, 2001: 64). As both Neanderthals and modern humans were in Europe during this time, it is unclear which first colonised the Arctic. However, this does show that hominids were able to adapt to colder conditions during an earlier period than previously thought (Gowlatt, 2001: 33), and suggests Ice Age colonisation of the Scandinavian Arctic should not be ruled out. As the ice sheets retreated, initial colonisation would have been restricted by the distribution pattern of land and sea, as Fennoscandia had been depressed beneath a large ice sheet. Denmark was the first area to be settled: the earliest date so far is a single stone tool (Zinken) found in a kettle hole near Slotseng, which has been dated to12,520±190 BP, using AMS radiocarbon dating (Housley *et al.*, 1997: 43). Southern Scandinavia was probably settled soon after in the early post-glacial, giving a timescale for colonisation as somewhere between 12,000 and 9,000 years ago. The southern Norwegian highlands were occupied very soon after deglaciation with sites on coastal areas as old as 8,500 BP and, on the highlands themselves, during the later ninth and eighth millennium BP (Moe *et al.*, 1978: 74). The most likely incentive for settlement of these areas comes from the exploitation of animals adapted to colder climates. As the ice sheets retreated and temperatures rose, these animals migrated northwards, and the humans exploiting them would either have to adapt to new conditions or follow the animals north. It is likely that both these strategies were employed (Clark, 1975: 99). As in the south, the colonisation of northern Scandinavia was dependent on the disappearance of the ice sheet and availability of land. As such the west and north Norwegian coasts were the first areas to be settled (the Fonsa-Komsa phase) with diagnostic sites in Finnmark and the Varanger Fjord (*ibid.*: 102). The sites of this phase are concentrated on coastal areas and islands, suggesting a strong reliance on fish and sea mammals. Middle and northern Sweden were the latest areas to be colonised due to the perseverance of the ice sheet in this area. Many sites in central Sweden were occupied successively for long periods of time, and it is therefore difficult to pinpoint how people came to this area. However, possible theories include traversing the Caledonian mountains from the Norwegian coast or migration directly from the south. Sites within this region were occupied by at least the fourth millennium BC (*ibid.*: 236).

During the nineteenth century, Nordic archaeologists viewed the Sami as the indigenous peoples of Scandinavia. The two Stone Ages that were identified in the region were thought to provide a long background for the separation of the Sami and other Scandinavian inhabitants. The Arctic, or northern, Stone Age provided the ancestors for the Sami and the southern Slate complex provided the ancestry for the southern Scandinavian populations (Storli, 1986: 43). However, during the early twentieth century, a rise in nationalism, and the increase in competition for land and resource access, led to political pressure to identify Sami origins as outside the region. Research from this period often stresses the lack of complex slate technology, rock carving, and pottery production in recent and historical Sami populations. Using this, it was argued that the Sami could not represent a continuation of cultural elements from the Stone Age, and therefore did not have their origins in the area. It was suggested that the Sami originated, instead, in a more eastern area and migrated to Scandinavia as late as *c.*1800-500 BC (Zachrisson, 1993: 172). However, this apparent lack of continuity may be more a result of misidentification of archaeological remains than a representation of reality. For example, Knut Helskog has dated the rock carvings at Alta, Norway, to 4,200-500 BC. The similarity between these carvings and the figures depicted on Sami shamanic drums has led to the suggestion that the two are connected. If so, this would imply a continuation and development of a shamanic-graphic system since the later Stone Age (Mulk, 1985: 435). Whether or not the use of these symbols was a distinct and unique Sami trait is not clear, and although the Sami have used these symbols in more recent periods it is difficult to ascribe ethnicity to artefacts further back in prehistory.

Sami ethnicity and archaeology

In the 1970s and 1980s a new approach to Sami ethnicity arose, championed by Povl Simonsen. This approach did not try to place Sami as indigenous ancient peoples, but treated Sami ethnicity as something that developed as a result of both internal and external societal pressures. As a result, research has concentrated more on why and how Sami ethnicity arose, rather than when and where (Zachrisson, 1993: 172). A particular focus of this debate has been the Sami Iron Age (SIA)

Distinct from the Norse Iron Age, the SIA covers a long period in Fennoscandian archaeology. Usually including dates from BC/AD to the medieval period, its boundaries are unclear, with some authors suggesting that it may have continued until as late as the eighteenth century, and may have been preceded by a separate Early Metal Age from 800 BC to BC/AD (Storli, 1986: 47). Whatever the dates of the period, it is associated with a different type of archaeological assemblage than that found on accepted Norse sites of corresponding age. In the north and the interior of central Sweden, the period AD 1-1000 yields sites which are interpreted as those of an egalitarian hunter-gatherer population using asbestos-tempered ceramics, flaked stone tools, burials on islands in lakes, and pitfall traps for catching reindeer and possibly elk. On the coast and further south, sites are typically agrarian in nature with remains of domestic cattle, iron forges, bronze casting structures, hill forts and grave mounds (Zachrisson, 1992: 13). This stratified farming society is equated with Norse/Germanic settlers in the area. The type of asbestos ceramics found at the hunter-gatherer sites is considered by some authors to be unique to the Sami, although it has only recently been found as far south as other aspects of the hunter-gatherer economy. The dates for use of this ware are from 1300 BC to AD 300. These finds indicate the presence of Sami, or proto-Sami, groups much further south than previously acknowledged (*ibid.*: 16). There is no unambiguous evidence for Norse settlement in northern Sweden during the Iron Age and, as late as AD 800-1200, the area north of 70°N was almost exclusively Sami (Urbańczyk, 1992: 57). One of the major problems with the Early SIA is that it is very difficult to identify sites and remains as irrefutably Sami. Although many finds are assigned to the SIA from north and central Sweden, such as burials on lake islands from Härjedalen dated to 200 BC – AD 200 (Zachrisson, 1993: 176), this is mainly through similarities with Sami sites from later periods.

From the existing archaeological record, tentative suggestions can be made as to the existence of ethnic Sami groups during the SIA. In the earliest centuries AD, a specialised reindeer hunting economy developed with settlement systems shifting westwards towards mountainous inland areas of northern Sweden (Zachrisson, 1993: 175). Finds of metalwork hoards, dated to the first millennium BC, have been compared with later Sami silver hoards (Urbańczyk, 1992: 61). However, interpreting these remains as solely Sami is not possible. Many ascriptions are made through comparison with later, although admittedly similar remains, and therefore ethnic affiliation is not certain. It seems likely that, during the SIA, the interior of central Sweden, and areas further north, were home to the Sami, but it is not until after AD 800 that a distinct Sami society is evident in the archaeological record (Zachrisson, 1993: 179). Although an early presence of Sami in Fennoscandia cannot be verified, all of the evidence points to the fact that the Sami were well established and numerous when the intensification of Nordic exploration and settlement in this area took place.

Settlement patterns prior to AD/BC

Settlement patterns for the period prior to 0 AD/BC have been modelled by Lars Forsberg, as part of the *Luleälvsprojektet*: an interdisciplinary project looking at the interaction of resource utilisation and social development in northern Norrland (Forsberg, 1985: 1). Sites from along the Umeälv and Luleälv valleys were analysed and classified according to their internal structure, size and the diversity and type of artefacts found there, and used to model the chronological development of the settlement patterns. Forsberg introduces five possible models for the settlement patterns, which are themselves subcategories of two principle models:

- That the river valley was inhabited by a single settlement or territorial group.
- That the river valley was inhabited by multiple territorial or settlement groups (Forsberg, 1985: 13).

Through criteria such as the size, diversity, chronological dimension and tool/debris ratios, Forsberg indicates that the most likely model was as follows:

'One group of people occupied the river valley, with spring, summer and winter settlements in the forest area and autumn settlement in the mountain foothill area. This settlement pattern would result in comparable residential camps in both areas, since the sizes of the social groups would have been about the same. These sites should furthermore be equally complex' (Forsberg, 1985: 270).

Figure 4 indicates a rough model of how the settlement pattern may have changed over time. As Forsberg (1985: 272) points out, this model is very tentative as some periods have very little material. Furthermore, the dating of sites is problematic; with few sites having been radiocarbon dated, and others dated through association with particular artefacts (*ibid.*: 1). During the Mesolithic the material indicates numerous small sites in different areas, suggesting perhaps that settlement patterns varied greatly during the changeable environmental conditions of the post-glacial. During the late

Mesolithic to the Early Neolithic the settlement pattern appears to have stabilised with winter and summer residential camps in the forest area, and little exploitation of the mountain foothill area (*ibid.*). Further analysis into particular types of dwelling sites from this period has been undertaken by Åsa Lundberg (1997). Over eighty house remains from the middle woodland of Norrland were investigated. These are characterised by a shallow pit surrounded by a raised mound, or midden, of fire-cracked stones and other household waste, and have been dated to between 4500 and 2500 BC (cal). The sites are interpreted as the winter dwellings of Neolithic hunter-gatherer bands, called the 'Redstone People' by Lundberg, as there appears to be a preference for using red slate as a raw material for tools (Lundberg, 1997: 174). The location of the sites is associated with elk pit-fall traps, and analysis of osteological remains from the sites suggests elk was the most important faunal resource (*ibid.*). Overall, 29 villages were identified where local bands of related families may have lived together during most of the year, gathering together with others to form a larger regional band at separate summer sites. In depth analysis of all prehistoric sites from the Vilhemina parish appears to support this hypothesis (*ibid.*).

In the Late Neolithic, the settlement pattern underwent significant changes, which may be linked to changes in the economic system (Forsberg, 1985: 275). By 1500BC the settlement pattern was split between two poles within a group's territory: a winter to summer residential base in the forest and an autumn residential camp in the mountain foothills. Fishing and the hunting of large game (elk, reindeer, and beaver) is associated with the forest residential sites, and the surrounding area may have had small hunting and resource processing exploitation sites. In the mountains, the principle resource was wild reindeer, and again there were specialised hunting stations in the surrounding area. In between the forest and mountain camps there were small transitory camps, possibly occupied for a short time each year to capitalise on seasonal salmon abundance (*ibid.*: 272). The movement to this bipolar settlement pattern suggests an increase in importance of reindeer as a resource (*ibid.*: 275). As the models are descriptive, rather than explanatory, they do not explain why these changes took place. However, what is clear is that during the period preceding BC/AD the dominant, if not only, subsistence strategy in northern Norrland was hunting.

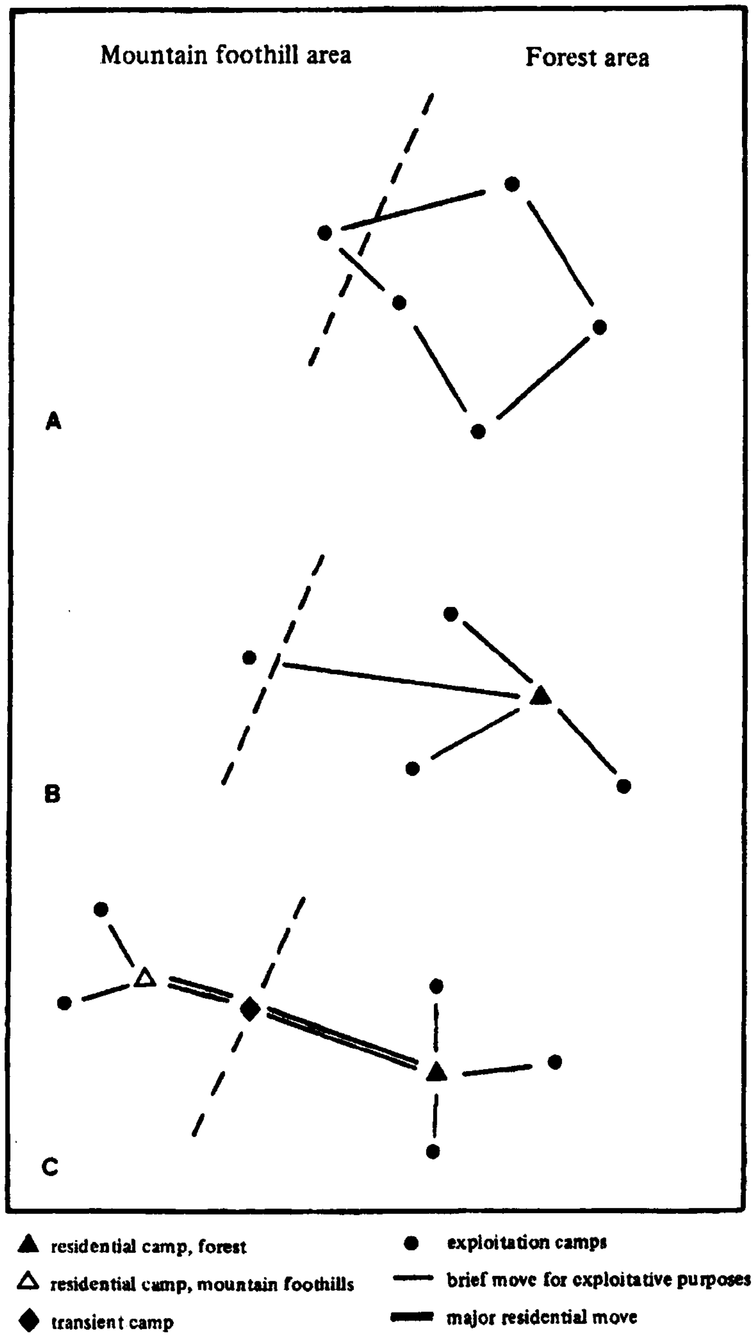


Figure 4. Change in site usage around the rivers Luleälv and Umeälv for the (a) Mesolithic (b) Early/Middle Neolithic and (c) Late Neolithic/Bronze Age/Pre-Roman Iron Age. After Forsberg (1985: 274)

Settlement patterns after AD/BC

A number of authors indicate that there are gaps in the archaeological record in Scandinavia, with little archaeological representation, between AD 300/400 and AD 1000 and again from AD 1200/1300 to AD 1500 (Zachrisson, 1993: 174; Storli, 1986: 49). These gaps in the record may be the result of differing preservation conditions of coastal and interior sites, a true reflection of the distribution of sites or the result of limited co-operation in the investigation of an area divided by different nation states. However, there are still some studies of settlement patterns during this period. During the first centuries AD, there was a westward shift of settlements into the mountains, and an increased reliance on specialised hunting of reindeer (Zachrisson, 1993: 174). Mulk (1997: 24) suggests this expansion may have continued until after AD 500. Settlement sites in the mountain area dating from AD 500 until the seventeenth century are sometimes called *Stalo*-sites or *Stalotomter*. These sites will be explored further, as they constitute a key source of archaeological evidence reflecting the period of the transition to herding.

***Stalo* sites**

These sites, situated in the Kjølen mountain range between Norway and Sweden, typically consist of a collection of between three and eight dwelling structures. The dwellings have sunken floors, hearth structures and a surrounding low peat wall (Storli, 1993: 3). The function of this peat wall is unclear; some believe it is the remains of a more permanent turf hut structure (Liedgren, 2003: personal communication[8]; Carpelan, 1993: 23), whereas others interpret it as marking where mobile *Kåta*[9]-like tent structures were placed (Zachrisson, 1993: 175; and figure 5).

There are numerous interpretations of the spatial and temporal distribution of these sites. Dates for the sites are of varying quality, with the earliest dates from AD 600/700 and the latest AD 1600, with the majority around AD 1000-1200 (Liedgren, 2003: personal communication; Storli, 1986: 54). Radiocarbon dates from Storli's investigations of 8 *stalo* sites in Lønsdalen (Nordland, north Norway) indicate the sites were used between AD 700 and the post-medieval period, with a concentration between AD 900 and 1400. There is an empty period, with no dates, between AD 1400 and 1650, then a later habitation phase until recent times (Storli, 1993: 5). However, doubts have been raised about the accuracy of these dates, as many are taken from test pits rather than from complete excavations, and each date has wide error margins (Mulk, 1993: 29).

[8] Post graduate seminar given at the University of Umeå, 16th April 2003.

Figure 5. A reconstructed Sami *Kåta* outside the Áttje Museum, Jokkmokk (author's photograph)

In the early twentieth century *stalo* sites were considered by many to be remains of Germanic or Nordic origin, partly influenced by the fact that the name for the sites in the Sami language alluded to *Stalo*; a giant character in Sami myths (Mulk, 1991: 42). In the 1960s, Ernst Manker presented a comprehensive study of known *stalo*-sites, and attributed the sites to semi-nomadic Sami hunters; who kept small numbers of tame reindeer for pack and draught purposes. In the 1970s, the origin of the sites again was attributed to non-Sami; with Kjellström suggesting that the use of the word *stalo* actually meant steel. This was interpreted to indicate the inhabitants of these sites were either foreigners who wore coats of mail or introduced steel to the Sami. Kjellström suggested the sites were used by Nordic tax collectors (*ibid.*: 43).

The current interpretation of these sites varies; with attribution to Norse, Norwegian Sami with winter camps along the coast, or Swedish Sami with winter camps in the forest area. The interpretation of these sites is inextricably linked with different perspectives on the timing and cause of the transition to reindeer herding in northern Sweden, with authors frequently

[9] The *Kåta* (or *Goahti* in North Sami) is a tent structure similar to a tipi. These could be permanent or mobile and made from a variety of materials including reindeer skin, tree bark, turf and, in more recent

drawing from the debate around the transition to support or refute interpretations, rather than relying on the evidence from the *stalo* sites alone. Although most authors attribute these sites to wild reindeer hunting societies (Mulk, 1997; Mulk, 1993; Odner, 1993; Hansen, 1993), it is possible that these sites could be linked with pastoral societies (Storli, 1993; Aronsson, 1993), especially since the latest use of these sites (AD 1650+) is synchronous with the known existence of a pastoral society (Liedgren, 2003: personal communication). The arguments for evidence of hunting and herding at *stalo* sites are summarised below.

(i) Reindeer herding at stalo sites

In a discussion paper in the *Norwegian Archaeological Review,* Inger Storli challenges the notion that *stalo* sites were associated with a Sami hunting society, and questions the importance placed on the fur trade and taxation in the interpretation of Sami Viking Age and Early Medieval society (Storli, 1993: 1). In contrast, Storli considers internal social factors as the impetus for change within Sami society, focussing on the change in Sami settlement patterns represented by the *stalo* sites (Storli, 1993: 3). The sites are located in areas not previously extensively exploited by the Sami, and the way in which they are organised is interpreted as representing an attempt to legitimise personal claims to land that would have been seen as a common resource. In particular, the peat walls may have functioned as a way of indicating to other pastoralists one particular family's presence and claim to an area (*ibid.*: 15-16).

Storli takes a post-processual approach, looking at the organisation of space within the *stalo* dwelling sites as a text which, when interpreted in context, may be symbolic of aspects of the social organisation (Storli, 1993: 4). In particular, the division between male (*boasso*) and female (*uksa*) space, sometimes marked by a *boassu*-stone[10] behind the hearth, is interpreted as being related to specific roles and cultural values (*ibid.*: 11). The presence of *boassu*-stones at 11 of the 32 sites investigated, coupled with artefacts associated with female work (*e.g.* spindle whorls), is taken to indicate that these

periods, canvas (Encyclopaedia of Sami Culture: last accessed 01/02/2008).

[10] The *boassu* stone is thought to be used in Sami dwellings to mark the boundary between male and female space; with male space at the rear, and female space at the front (Storli, 1993: 11)

sites were occupied by complete family units. This, in turn, is suggested to indicate occupation by pastoralists rather than all-male hunting groups (*ibid.*: 13).

The location of the sites, away from lakes and rivers and in areas of good reindeer pasture, is interpreted as representing a decreased importance of fishing as a summer economic activity. Storli argues that milk pastoralism, with milk products providing sustenance through the summer, is a more appropriate way of interpreting these sites. This is strengthened by the fact that the sites occur in historical reindeer herding areas (Storli, 1993: 14). She sees no connection between reindeer hunting pit systems and *stalo* sites, and argues that hunting reindeer for skins could not have been of great importance since reindeer was not an important element of the fur-trade during the period the sites were used (*ibid.*: 16). Through comparison with known forest Sami dwellings, from the north Swedish coniferous forest zone, Storli argues for a cultural connection between these types of sites.

'I will suggest that the stallo sites in the Kjølen Mountains together with the coniferous forest sites represent seasonal sites for Sami who migrated between the two areas. Ethnographically this settlement pattern is similar to the one practised by the reindeer pastoralists, or Mountain Sami, who spent their summers in the high mountain region and the winter in the coniferous forests of Northern Sweden' (Storli, 1993: 8).

Storli interprets the void period, between AD 1350 and 1650, as representing desertion of sites as a result of the Black Death around AD 1350. Decreased population meant that grazing pressures were lower and sites closer to the winter forest sites were available. Dating of the winter sites suggests they were in use throughout this period. As the population increased, pressure for pastures grew and the *stalo* sites were re-used from *c.* AD 1650 (Storli, 1993: 19).

However, not all authors agree with the scale of the pastoral activity which Storli interprets as occurring at the *stalo* sites. Aronsson agrees that the sites represent Sami settlements, and a 'qualitative change in Sami society', but does not agree that they represent complete pastoralism (Aronsson, 1993: 21). Instead, he considers the sites to indicate a mixed economy, with reindeer pastoralism as one component of the subsistence strategy, which may have also included keeping small numbers of cattle, sheep, or goats (*ibid.*: 21). The new settlement pattern in the mountains was not a result of internal pressure for pastures but was influenced by internal and external pressures; such as trade and interactions with neighbouring Nordic populations (*ibid.*: 22).

From excavations of *stalo* sites in Västerbotten, in conjunction with Rolf Kjellström, Carpelan suggests that the sites represent two separate phases of use by Sami employing different subsistence strategies. The dates from the sites investigated indicate that they were constructed and occupied between AD 800 and 1400, with a secondary occupation phase from AD 1600 (Carpelan, 1993: 24). Carpelan does not identify similarities between *stalo* and other Sami sites, but does see similarity between *stalo* and the Norse building tradition, and sees the location of the sites as indicating a connection with the north Norwegian chiefdom of Hålogaland (Carpelan, 1993: 24). The dwellings themselves are considered to be traces of permanent peat huts, rather than seasonal dwellings, and therefore the sites represent year round occupation. Instead of viewing the *stalo* sites as solely Sami, Carpelan suggests they represent the integration of Sami into 'a Norse chiefdom economy based on economic specialisation and redistribution' (Carpelan, 1993: 25). The development of reindeer herding at these sites is a result of the combination of Norse knowledge of animal husbandry techniques with Sami expert knowledge of reindeer. However, the occupants were not exclusively herders; hunting and fishing would still have played an important role in Sami economy, providing surplus meat and skins for trading and meat to complement milk products (Carpelan, 1993: 26).

The sites were abandoned following the Black Death and the traces of secondary occupation of the sites are interpreted as seasonal re-use by Sami, using the hut foundations as temporary locations for their tents and practising more extensive pastoralism. Carpelan sees this as an indigenous development within the Sami, with the previous experience of small-scale herding as a starting point (Carpelan, 1993: 25).

(ii) Reindeer hunting at stalo sites

Inga-Maria Mulk has carried out extensive investigations of *stalo* sites in the Sirkas-*siidda,* in the upper areas of the Stora Luleälv river, and focuses her interpretation on a consideration of the sites within their environmental and cultural context. In particular, from the environmental context, Mulk argues there is no evidence for herding during the early period of *stalo* site occupation (e.g. pollen and soil analysis, changes to vegetation; Mulk, 1993: 32). However, it is unclear as to how strong a signal herding would have at these temporary settlements; particularly if it reflects a shift of emphasis within an already mixed economy. Like Storli, Mulk sees a relationship between the forest Sami sites, in the northern Swedish coniferous forest, and the *stalo* sites but considers the relationship to be more complex than the simple winter and summer division proposed by Storli. Since some of the *stalo* sites are only 20-30km from sites in the foothills, along lakes and rivers, she argues for the *stalo* sites as components of a more complex settlement pattern.

'At the same time as the mountain sites were being used in the summer by mobile groups of hunters using tame reindeer as draught animals, other groups in the same society would have been living and fishing in the foothills zone' (Mulk, 1993: 31).

One of the similarities between the forest and *stalo* sites, identified by Mulk, is their connection with hunting pit systems and other elements of hunting technology. Although she does not explain the detail of this 'functional' connection, the dates from the hunting pit systems suggest they were in use until the medieval period, and therefore contemporaneous with the *stalo* sites (Mulk, 1993: 32).

Mulk disagrees with many of Storli's interpretations of the spatial organisation of the *stalo* sites. The sites are considered as being occupied by several households at once between AD 1000 and 1200, rather than Storli's suggestion that specific families or households had claims to specific sites (an interpretation that Mulk believes does not take into account the error margins of the radiocarbon dates or the fact that many dates were obtained from test pits rather than full excavations; Mulk, 1993: 29). She questions the interpretation of the spatial organisation of the dwellings within the site as similar to traditional pastoral sites, stating that this is contradicted by Manker who describes such traditional sites consisting of scattered *Kåta* with sufficient space between to tether tame reindeer and dogs (*ibid.*: 31). Mulk's interpretation of the division and organisation of domestic space within the *stalo* dwellings is also inconsistent with Storli's, and she casts doubt on Storli's identification of *Boassu*-stones (*ibid.*: 34).

Like Mulk, Odner agrees that Storli has not presented sufficient evidence that reindeer pastoralism was underway by AD 900, and interprets the *stalo* sites as remains from a hunting Sami society. The location of the site would be convenient for summer hunting of reindeer, as they would be grazing here to avoid the insects and heat of lower lying pastures (Odner, 1993: 27). Hansen, Mulk and Odner all highlight that the presence of women at the *stalo* sites would not necessarily exclude or indicate particular subsistence activities. For example, women were present at Sami bear hunting camps, but strict rules and taboos were observed around each gender's role in the treatment of the meat (Hansen, 1993: 40). Women are depicted in Olaus Magnus's (1555) description of Sami hunting (Odner, 1993: 27), and other members of the household were involved in small-scale trapping and hunting of smaller animals and birds (Hansen, 1993: 40). Odner goes on to suggest that the division of male and female space within Sami dwellings, that Storli interprets as indicating pastoral cultural values, may in fact represent broader Sami cultural values (*ibid.*: 27). Furthermore, the lack of association with hunting pit systems does not preclude the possibility of hunting; many other hunting techniques were used by the Sami (*e.g.* using bow and arrows; *ibid.*).

Odner does not believe, as Storli does through her interpretation of the peat walls around the *stalo* dwellings, that the Sami would have felt the need to articulate their cultural presence in nature. This interpretation is in fact at odds with traditional indigenous beliefs about relationships with nature (Odner, 1993: 27), and implies a distinction between nature and culture more in tune with Western worldviews. The exclusive claim over pasture is a concept more aligned with ranching economies than early pastoralism (*ibid.*).

Hansen draws from historical and ethnographic data to argue that pastoralism is unlikely to have been practised for the whole period the *stalo* sites were used. For example, court records of conflict between hunting and herding Sami are concentrated around the late seventeenth and early eighteenth centuries, indicating that this was a period of economic change. If the transition to herding had taken place earlier, such conflicts would have also taken place earlier (Hansen, 1993: 35). Analysis of Sami place names indicate that wild reindeer hunting is recent enough to still be remembered linguistically and in connection with certain places (*ibid.*). Furthermore, since many authors suggest that pastoralism is more labour intensive than hunting, Hansen argues that it is unlikely Sami could have adopted full pastoralism prior to AD 1600 and still have been able to produce a surplus of furs and skins, required by the fur-trade and taxation, through hunting (*ibid.*: 36).

(iii) Summary

Inger Storli's paper stimulated considerable debate on the interpretation of the *stalo* sites and the transition to herding in northern Sweden. It also identified some weaknesses in commonly accepted theories and raised some interesting ideas. If *stalo* sites are taken as representing reindeer pastoralism then this calls into question the accepted transition date, and suggests pastoralism may have been extensively used as early as AD 900 (Storli, 1993: 10)

However, it is very difficult to ascribe a particular subsistence strategy to the *stalo* sites. Firstly, the same artefacts are interpreted in different ways by different authors. Secondly, the close relationship between these sites, and the debate about the transition to herding, means that the context of the sites varies for different authors. Therefore, the sites are used both as evidence for a particular position or theory but are also interpreted within the framework of that theory. This is not to suggest that the sites should be interpreted without consideration of their context but that they should be considered within *all* possible contexts. Overall, the evidence from the *stalo* sites does not seem to be able to confidently support or refute full-scale pastoralism prior to AD 1500/1600. However, it can possibly be taken to indicate small scale keeping of domestic reindeer prior to this date. As Hansen (1993: 39) points out, this raises issues around the definitions of pastoralism used by different researchers. Many authors agree that the Sami used small numbers of tame reindeer for a long period before the transition to full pastoralism. How these sites are interpreted could be placed within the context of that transition, but their interpretation will vary according to whether the transition is considered to be slow and gradual or short and radical (*ibid.*). It is possible that some *stalo* sites could represent a localised intensified pastoral effort. Furthermore, it is possible that some of these efforts were in the short-term unsuccessful; the inhabitants of *stalo* sites may have tried and failed a number of times, or may have focussed their subsistence efforts on pastoralism when conditions favoured it, and hunted when they did not. The abandonment of some *stalo* sites for extensive periods is of particular interest in this context. Could the gaps in the archaeological record reflect periods when environmental conditions were not conducive to expanding herding activity? Or could they reflect difficulty accessing and maintaining these settlements in periods of unfavourable climate? What this interpretation suggests is that if herding was practised at the *stalo* sites prior to the late sixteenth/early seventeenth centuries, it was likely to be small in scale and was one component of a broader, mixed subsistence strategy.

Other settlement sites

Hedman's (2003) analysis of settlement and sacrificial sites among Norrland's forest Sami area covers the period between AD 700 and 1600, therefore including the early part of the generally accepted transition to reindeer pastoralism. In particular, the research focussed on connections between settlement and sacrificial sites and how this material may be applied to questions concerning the transition to reindeer herding (Hedman, 2003: 5). Of four settlement sites investigated in depth, he found that two were active during the same period (AD 800-1350) as nearby ritual metal deposits, another was dated to a synchronous period by an arrowhead and, at the final site, a relationship was not ruled out but further dating of hearths was required. The settlements are characterised by groups with 6-10 hearths (with around 2-3 hearths representing a single occupation event), and tended to be in areas where reindeer herding Sami were known to have lived in the historical period. Overall, Hedman argues that a number of factors indicate that a transition to reindeer herding was underway during the time of these settlements:

- *'changed settlement pattern, where settlements become oriented around good grazing land*
- *the settlement's organisation/ internal structure*
- *the dates from the hearths*
- *the form and construction of the hearths'* (Hedman, 2003: 241).

The hearths were considered to have similarities with hearths used historically by Sami in *Kåtas*, and are hypothesised to have similarly been covered with a tent (Hedman, 2003: 240). The location of the settlements near sources of water (such as bogs and small lakes) differs from patterns in the preceding period, and indicates a selection of sites where there is good pasture for reindeer (*ibid.*: 240). Furthermore, the range of artefacts from the sites (including weights, coins, jewellery *etc.*) indicates extensive contacts with external groups, considered by some to be a pre-requisite for the introduction of tame reindeer into a society (Khazanov, 1984: 84; Hedman, 2003: 241).

Changes in faunal species exploited

In remote prehistory, the inhabitants of northern Sweden were predominately hunters, fishers and gatherers. This is well demonstrated in a synthesis of osteological material from this period by Ekman and Iregren (1983). The bone material from 174 occupation sites across Norrland, excavated between 1920 and 1980, was analysed. They found a distinct difference between hunting sites from the interior and those from the coast. The main species found inland were elk, reindeer, and beaver, alongside rarer occurrences of smaller mammals, such as hares, otters and martens. Fish such as pike, bream and perch were exploited and there is some evidence for the hunting of waterfowl and other birds (Ekman and Iregren, 1983: 31). Mammal hunting occurs at 99% of these sites and fishing at 34.5% of sites, compared with only 16.5% with evidence of bird hunting. Although differential preservation of the smaller fish and bird bones, and possible deposition away from the dwelling site, may have affected these statistics, it can be tentatively suggested that mammal hunting and fishing were the most important economic activities for these hunters. In fact, mammals may have provided an estimated 85% of the total meat consumed by these prehistoric hunters with elk providing 75% of all the meat from mammals (*ibid.*: 38). Again, it should be remembered that, alongside the normal problems of deposition and preservation of archaeological remains, human behaviour may cause some species to be under-represented at sites. For example, the ritual deposition of reindeer bone caches and bear skeletons is known to have occurred in northern Sweden in the later prehistoric period. The proportion of elk to reindeer remains found at inland sites is broadly in line with the animals' natural distribution, with elk becoming less common and reindeer increasing in frequency towards the north. This would have a strong impact on the strategies of hunting groups as these animals differ both behaviourally and in habitat (*ibid.*: 40). Elk and beaver were also hunted at coastal sites but the most important species found here is the seal. A number of wetland birds and fish, including freshwater and saltwater species, were also important resources. As well as indicating differences in resource exploitation, it is likely that the occupation patterns of coastal and inland sites were seasonally different, with coastal sites inhabited possibly all year round by a sedentary population and inland sites showing temporary occupation, although in more than one season (*ibid.*).

The type of economy practised by Sami groups in the later prehistoric and early historic periods is unclear; in fact there are almost as many opinions about the particular subsistence activities as there are authors on the subject. A prevailing theme is the extent of use of domestic animals compared with reliance on the hunting and fishing of wild resources. One problem with trying to date the moment when Sami started using domestic animals is that it simply may not be visible in the archaeozoological record. Reindeer show negligible signs of domestication through skeletal morphology and at the earliest incidences of domestication there would be no differences, other than that castrated animals may be indicated by antler asymmetry, and animals habitually tethered may show abnormal tooth wear patterns. This ambiguity is manifested through interpretations of Late Glacial reindeer hunting sites in northern Europe, dating to 13,000 years ago. At Stellmoor, north Germany, some skeletal material has been suggested as coming from castrated animals, leading some researchers to suggest that up to two thirds of the population were herded animals. Whether this actually represents purposive castration by humans, anomalous natural castrations, or normal variation in skeletal morphology of uncastrated wild reindeer remains unclear (Ingold, 1988: 125). Osteometric analysis by Weinstock (2000) suggests that the remains from Stellmoor actually represent non-selective hunting of a natural/wild reindeer population. Although previous research had placed the ratio of male to female reindeer at 10:1 (indicating selective hunting) Weinstock's careful analysis of several different osteometric sexing methods, treating subadults and adults separately, and the consideration of various natural and cultural taphonomic processes (*e.g.* selection of particular body parts), provided a more balanced ratio in line with extant natural population profiles (Weinstock, 2000: 1189-1192). The research does not support the hypothesis that the society who killed the animals at Stellmoor practiced any kind of herd control (*ibid.*: 1193). However, the debate surrounding this site suggests that the evidence is still considered by some to be ambiguous, and that experimentation with animal husbandry in prehistory cannot be completely ruled out.

'[The] conventional hypothesis that for over 99% of human evolutionary history man has lived as a hunter-gatherer cannot be proved on the basis of morphological evidence in the prehistoric record' (Ingold, 1988: 92).

Nonetheless, a few authors have asserted that until relatively recently the Sami were exclusively hunter-fisher-gatherers. For example, Inga Maria Mulk (1997: 26, 28) argues for an egalitarian hunting society in Sirkas *siida* throughout the whole period AD 1-1600. Similarly, Aronsson (1991) states that there was no reindeer herding in the south Sami area prior to AD 1700, although northern Sami may have practised 'Arctic reindeer herding' during this period. Povl Simonsen has suggested that reindeer herding developed through three distinct stages, which Storli (1996: 101; table 4) equates respectively to 'Arctic reindeer herding', 'reindeer pastoralism', and 'reindeer ranching', thus giving reindeer herding a much longer history. Some argument for early domestication has been drawn from archaeological remains from the Norwegian coast dating to BC/AD which may suggest use of domesticated reindeer (Lundmark, 1989: 29). One problem with ascertaining the past economy of the Sami is that, as today, they were not a single homogenous group and, as such, the nature of resource exploitation largely depended on individual circumstances, both social and ecological, of the society in question.

Extensive reindeer herding	AD 200-900	A small number of animals kept mainly as decoys and draught animals. Subsistence based on hunting and fishing
Intensive reindeer herding	AD 900-1500	A small number of animals kept but exploited for milk and meat. Hunting and fishing lose importance as subsistence activities.
Full reindeer nomadism	post AD 1500	Large herds of reindeer kept for providing meat, involvement in a market economy. Milk no longer of significant importance.

Table 4. Summary of Simonsen's stages of reindeer herding development. After Storli (1996: 101).

To summarise, the evidence and current state of research on previous Sami economy provides a varied picture. The faunal remains themselves are inconclusive, primarily because reindeer show few skeletal signs of domestication.

Ideological changes

The examples provided in the literature suggest a complex diversity of practices and sites associated with the traditional Sami ritual or religious activity, and the categorisation of these sites is problematic. There are varied interpretations of sites and a number of different terms are used to describe them: bone caches; cult sites; sacrificial sites; metal deposits; silver hoards; ceremonial/ritual places; buried gifts *etc.* Many authors acknowledge that these terms are by necessity very vague, and are used to describe sites that vary in both period of usage and location (Kjellström, 1985: 120). For the purpose of this thesis, sites have been identified as those involving ritual deposition of reindeer remains and other types of deposits. Few of the sites described in the literature have dates for periods of usage. Therefore, some historical and ethnographic data are also presented which refer to elements of ideological continuity.

The treatment of reindeer remains within the context of Sami ideology indicates its symbolic importance. Kjellström (1985: 115) found 20 constructions in Jokkmokk parish, where the bones and sometimes antlers of reindeer had been gathered and placed in a protected position; often between or underneath stones, or in crevices between blocks of stone (*ibid.*: 116). From investigations in the upper shores of Lake Storuman, Zachrisson (1985: 84) identified two distinct types of bone deposits; one where the bones of a single reindeer were collected and placed under a cairn or boulder, another where bones from more than one reindeer were placed in a crevice in boulders. All of the dated sites from Zachrisson's survey suggest they were still in use during the last 250 years (*i.e.* after the transition to pastoralism) (Zachrisson, 1985: 86). Written sources suggest there may be other bone deposits which may not be detectable in the archaeological record: for example, the practice of placing bones on wooden platforms or in boxes hung from trees (*ibid.*).

Reindeer deposits at other kinds of ritual/religious sites have also been described. Vorren (1987:95) details eight separate forms of Sami religious sites, defined by their form and location in the landscape: holy fells; rock formations; stone boulders; holes; cracks in fells; springs; lakes; and, ring-shaped sacrificial sites. The ring-shaped sacrificial sites are suggested as being linked to hunting societies, as reindeer antlers and bones have been found on these sites and they tend to be located near reindeer hunting grounds and pitfall trapping systems (Vorren, 1985: 76-77). However, some of these sites also occur near lakes and fiords so they may not be exclusively linked to hunting (*ibid.*: 79). Vorren also describes historical anecdotal accounts of reindeer sacrifices and bone deposits at many of the other forms of sites (Vorren, 1987: 96-103).

The purpose of these sacrifices and offerings is unclear. Fjellström suggests there may be three types of rituals associated with religious sites: crisis rites, where individuals or groups make offerings to improve the outcome of a particular activity (e.g. better hunting, herding or fishing); traditional rites, associated with life events such as births, deaths, marriages *etc.*; and, calendar rites: associated with particular events during the year (e.g. midsummer, Christmas *etc.*) (Fjellström, 1985: 51). The correct treatment of animal remains is considered by many indigenous northern societies as a way of ensuring future success in hunting and future abundance of animals (Mebius, 1965: 359; and box 1). This is evident in accounts of the treatment of reindeer meat in Sami dwellings: with separate entrances to the dwelling space for meat from wild and domestic animals, the division of the dwelling space, and different gender roles in the handling of wild and domestic reindeer meat (Storli, 1993: 11).

As it is hard unambiguously to link these sites to specific hunting or herding activities, it is difficult to establish whether there were significant changes in the indigenous belief system that accompanied the transition to herding. Documentary sources indicate that, instead, there was considerable continuity in Sami beliefs. There are numerous accounts of hunting rituals being carried out in the seventeenth and eighteenth centuries (Mebius, 1965: 358-360; Hultkrantz, 1985: 23), and even anecdotal accounts of reindeer sacrifices being made to deities during the twentieth century (Kjellström, 1987: 24-27). For example, although specifically associated with hunting, the rituals surrounding the hunting of bear persevered until the eighteenth century at least (these may have continued later but were concealed from the Christian Swedish populations; Zachrisson and Iregren, 1974: 94; Elgström and Manker, 1984). However, there are also some practices which have been exclusively associated with reindeer herding. Mebius (1965: 354) makes the distinction between hunting rites (which were largely an interaction between an animal and hunter) and sacrifices (which were an interaction between man, animal and a deity or party receiving the sacrifice), with sacrifices more associated with herding than hunting. With regard to the ritual deposition of reindeer bones, it is impossible to infer whether the deposition was intended as a sacrifice to a deity or more directly as a way of treating the animal's remains with respect (see box 1). Furthermore, some evidence suggests there may be continuity in the way hunting ritual deities have been incorporated into herding economies. For example, Hultkrantz (1985: 24) describes how a deity, who was considered to be the master/mistress of tame reindeer in the Kola region, may be a modification of the master/mistress of wild reindeer petitioned by previous hunting groups. Similarly, the use of *siejdde* by herding groups may also indicate elements of continuity. *Siejdde* are ritual sites often marked by a naturally occurring rock formation or large boulder, sometimes of a vaguely anthropomorphic form (Rydving, 1993: 21). These were traditionally found near hunting grounds and fishing areas, but there are high mountain *siejdde* associated with nomadic herding groups (Hultkrantz, 1985: 26).

In many northern indigenous groups success in hunting is not simply related to the hunter's technical expertise, but to the ability to foster and maintain a 'correct' relationship with the animal (*e.g.* Berkes, 1988: 13). One instance of this is the fact that northern hunters often consider it improper to name the animal they are hunting. For example, taboos existed in Scandinavian and Russian Sami bear hunts, where the bear was either referred to in a descriptive way, 'wintersleeper' or 'the woolly one', or in terms of an ancestral relationship as 'grandfather' or 'old man' (Collinder, 1949: 158; Vokov, 1996: 102). After the animal is killed the body must be given the correct respect. Failing to utilise the full carcass is still viewed by some elders in Inuit communities as showing a lack of respect for the animal killed (Thorpe *et al.*, 2002: 22). Evenki hunters often bring animals into the camp via a separate path, on a different sled, and through a special entrance to their home. Andersson (2000) hypothesises that this may be due to the desire not to anger the animal's spirit by concealing the violent aspects of hunting, such as the act of death itself. Similarly, Inuit hunters often butcher seals away from the breathing holes where they were caught, so that their blood does not offend other seals (Wenzel, 1991: 136). After slaughter and consumption, respect still needs to be shown in the way the waste is disposed of. In some instances this means gathering all bones, sometimes intact, and placing them where they will not be contaminated or disturbed. For instance, the Dene stress the importance of keeping the land 'clean' of animal remains: bones and carcasses are frequently buried, placed on stages in trees or deposited in lakes (Rochon, 1993: 85). In Sami bear hunting rituals, the bones were gathered, buried, or placed in cracks in rocks or on platforms in trees. Sometimes, bear burials had characteristics of human burials, in that the bones were laid out in anatomical order or buried on islands (Zachrisson and Iregren, 1974: 88). These practices are believed to not only placate the spirit of the animal killed (so that it will not take revenge on human hunters), but positively affect the regeneration of animal souls. For example, Rydving (1993: 85) describes how 'a Saami who had sacrificed the head, feet and wings of a capercaillie justified the sacrifice by the argument that "there would of all this grow other and new birds again, which he would shoot"'. This may be one reason why there are often taboos around women having contact with carcasses of hunted animals (in particular when menstruating), as their life giving properties as women may interrupt this regeneration cycle (Brightman, 1993: 131). In all of these ways the correct treatment of animal remains is believed to promote continued good fortune for the hunter.

Box 1. The ideological importance of treating remains of hunted animals with respect.

Sites with accumulations of metal deposits (referred to as Sami metal deposits or silver hoards) have been dated to between AD 800 and 1350 (Mulk, 1996: 55; Zachrisson, 1985: 91; Hedman, 2003: 238) and may therefore be associated with the pre-herding hunting society. Zachrisson (1987: 63) suggests that these may indicate influence from the Nordic Viking culture; where riches from life are taken with the dead to Valhalla and therefore are hidden or buried prior to death. She suggests that elements of this custom persevered into the nineteenth and twentieth centuries in some Norwegian and Swedish Sami groups. The latest date for these sites, AD 1350, coincides with the spread of the Black Death across Europe and has been suggested as a possible reason for the abandonment of this practice (Zachrisson, 1987: 63).

In summary, the archaeological evidence for a significant change in religious beliefs coinciding with the transition to herding is inconclusive. Various elements of previous beliefs and rituals associated with hunting may have continued long after the transition, but the scale of this is unknown. The lack of secure dates, and the possible re-use of many ritual sites, means that a chronology of usage is hard to establish. Since the traditional religion is bound up with values and customs passed down between generations and, since the social structure may not have been immediately altered as a result of the transition to herding, there may not have been a great change in religious practice (Hultkrantz, 1985: 28). Some hunting rituals may have been modified slightly to accommodate the change in subsistence strategy.

There are also other influences that may have impacted upon Sami religious practice, such as pressure from the Swedish state to adopt Christianity. It is difficult to reconstruct a clear picture of Sami traditional religion, because of the deculturation[11] that occurred during the late seventeenth and early eighteenth centuries. Whilst it may be possible to take Christian elements out, it is not possible to replace the indigenous elements that were lost (Rydving, 1993: 18). Many of the literary sources used to recreate a partial picture of the religion are far from objective, as they are largely secondary sources written by non-Sami (*ibid.*: 28). This also creates problems for attempting to establish whether there was continuation of Sami traditional religion during this period. The punitive approach to encouraging Sami to practice Christianity may have resulted in compliance amongst the Sami community, but may not have necessarily meant indigenous religious practices ceased. Rydving (*ibid.*: 108) highlights the fact that the ritual aspects of both religions did not coincide therefore could co-exist. Rydving (*ibid.*: 135) goes on to describe how responses to Christianity could have varied between those who adopted it and abandoned indigenous religion, those who did not comply and stuck to traditional beliefs, and those who may have alternated between the two according to the context. Furthermore, the space used for the different ritual activities may not be the same. Whilst Christian practices were focussed at the community level (attending church and religious festivals), the indigenous religion tended to be focussed more at the family or *siidda* level (although there were some community level practises and spaces; *ibid.*: 98-101). This may mean that the continuation of indigenous religious practices could have been at a level (or in spaces) that would not have been visible to the Christian settlers writing these sources. Some of the deculturation activity focussed on removing visible signs of the indigenous religion (*e.g.* shamanic drums - see figure 6) which do not reflect the full range of indigenous religious practises (*ibid.*: 62). This, coupled with the later use of Sami informants to identify those practising the indigenous religion after it was prohibited, may have led to the development of a subculture (away from the Swedish community) where it was safe to practice the indigenous religion (*ibid.*: 76). For example, some Sami took part in Christian naming ceremonies then carried out Sami naming ceremonies at home to remove and replace the Christian name with a Sami one (*ibid.*: 122).

[11] Deculturation is defined in Rydving (1993: 11) as the process of weakening indigenous culture, usually accompanied by a process of enculturation (strengthening) of the foreign culture. This term is preferred to acculturation which implies a more equitable process.

Figure 6. A Sami drum. Image by Risto Pukkinen, available from the Encyclopaedia of Sami Culture (SENC) hosted by the University of Helsinki.

There are numerous examples in Rydving's book of the continuation of traditional Sami religious practices, and he outlines a number of possible reasons that have been put forward for this. Firstly, the integrated nature of the indigenous religion meant that it may have been perceived as more directly relevant on a daily basis. In particular, the strong links with aspects of the environment and subsistence activities led some Sami to argue that to cease practicing the indigenous religion would be harmful to Sami economy (*ibid.*: 84). Secondly, the lifestyle of nomadic reindeer herding Sami may have been incompatible with the type of Christian practises endorsed by the Swedish settlers: they would not be able to attend church regularly. Finally, the way in which the Sami were treated may have increased resistance: attending church was presented as compulsory and, although the idea of being equal in the eyes of god may have been espoused from the sermon, it was not evident in the way that Sami were forced to give up their seats for Swedes. Converting to Christianity did not improve the status of many Sami within the Swedish community (*ibid.*: 73-74).

The discussion above indicates the complexity inherent in the change within Sami ideology, between the sixteenth and eighteenth centuries. There are multiple factors which played a part in this process; therefore it is difficult to ascertain whether the transition to herding was accompanied by a transformation in religious beliefs. However, a key point is that practising the indigenous religion was actively discouraged through a process of Christian enculturation. The fact that some elements of the traditional religion are recorded as late as the nineteenth and twentieth centuries could be interpreted as signifying the continued importance of these practices. As reindeer sacrifices continued, even during a period of deculturation, it shows a strong continuation of the symbolic importance of reindeer within Sami culture.

Technological changes

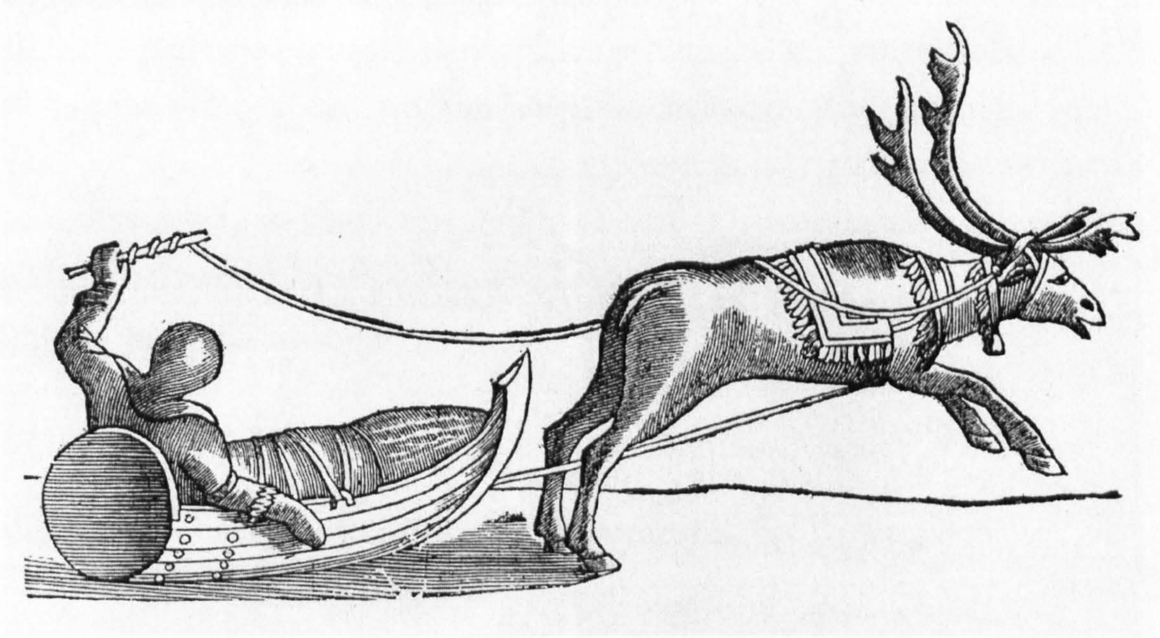


Figure 7. Depiction of a Sami Pulka, from Schefferus (1971:106)

One of the problems in identifying the transition to herding from technological changes is that there may not have been any distinct changes. Most research indicates that small numbers of tame reindeer were kept by the mixed/hunting Sami economy preceding the transition to herding for traction, hunting decoys and possibly milking. Therefore, the accoutrements we would expect to be associated with a herding economy may well have been present in the preceding period. For example, reins, sleds and other devices for using reindeer for traction, lassos for catching reindeer, and possibly milking utensils. Sled runners found in Finland, dating to 3,000-4,000 years ago, have been used to suggest that reindeer were used for transport from an early period (Lundmark, 1989: 29). Similarly, Ernst Manker has used the pictures of reindeer pens and transport devices on Sami shamanic drums (figure 6), and the highly developed nature of the pastoral transportation modes in the sixteenth and seventeenth centuries, as evidence of a long development of pastoral technology. It is unlikely that advanced forms of transport and the conceptual depictions of herding activities occurred overnight (Storli, 1996: 89). Based on archaeological material from the North Varanger area in Norway, Tanner has argued that remains of 'herding dogs' and a possible reindeer *pulka* sled (figure 7) point to early herding activity occurring in the seventh to eleventh centuries AD (summarised in Storli, 1996: 84). However, Knut Odner has used archaeological material from the same area to suggest that, from around *c.* AD 1200 until the late seventeenth century, pastoral activity in this area was limited to small household herds kept for transport, decoy, and milking purposes (Odner, 1992: 17). A further problem may be that, because items may have often been produced from organic materials, they may not be preserved in the archaeological record.

The use of particular hunting techniques may also be a possible source of information for the relative dependence placed on hunting, both before and after the transition to herding. Two main categories of hunting methods are identified, which encompass a range of hunting techniques: collective and individual methods (Holm, 1991: 98). Individual methods may have included setting snares, decoy hunting, stalking and ambushing animals, and the use of isolated pitfall traps (figure 8). Historical sources from the seventeenth and eighteenth centuries indicate that snares, tracking reindeer with dogs, and using decoy reindeer to approach wild reindeer were all methods used by Sami hunters at this time (Vorren, 1965: 513-515). Collective hunting methods may have included driving reindeer to natural or man-made enclosures in order to kill the animals at close range, driving animals into water where hunters could kill them from boats, and the use of extensive pitfall systems (Holm, 1991: 99). Surveys of the remains of pitfall systems indicate they are typically located in areas along the spring or autumn migration routes of reindeer (Manker, 1960: 297; Vorren, 1965: 519), and were made up of series of 10-50 pits (Holm, 1991: 102), although larger and shorter series have been recorded. Reindeer were driven towards the pit systems by the topography of the location, creating a natural bottleneck (Manker, 1960: 298), or man-made fences of stone or wooden poles converging on the area where the pits were dug (Vorren, 1965: 517). The traps may have been used to catch both elk and reindeer, although there are conflicting interpretations of which animals were actually trapped. For example, Manker (1960: 295) asserts that elk traps tended to be used in isolation, or in very short groups, whereas reindeer traps were often constructed in lines or series across an area. Vorren indicates the systems for trapping Elk and reindeer would have been similar (1965: 534), and Holm (1991: 103) states that in northern Sweden, 'without question, the majority of pits were used for Elk trapping'.

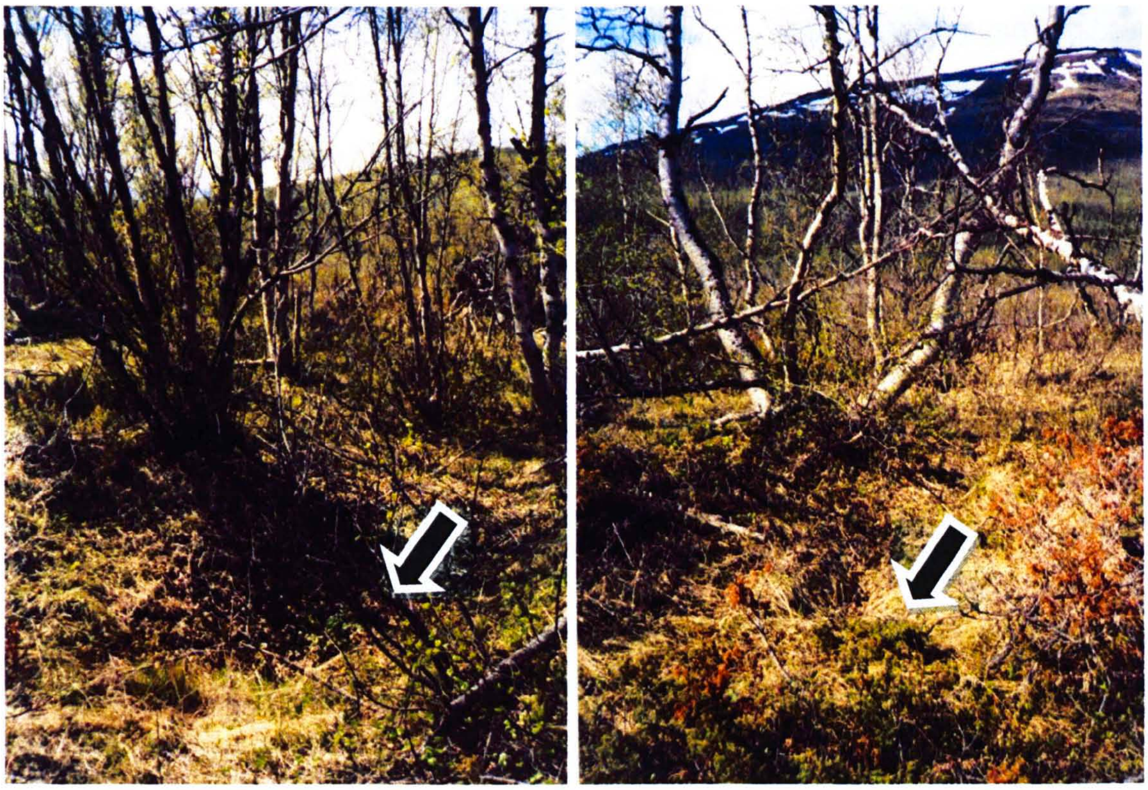


Figure 8. Remains of hunting pits near Åbisko Scientific Research Station (author's photographs)

The dating of the pits is problematic because they have been subject to considerable re-use. Pits may have been initially dug in the eighth century (Hvarfner, 1965: 325; Vorren, 1965: 527), but historical records suggest that they were still in use at the time of the transition to herding, and continued to be used for some time afterwards (Manker, 1960: 294-295). For example, Vorren (1965: 522) describes records from 1694, detailing the Sami paying to have the right to have trapping devices across mountains in the Varanger area. Radiocarbon dating of pitfall systems in northern Sweden has given dates from the Late Mesolithic to the Middle Ages (although most dates fall between the Iron Age and Middle Ages; Holm, 1991: 103).

It is hard to draw any firm conclusions from the use of hunting techniques after the transition to herding. Although the pits continued to be used for some time, this does not mean that herding did not also take place. However, it does reinforce the theory that the transition was not universal or complete and there may have been considerable spatial and temporal variation in the transition. An increase in reliance on herding as a subsistence strategy does not preclude the continuation of hunting activities alongside this. It could be argued that the fact that the pits eventually went out of use may indicate large-scale abandonment of hunting, but the relationship between hunting and herding may not be this simple. For example, if there is increased reliance on domestic herds of reindeer, collaborative hunting may become less important; collaborative hunting relationships would be less close and the larger pit systems would not be maintained. This does not mean that individual hunting techniques, such as snares and isolated pits, would not continue to have an economic importance. As Manker points out (1960: 301), after the adoption of firearms, pit systems would have limited use and are unlikely to have been maintained, but individual hunting with firearms may have continued.

The decline of hunting has also been tracked through language changes. Sami dictionaries, published in 1887, contain fewer words for specific hunting activities than those published in 1768, and by the twentieth century many more terms had gone out of use (Sammallahti, 1982: 105-106). However, many trapping terms still remained in the language, which may indicate that although large-scale group hunting declined during this period, small-scale individual trapping of animals may still have been an important economic activity (*ibid.*: 109).

Environmental archaeology

The potential use of environmental evidence for the identification and interpretation of Sami cultural sites has not been fully realised. Arguably the main reason for this is that environmental signals of past economic activity of the Sami tend to be very weak, because of the way natural resources were used. However, a number of recent studies suggest these may be possible directions for future research.

Carpelan and Hicks (1995) have examined the pollen record associated with the remains of a Sami *Kåta* in Finnish Lapland. The *Kåta* is dated by artefacts, radiocarbon and thermoluminescence techniques as being in use between the fifteenth and seventeenth centuries (*ibid.*: 199). The vegetation at this site followed the same general pattern as other Sami winter village sites; with birches, junipers, dwarf shrubs, herbs and mosses along the row of the *Kåta*, and pine, dwarf shrubs and lichen in the surrounding forest (*ibid.*: 197). The analysis resulted in a particular pollen record, which was considered to be a representative profile of long-term seasonal use of the boreal forest. Initially pine was cleared (for fuel *etc.*), which allowed the establishment of more dwarf shrub species and *Lycopodium*. When the site was abandoned *Epilobium*, *Betula* and *Juniperus* invaded, and eventually pine became re-established. However *Betula* and *Juniperus* were still more common at winter village sites than elsewhere in the forest (*ibid.*: 204). Whilst the profile of this record may be useful when identifying other winter village sites, the authors point out that human influence will only be recognisable in the landscape where several families are gathered together at sites like the winter village sites (*ibid.*), therefore the applicability of this method for recognising evidence of smaller scale forest use may be limited.

Where economic activities have more discrete impacts on the environment these may also be visible in the environmental record. For example, as evidence of the transition to reindeer herding in northern Norrland (northern Sweden), Aronsson (1991) has analysed the palaeoecological profile created by enclosures used for milking reindeer (*ibid.*: 34). Observations of recent and historical milking pens indicate four characteristics which may alter the pollen profile of the sites: light, erosion; manuring; and, grazing. Clearing the enclosure of trees means that more light is available, favouring grasses and herbs. Erosion, as a result of trampling by reindeer, causes physical damage to trees and roots, destroys vegetation, and favours certain herbs such as fireweed and sheep's sorrel (*ibid.*: 35). Manure from the animals enclosed in the pen raises the nutritive content of the soil, favouring rich herbs. Finally, the pressure of grazing favours resistant genera such as juniper and plantain (*ibid.*:

36). Therefore, a pollen profile representing a *renvall* site would be expected to have rich nutrient demanding herbs, wild grasses, and culturally indicative species. Aronsson found that the sites were best represented by a particular combination of pollen types, but these could only be confidently interpreted as evidence of cultural activity when found in association with archaeological remains (*ibid.*: 49). All of the sites analysed showed similar pollen curves. Cultural indicators were only present in the last 2000 years and grasses and herbs were more common in the last centuries (*ibid.*: 98). Aronsson interprets this as evidence that, although the keeping of small numbers of reindeer may have begun several hundred years earlier, large-scale pastoralism is a feature of the last 200-250 years (*ibid.*: 100). The results of his analysis do not support the widely accepted transition to herding around AD 1600. However, Aronsson looked at sites in a particular area. The picture that emerges from previous research on the transition to reindeer herding in northern Scandinavia is one of regional differences. Therefore, the timing of the transition may have been different in different areas.

The possibilities of using soil chemical analysis are discussed by Karlsson (2004), with particular reference to Forest Sami sites in northern Sweden. Cultural activity can produce particular traces in soil composition and structure. For example, burning causes the oxidation of iron in the soil making it suitable for magnetic susceptibility surveying; different forms of agriculture result in different levels of phosphates and organic matter in soils (*ibid.*: 113). However, natural as well as cultural activity can affect soil composition. Therefore, analyses also need to take into account the natural context and factors such as local hydrology, topography, vegetation, and geology (*ibid.*: 112). Results from soil analysis alone are unlikely to produce the kind of information needed for reconstruction or understanding of archaeological remains. Therefore, it is important to combine sources of information to produce as full a picture as possible, including evidence from scientific, archaeological, ethnological, and historical sources (*ibid.*: 106). This is borne out in Karlsson's investigations of milking pens and dwelling structures from Forest Sami sites. Milking pens can be located in the landscape by a number of visible signs: traces of pen structures; marks on trees; and, vegetation changes. Soil analysis within a milking pen showed that phosphate levels were not uniform across the pen, but located in concentrations within and just outside the enclosure. This has been used to provide more detail about how the pens were used; possibly indicating that few reindeer were actually taken into the pen to be milked, whilst the others were tethered outside (*ibid.*: 115). In dwelling structures, soil analyses were interpreted within the context of ethnographic data about how space was organised in traditional Sami dwellings. The outer border of the hut, and activity areas within, were evident from the analysis of phosphates and organic content. The analysis indicated concentrations of phosphate/organic content in the *Boassjo* area (identified through stones near the hearth), which could reinforce the notion that this is where food was prepared and cooked (*ibid.*: 118).

Other ways human impact on forest environments may be recorded is through cultural modification of trees. Őstlund *et al.* (2003) have examined culturally modified trees in Nilasjokk Forest Reserve, Norbotten (northern Sweden). A Sami settlement dating from the mid-eighteenth century to the first half of the twentieth century lies within the reserve, consisting of a hut, an enclosure for milking reindeer and an elevated storehouse (*Njalla*; *ibid.*: 79). From random sample plots, and more thorough observation strategies, three types of forest within the reserve that showed evidence of cultural use were identified:

1. The forest stand surrounding the settlement itself had younger trees (under 200 years old), representing slow deforestation for use as firewood and construction materials. There were also a few bark-peeled trees,[12], and blazes on trees marking the start or end point of particular trails through the forest.

2. The forest stand within the reindeer enclosure contained many large old trees. These would have provided shade and a place to tether animals whilst milking. Some trees had wedges cut out where milking vessels would have been set.

[12] The inner bark of trees was used by the Sami as a staple food, as a wrapping material, and during the preparation of sinews. It was typically taken in spring or summer when the sap flow made the bark easy to peel (Őstlund *et al.*, 2003: 84).

3. The exterior forest stand included many bark-peeled trees (although the frequency increased nearer the settlement itself), and many more older and dead trees than nearer the settlement. There were also some blazes on trees marking trails, accompanied by depressions in the soil marking the trail itself (*ibid.*: 85-86).

Although this research details culturally modified trees from a period after the known transition to reindeer herding, and therefore after the time period focussed on in this thesis, it does provide useful data about how past economic activity may be recorded in the environment. If similar culturally modified trees were dated to earlier periods, it may be used to suggest particular economic activities: for example, wedges cut into trees to hold milking vessels indicate that milking was practised, bark-peeling indicates the site was probably used during spring/summer when the bark was easiest to peel. One of the main barriers to using evidence of cultural modification of trees is the fact that many forest areas have been substantially altered by other human activity such as logging and forest management (*ibid.*: 79).

Summary – archaeological evidence for the transition to herding

The archaeological material considered in this chapter suggests that the transition to herding left a relatively weak archaeological signal. The osteological evidence is inconclusive, principally because reindeer do not exhibit strong skeletal signatures of domestication. Perhaps analysis of faunal remains from Sami dwelling sites (where possible) would provide more evidence, with the possibility of comparing the relative importance of reindeer compared with other species at the sites. However, the fact that reindeer have been an important species to both hunters and herders, and the lack of differences in morphology between domestic and wild reindeer, would make interpretation difficult.

Changes in technology during the transition are also hard to identify. Since elements of the herding economy were present in the previous predominantly hunting system, items relating to herding may have already been present. The decline in use of hunting pit systems for trapping wild reindeer after the transition may be evidence of the decline in hunting, but this could have many causes.

The potential for identifying economic activity through environmental analysis is great. Previous studies have identified sites where reindeer milking has occurred (Aronsson, 1993), and even how milking pens were used (Karlsson, 2004). However, not all cultural activity will leave traces which are possible to detect. Wennstedt Edvinger (2002) argues that the differentiation between nature and culture is a particularly western phenomenon and that, if a society does not view itself in opposition with nature, there may be less desire to place its mark in the environment (*ibid.*: 130-131). Therefore the presence or lack of cultural impact on the environment may be more associated with cultural values rather than specific activities (*ibid.*: 132).

Drawing connections between archaeological and historical material, Hansen (1984: 54) argues that conflict between hunting and herding Sami groups documented in court records, from the seventeenth to eighteenth centuries, indicates this was a period of economic change. However, there may be other explanations for why conflict increases during this period. Firstly, it could represent further expansion of Nordic populations into previously Sami areas, which may have resulted in more frequent and detailed accounts of such conflicts. Furthermore, there is no reason to suggest that conflict between herding and hunting groups is inevitable during a period of change (especially since many early pastoralists are likely to have combined reindeer herding with a continuation of hunting and fishing). Other environmental or cultural pressures may have led to the conflict that is recorded during this period: for example, increased competition for pasture due to poor environmental conditions or pressure for land from Nordic settlers. Finally, the conflict may be a result of an *expansion* of one economic strategy rather than its inception; *i.e.* if reindeer herding was intensified (rather than originated) in this period.

The brief review of religious practices offers a complex picture. There is evidence for continuation and modification of beliefs during the transition to herding, but the implications of this are unclear. One possible explanation is that the transition may not have altered fundamental Sami belief systems (particularly around interactions with nature). However, conclusions that can be drawn from this are limited by the fact that reindeer had an important symbolic function in both hunting and herding systems.

Research on settlement patterns provides a varied view, with the possible interpretation of *stalo* sites as both hunting dwellings and places where small scale herding took place. The political nature of Sami archaeology is demonstrated through the interpretation of *stalo* sites. If they are perceived as early reindeer herding dwellings, this has political implications for both the Sami and the Swedish state. Firstly, it reinforces the position of Sami in their claims to grazing rights over land where *stalo* sites are found. Secondly, a long history of reindeer herding legitimises the approach taken to recognising Sami identity by the Swedish state. At present, reindeer herding is seen as key to Sami identity to the state, even though only a small percentage of Sami actually take part in this activity. The idea that Sami reindeer herding is an exclusive subsistence strategy has been a key part of the debate about the transition to such an extent that some authors have been explicit in saying that reindeer herding and reindeer hunting could not have co-existed in the past (Head, 2000: 142). Whilst this might be true on a large scale, and it is obvious that it may caused tensions and conflict where wild and herded reindeer co-existed in the same location, the idea that herding and hunting were mutually exclusive subsistence strategies in untenable. There are numerous examples of small numbers of tame animals kept by predominantly hunting and gathering cultures. What is of interest here is where the pivot in the balance is. When does hunting with small numbers of tame animals become herding supplemented by some hunting? During the period that *stalo* sites were in use both wild and (possible small) numbers of domestic reindeer co-existed in northern Sweden. Therefore, there could have been numerous shades of subsistence strategies employed, with varying emphasis on hunting or herding as the dominant activity.

All of the evidence discussed in this chapter indicates that a transition to herding may not be explicitly visible in the archaeological record and that there is considerable support for cultural continuity during this period. This supports a picture of the transition to herding as a gradual development rather than a radical transformation: an extension and intensification of one aspect of Sami economic activity, rather than a dramatic shift toward a previously unpractised activity. The alternative interpretations of evidence from different areas also support the notion that the nature of the transition was highly contextual, and may have had a different timescale in different localities.

For example, Hedman (2003) interprets the forest Sami sites as indicating reindeer herding, but *stalo* sites from the same period have more problematic interpretations. It is entirely possible that *stalo* sites in different locations, but used under the same time period, could have practiced subsistence strategies which placed greater emphasis on different activities.

Chapter 4: The Little Ice Age in northern Sweden

The preceding chapters have laid down the context for the thesis and explored some of the previous research on this topic. This chapter begins the bottom-up investigation of the impact that climate change during the sixteenth and seventeenth centuries may have had on the indigenous Sami communities in northern Sweden, and the consequent role that it may have played in the transition to reindeer herding. This time period lies within a period of environmental change in northern Europe referred to as the Little Ice Age. Therefore, to understand how climate may have had an impact we first need to understand the nature of this period of climatic change. The possible driving forces of the Little Ice Age will be considered and a picture of how this period may have manifested itself in the study area will be built using a range of climate proxies and documentary evidence.

Introduction to the 'Little Ice Age'

The term 'Little Ice Age'(LIA) was first used by the glaciologist Matthes in the 1930's to refer to the most recent major glacial advance during the Holocene; an 'epoch of renewed but moderate glaciation which followed the warmest part of the Holocene' (Grove, 1988: 3). However, the term has been used since then to refer to a period of relatively cold temperatures directly following the 'Medieval Warm Period' (MWP). In recent years, it has become clear that the LIA is perhaps a misnomer for actual climatic events. Firstly, renewed glaciation did not occur throughout all areas of the world and there was no increase in continental glaciation (Ogilvie and Jónsson, 2001: 11). Secondly, there is considerable spatial and temporal variation in the LIA, both concerning its initiation and when it reached its maximum extent. For example, the Greenland ice core records in the GRIP core date the first cold period of the LIA at AD 1550 (Dahl-Jensen *et al.,* 1998: 270). A much earlier date is obtained from the study of glacial expansions from Canada, Spitsbergen and the European Alps during the thirteenth century AD (Grove, 2001: 55-68). In most recent papers, there is a nominal acceptance of the LIA as occurring roughly between AD 1400 and 1900, with maximum expansion occurring at different times in different regions. Thirdly, there is little evidence to suggest that temperatures were consistently low throughout this period. On the contrary, the

LIA is a period of extremely variable climate, with periods as warm as today as well as much colder periods.

'Most palaeoclimatologists are now in agreement with this conclusion: rather, the last 500-600 years are characterised by decadal-scale periods of relatively lower temperature interspersed with periods of relatively higher temperature and that spatial and temporal differences exist in the data' (Barlow, 2001: 103).

Possible causes of LIA climatic change.

If the LIA was not a period of consistently low temperatures but an extremely variable climatic period, both temporally and geographically, then the forcing mechanisms, which caused this, are likely to reflect this complexity. In the following section some of the most important factors will be considered including those internal and external to the climatic system.

Internal factors

Interaction between the atmosphere and oceans.

Complex feedback systems between the oceans and the atmosphere may be important mechanisms forcing long-term climatic change. However, the causes of changes in atmospheric and ocean heat circulation are extremely complex and little understood; natural oscillations may be associated with such factors as solar activity, orbital variations of the earth, or tidal pulls (Lamb, 1995: 327). Furthermore, regional climate, especially that of northern Europe, is closely linked to ocean circulation. Therefore, any changes in this circulation may have large implications for the climate of the region or hemisphere (Lowe and Walker, 1997: 362). In the North Atlantic Basin, water moves northwards in the upper level of the ocean by way of a conveyer system. This water sinks at about 60° latitude and forms the North Atlantic Deep-Water (NADW) mass, which is then returned to the southern oceans by the conveyer system. This is an important source of heat for the North Atlantic during winter, when the sinking of surface waters releases a considerable amount of heat into the atmosphere (*ibid.*:363). Disruptions or modifications in this thermohaline circulation system in the North Atlantic may, therefore, influence both northern transport of heat and the formation of deep water and this air-sea heat exchange is integral to world-wide heat circulation (Clarke, 1992: 17). In the context of 'global warming' and increased greenhouse gases, we could expect the temperature of the ocean waters to rise and the amount of freshwater entering the oceans, via atmospheric vapour transport, to increase. Both of these factors will cause a decrease in density of the surface ocean waters, preventing it from sinking and transferring heat to deep waters (Keller *et al.*, 2000: 18). This is a great simplification of a very complex process, but what we would expect to see is the shutting down of the North Atlantic Ocean convection with deep ocean convection limited to around Antarctica (Clarke, 1992: 17). The consequences of this thermohaline collapse would be the reduction of heat transfer from low to high latitudes, resulting in warming in the southern hemisphere and cooling in the northern hemisphere (especially northwestern Europe). The temperature change as a result of this collapse has been estimated at somewhere in the magnitude of -20°C in the northern hemisphere (Keller *et al.*, 2000: 34). This has often been overlooked in previous studies where authors have suggested areas in northernmost Europe (including Scandinavia) stand to gain most from global warming, in terms of increased agricultural yield (Parry, 1992: 81). However a thermohaline circulation collapse would actually decrease the temperature in northern Europe and reduce the viability and yields of fishing and agriculture (Keller *et al.*, 2000: 19).

During the LIA there was lower cyclonic activity in the northeast Atlantic sector resulting in reduced water transport towards the poles. This leads to a reduction in the northwards transport of warm saline water, increasing the incidence of sea ice in the North Atlantic. The consequent reduction in temperature and salinity of surface waters reduces the formation of NADW, leaving the Antarctic as the main source of deep-water formation (Grove, 1988: 360-362). The influx of meltwater and freshwater into the North Atlantic serves to reduce the salinity of the ocean, leading to a reduction in the sinking of surface waters. This, in turn, may lead to a gradual slowing of the conveyer belt until it may eventually 'turn off' (Lowe and Walker, 1997: 363). Recent studies looking at the size of sediment grains from the Iceland basin have reconstructed the speed of past deep water flow under the influence of the Iceland-Scotland Overflow Water (ISOW): an important component of the thermohaline circulation system (Bianchi and McCave, 1999: 515). The LIA coincides with a period of reduced ISOW flow intensity centred around 400 BP, supporting the theory that deep-water circulation has an important role to play in the modulation of Holocene climate (*ibid.*: 516). The increased incidence of sea ice in the North Atlantic would also cause modification of planetary albedo[13] and therefore the level of solar radiation received at the Earth's surface, enhancing the cooling effect (Grove, 1988: 362).

Changes in the top kilometre of the oceans may also cause changes in atmospheric CO^2 concentrations, especially in higher latitudes (Grove, 1988: 363). A decrease in CO^2 concentration of 6 parts per million (PPM), from the seventeenth to eighteenth centuries, is evident in ice core records, possibly accounting for a decrease in global temperatures of 0.05°C (Crowley, 2000: 273). Since concentrations of CO^2 vary spatially in the atmosphere, the reduction in temperature due to changes in CO^2 concentrations varies geographically. This is consistent with the pattern of climate change seen during the LIA. The onset of the LIA also coincides with an abrupt change in sodium concentrations in the GISP2 ice core at *c.* AD1400 indicating a dramatic change in atmospheric circulation (within 20 years), although the cause of this change is unclear (Kreutz *et al.*, 1997: 1294).

Orbital forcing.

The role of orbital forcing in long-term climatic change is encompassed within the Astronomical Theory of climate, also called Milankovitch Theory, proposed by Milutin Milankovitch in the 1920s. This suggests that changes in the shape and axis of the earth's orbit would result in alterations of the amount of radiation received at the earth's surface, and its seasonal distribution (Bell and Walker, 1992: 60). Within this theory there are three main elements (figure 9).

- Precession of the equinoxes - changes in the elliptical orbit of the earth affect the amount of radiation received at the surface due to the earth's proximity to the sun, caused by the tilting and wobbling of the earth on its axis.

[13] 'That proportion of solar radiation reflected from any surface, such as clouds (meagre from tenuous stratus cloud, but up to 80% from thick strato-cumulus), or bare rock... Lighter, whiter bodies have higher albedos than darker, blacker bodies. The total albedo of the earth is about 35%.' (Mayhew, 2004)

- Obliquity of the elliptic - changes in the angle or tilt of the earth in relation to the plane of the elliptic affect the distribution of radiation received at the surface.

- Eccentricity of the orbit - changes in the elliptical shape of the orbit due to gravitational pulls.

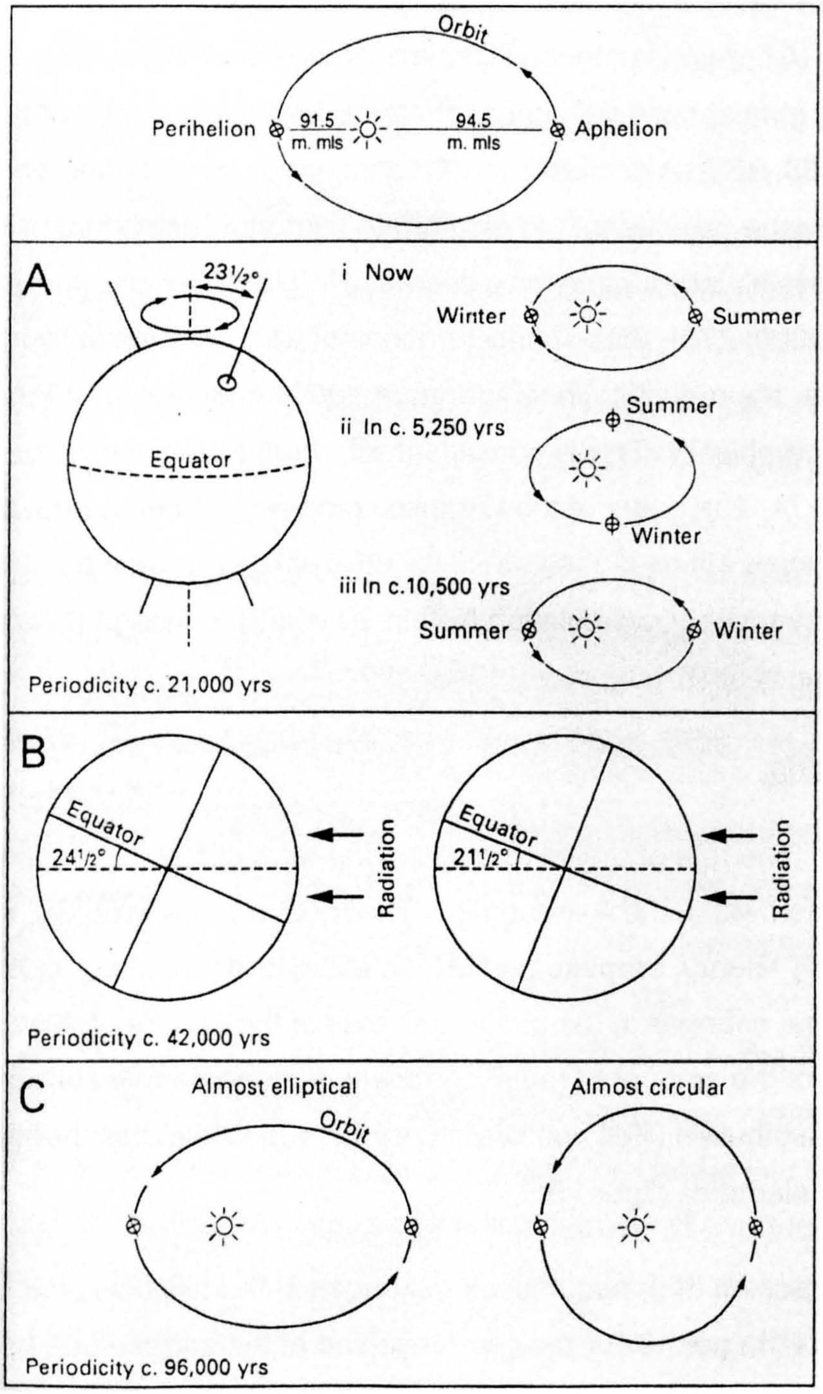


Figure 9. The three components of the astronomical theory of climate change: (a) precession of the equinoxes (b) obliquity of the elliptic (C) eccentricity of the orbit. After Bell and Walker (1992: 60)

As is evident from figure 9, these changes do not simply affect the amount of radiation received by the earth but its geographic and temporal distribution. These changes in seasonal radiation cycles can have profound effects on the earth's climate system and lead to long-term climatic changes: for instance, the timing of the last eight or nine glacial terminations correlates with the 100ka periodicity of the eccentricity of the orbit (Williams *et al.,* 1993: 67). Similarly, climate changes during the Pliocene correspond with the 41ka periodicity of the obliquity of the elliptic (Maslin *et al.,* 1998: 420). However, it is unlikely that these relatively small changes in solar radiation received at the earth's surface directly affect climate, rather they have consequent effects on systems, which modify the climate through various feedback mechanisms. For example, the seasonal and geographical changes in distribution of insolation may be intensified by albedo effects, and lead to the growth and decay of northern hemisphere ice sheets (Lorius and Oeschger, 1994: 32). The lower levels of radiation lead to the survival of summer snow, the resultant albedo effect leading to atmospheric cooling and consequent glacial expansion (Williams *et al.*, 1993: 61). This may explain why cycles of profound climate change exist slightly out of synch with the frequencies of the characteristics of orbital forcing (Rial and Anaclerio, 2000: 1710), allowing for a time lag in the response of climate systems and mechanisms. Although it is widely accepted that changes in Earth's orbital characteristics have profound effects on global climate on a long-term scale, such as interglacial and glacial cycles and early Holocene warming in the northern hemisphere (Bush, 2001: 25), it is unclear whether they contribute towards medium and short-term fluctuations such as the LIA. It is generally accepted that the extremely complex and variable picture of climatic change emerging from proxy evidence is unlikely to have been caused by the widely spaced changes in orbital characteristics alone (Lamb, 1995: 322).

External factors

Geomagnetism

The pattern of the Earth's magnetic field over the northern hemisphere shows a strong similarity with the pattern of mean height contours of atmospheric pressure, indicating that this may have some influence on climate patterns during the LIA. Remnant magnetism from deep-sea cores has shown a concurrence with high magnetic intensity with colder periods like the LIA. However, it is likely that this is operating on a much longer timescale and is unlikely to be a major driving force (Grove, 1988: 365).

Variations in solar radiation

The level of solar radiation received at the Earth's surface is dependent on both the transparency of the atmosphere and changes in solar output. A reduction of 1% in solar radiation may lower global temperature by between 1 and 2 °C (Grove, 1988: 365). Directly before and during the LIA, three major periods of lower solar radiation have been observed, indicated by low sunspot activity: the Wolf Minimum (1282-1342); the Sporer Minimum (1450-1534); and, the Maunder Minimum (1645-1715). These minima are believed to influence climate on the medium scale (from decadal to centennial scale), so are strong candidates for causing fluctuations during the LIA (Crowley, 2000: 271). Statistical analysis of the Maunder Minimum period has shown that it is a highly significant factor in forcing the climate of the seventeenth and eighteenth centuries (Mann, 1998: 785). However, the relationship between earlier minima and climate is less clear, indicating that solar activity is not a major causal factor of climate *throughout* the LIA (Overpeck *et al.*, 1997: 1252). Furthermore, how variations in solar radiation may actually affect the climate system is complex, and an area of much conflicting research. For instance, Carslaw *et al.* (2002) highlight three mechanisms, which are thought to provide some explanation of the interaction between solar radiation variability and weather. In particular, they feel that the third mechanism is a fruitful area for future research as it may identify why small changes in solar radiation correlate with large changes in Earth's climate system:

- changes in solar radiation have a direct impact on the input of heat in the lower atmosphere;
- the impact of solar radiation is mediated though a coupling mechanism in the stratosphere; and,

- the galactic cosmic rays generated as solar radiation have a direct effect on the formation of clouds and storms in Earths weather systems (*ibid.*: 1732-1733).

<u>*Volcanism.*</u>

During volcanic eruptions large amounts of aerosols, including sulphur diaoxide and sub-microscopic particles derived from sulphur dioxide, are ejected into the atmosphere, where they reduce atmospheric transparency, and thus the incident radiation received at the Earth's surface. Numerous volcanic eruptions during the LIA are evident from influx of non sea-salt (nss) sulphate into both Antarctic and Greenland ice cores, and whilst this does not seem to have influenced climate on the multi-decadal timescale it is likely to affect climate on the 1 to 3 year timescale (Crowley, 2000: 271). The impact of these eruptions may be considerable. Within the historical period, average temperature reductions of 1.5°C have occurred after some eruptions (Lowe and Walker, 1997: 367). The length of time that a volcanic eruption will affect climate for is dependent on the height that the particles are ejected to. The fall rate of these particles is very slow and, in some cases, may take more than 7 years to fall through the atmosphere (Lamb, 1995: 323). The Crete (Greenland) ice core also shows an increase in volcanic activity during the LIA, with AD 1200-1500 and 1550-1700 being the most significant (Grove, 1988: 376). However, not all recent large volcanic eruptions have caused cooling and, in the historical period, the relationship between volcanic activity and temperature is variable. There were nineteen recorded volcanic eruptions between AD 1500 and 1963, not all of these have coincided with cooling events shown in proxy environmental records; such as, the incidence of frost rings in trees (*ibid.*: 369). In summary, the impact of volcanic eruptions is not a major driving force for long-term climate change but may have short-term local effects, or amplify existing climatic changes (Lowe and Walker, 1997: 368).

Summary

It is clear that the causes of climatic change in the LIA are complex and variable. From statistical analysis of multi-proxy records, Crowley (2000: 275) has suggested that, between AD1400 and 1850, volcanic activity accounted for 41% to 43% of decadal-scale variability, with external factors together accounting for between 41% and 64% of low-frequency climatic variability. However, this still leaves a large proportion of variability unexplained. It is important to note here that when considering climate change in the Arctic, we must accept that natural variability is high and it does not necessarily need an external factor to cause climatic change (Overpeck *et al.,* 1997: 1255). However, it is clear that there are a number of strong external candidates for short-term climatic changes, which may then have caused consequent effects on internal climatic systems such as atmosphere and oceanic interactions. Grove (1988: 378) suggests that alterations to solar radiation may have initiated global cooling, which then led to the development of sea-ice and increased snow cover. This consequently changed atmospheric and oceanic circulatory patterns. Within this scenario, smaller-scale variability may be explained by geographical and temporal differences in response to stimuli. However, it is important not to rule out volcanism as a potential trigger for the LIA. The onset of the LIA coincides with high sulphate loading in the GISP2 core (Overpeck *et al.,* 1997: 1252). In a combination of historical and geological records of volcanism over the past 500 years, Bradley and Jones (1992) found that there was high volcanic activity during the LIA. The volcanic explosivity index (VEI), compiled from only volcanological criteria, details 110 eruptions of VEI values 4 or above (on a scale of 1-8) in the last 500 years. Similarly, a dust veil index (DVI) compiled from estimates of eruption magnitude indicates the 1600s, 1630s, 1640s, and 1660s as periods of high dust loading, and therefore high volcanic activity (*ibid.*: 609-610). The historic volcanic record also shows a peak of activity at *c.* 600 BP, a date that, when calibrated to calendar years, would coincide with the early LIA (Bryson and Goodman, 1980: 1042). However, there are many problems with the extant volcanic record. Firstly, many eruptions, especially submarine ones, may go unrecorded so it is unlikely that all eruptions are present in historic records. Secondly, there is a bias toward areas that have been intensively studied, leading some volcanoes to be over-represented. Ice core records also enhance this bias, as most are from the northern hemisphere, thus exaggerating the impact of eruptions in this area (*ibid.*; Bradley and Jones, 1992: 615). In summary, the present state of research is insufficient to pinpoint exact causes of the LIA downturn in climate. We can only suggest that it involved a complex network of interactions between various internal and external factors causing long, short, and medium term climatic responses.

Reconstruction of the LIA climate in Scandinavia

The exact timing of the LIA is inconsistent in the literature, depending on the type of measurement used and the location of the study site. Therefore, it is obvious that, to ascertain how the LIA climate developed in northern Sweden, we need to consider records and reconstructions of climate from as close to this region as possible. In order to do this it is pertinent to consider some of the evidence from areas surrounding Scandinavia, in order to understand better the temporal and geographical variability of this phenomenon. As the LIA is an extensive period, this discussion will refer mainly to the sixteenth and seventeenth centuries, as this is the focal period of this thesis.

Evidence from ancient dunes

Infrared stimulated luminescence (IRSL) dating and radiocarbon dating of former dunes in Fennoscandia has revealed that the LIA coincided with a period of increased aeolian activity. A number of sites in northern Norway and Finland have provided dates between *c.* AD 1100 and 1650 for renewed Aeolian activity (825±125 to 235±135 years BP), which is continued into the modern period, perhaps under the influence of heavy reindeer grazing (Clarke and Käyhkö, 1997: 347). Although there is some discrepancy in the dating, because of using both IRSL and radiocarbon dating techniques, the results are consistent with a major change in the environment of northern Fennoscandia after 800 years BP (Käyhkö *et al.,* 1999: 204).

Evidence from lacustrine sediments

Spitsbergen Knowledge of Holocene glacial advances on Spitsbergen is based mainly on fragmentary moraine deposits. Therefore, the studies of long proglacial lake sediment chronologies offer opportunities to enhance this understanding. Changes in the calcium carbonate content and total organic carbon (TOC) content of these sediments varies according to glacial activity, with high TOC and low calcium carbonate values indicating glacial advances (Svendsen and Mangerud, 1997: 48). The study of a proglacial lake in the mouth of Isfjorden, Linnévatnet, displays a high TOC content during the last few hundred years, indicating a long-term glacial maximum after AD 1500. One core, 06, shows increased sedimentation rates between 600 and 400 cal BP

(AD 1400-1500), indicating that the glacier was also growing before this period. This early advance is consistent with moraine evidence, which suggests a phase of moraine stabilisation around 650 BP, and correlates well with reconstructions from ice-cores and other lakes on Spitsbergen (*ibid.*: 52-55).

Norway Glaciofluvial sediments from glaciers in Jotunheimen, southern Norway, were examined in terms of visible lithostratigraphic variations, organic carbon content, calcium carbonate content, magnetic susceptibility, and sediment grain size, in order to reconstruct past glacier fluctuations (Matthews *et al.*, 2000: 1629-1630). These revealed that the glacier reached its maximum extent somewhere after cal 400 cal BP, increasing in size during the latter half of the focal period (AD 1600 –1700). Combining this with the equilibrium line altitude (ELA) calculations for the glaciers gave an estimated lowering of mean summer temperature by 0.5-1.0°C from the present (*ibid.*: 1641). Unfortunately, as many glaciofluvial lakes are not varved, the dating of these deposits is not detailed; relying on AMS and conventional radiocarbon dating of bulk samples.

Fennoscandia Data collected from 38 lakes in northern Fennoscandia have been used to reconstruct mean July temperatures for the Holocene, using diatom compositional changes calibrated with climate normals from nearby weather stations for 1961-1990. This has revealed an extremely variable climate throughout the Holocene, and also a period of sustained low temperatures from cal 500-200 BP when the mean July temperature was *c.* 0.7°C colder than the present (Korhola *et al.*, 2000: 291). Analysis of diatom and pollen assemblages from cores of Lake Tsuolbmajavri (68°41'30"N, 22°05'E, 526m a.s.l.), northern Sweden, have been used to reconstruct July temperatures and annual precipitation trends during the entire Holocene. The late Holocene is characterised as cool and moist with consistent cooling over the last 1500 years (Seppä and Birks, 2001: 535). Although peaks and troughs within the pollen record may evidence smaller-scale climatic change, the authors point out the need for caution because of uncertainties with dating, sample specific reconstruction errors and the possible insensitivity of pollen to small-scale climatic change (*ibid.*; 533). A downturn in temperatures is also indicated from cal 400 BP from the same lake using diatom assemblages (Rosén *et al.*, 2001: 560).

Evidence from deep sea cores

The Baltic Cores from the Baltic Sea have revealed a variety of information about the surrounding region's climate during the LIA. Since the topography of the Kattegat and Belt Sea at the Baltic entrance is very shallow, the exchange of water between the Atlantic and Baltic is restricted (Backhaus, 1996: 363). This makes the Baltic one of the largest enclosures of brackish water in the world and, because of its isolated position, an area very sensitive to climate change. For example, any change in the continental fresh-water discharge into the Baltic will have profound effects on its haline stratification and thermodynamics (*ibid.*: 367). The latest change in the Baltic (to the Recent Baltic Sea Stage) took place around cal 800 BP, with an increase in freshwater and brackish-freshwater species in the microfossil assemblages from the Bornholm Basin. This also coincides with a shift to more cold-water taxa, indicating a deteriorating climate. Although this is well before the accepted LIA maximum in Scandinavia, usually cited as from the sixteenth to eighteenth centuries, it does indicate when the change to a colder climate may have begun (Andren *et al.*, 2000: 247). Marine sediments from the Skagerrat, a sedimentary basin between the North and Baltic Seas, show a similar pattern from analysis of stratigraphy, granulometry, and oxygen isotopes. The slow sedimentation rates, or a possible hiatus, between AD 1550 and 1750, coupled with finer grained deposits at this time may be indicative of increased storminess due to changes in atmospheric circulation during the LIA. The oxygen isotope profile points to a cold period, with increased values *c.*AD 1500 followed by a decrease until another increase after AD 1600 (Hass, 1996: 125-131).

Greenland This post-AD 1600 cooling is consistent with Greenland deep sea cores from Nansen Fjord; where AMS radiocarbon-dated foraminiferal records suggest AD 1630 as a peak cold period with increasing calcium carbonate dissolution indicating polar water conditions (Jennings and Weiner, 1996: 188).

Evidence from glacial deposits

Although not consistent across Europe, the LIA was a period of renewed growth of glaciers in many areas. By examining glaciers and their associated sediments, we can elucidate when these re-advances took place and to what extent.

Norway Dahl and Nesje proposed a relatively new approach in the study of Holocene glaciers in 1996, using the equilibrium line altitude (ELA) of glaciers to reconstruct winter precipitation. Since the ELA is a function of the mean temperature of the ablation period (May to September), and the level of winter precipitation (October to April), it is possible to use independent records of past temperature, such as dendroclimatological evidence, to calculate the precipitation (Dahl and Nesje, 1996: 382). Through this method, they were able to reconstruct precipitation records from Hardangerjøkulen glacier in central Norway. This showed the LIA as beginning *c.* 600 BP, involving a shift to winter precipitation levels of more than 120% between this date and the LIA maximum in *c.* AD 1750, indicating the period between AD 1500 and 1700 as one of increasing wetness (*ibid.*: 389). Other glaciers in south central Norway, in the Jotunheimen mountain range, have been examined using both lichenometric and rock weathering dating techniques. This showed that, although the maximum extent of glaciers in LIA Scandinavia is taken to be relatively late (usually in the eighteenth century), there is evidence to suggest that glaciers here exhibit an earlier pre-LIA neoglacial maximum (Matthews and Shakesby, 1984: 342). Unfortunately, this date cannot be more precise because of the limitations of dating techniques, but it does stress the geographic variability of the LIA, which could be caused by a small regional difference in temperature. Other evidence of early LIA glacial advances comes from stratigraphical analysis at Omnsbreen (north of Hardangervidda), where a rapid change in climate during the fourteenth century may have been so quick that the vegetation did not have time to adapt (Grove, 1988: 67). Further, early advances may be evident at Svartisen but the dating here is problematic (*ibid.*: 101).

Sweden From a compilation of more than fifty lichenometric dates from glacial moraines in northern Sweden, periods of glacial retreats have been identified around AD 1590-1620, 1650, 1680, 1700-1720, 1780, 1800-1810, 1880-1890 and 1916-1920. These occur about 10 years after dendrochronological evidence suggests lower temperatures, and therefore proposed periods of positive mass balance (Karlén, 1984: 267). It is important to note that these dates may not be accurate, as there are many problems using lichenometry to date sediments from the last few hundred years (Grove, 1988: 102). For example, the initial construction of a reference growth curve for lichenometric dating requires the identification of a rock surface of a known age. Furthermore, the methods used to establish a representative measure vary. From a comparison of different lichenometric techniques used to date glacial moraines in Iceland it was found that dates varied by up to two decades, depending on the technique used (Kirkbride and Dugmore, 2001: 160).

Greenland Although not strictly glacial deposits, sediments from seasonal and perennial snow-patches and nivation forms from northeast Greenland have also provided information about the LIA. They show that this was an extremely variable low magnitude event with widespread environmental influences. Snow patches and nivation processes are strongly influenced by the prevailing climate, so variability is more likely to be expressed here. This could be used to suggest that the LIA was a period of increased extreme events, such as storms and sea floods. The timing and length of this event varied geographically and this study suggests it occurred almost 300 years earlier in Greenland than elsewhere at *c.* AD 1150-1400 (Christiansen, 1998: 720). A similar date was revealed for a period of glacial expansion for glaciers in the Miki and I.C. Jacobsen Fjords in East Greenland. However, the latest of five periods of expansion evident here occurs within our study period (AD 1600-1700). This date was obtained through lichenometric dating and mapping of marginal moraines and their sediments (Geirsdóttir *et al.*, 2000: 132). This correlates well with other proxy data from Greenland; marine sediments from Miki Fjord indicate an ice advance *c.* 1700, and a similar cold period is evident from Nansen Fjord with a variable but cold period from AD 1630 to 1905 AD (*ibid.*: 133). Other proxy data from Greenland are sparse, but periods of cooling are evident from oxygen isotope studies of enamel from Norse and Inuit teeth during AD 1400 – 1700. Similarly, burials after AD 1350 are unpenetrated by roots and are well preserved, indicating a deeper penetration of permafrost after this time (Grove, 2001: 63).

Iceland From a review of various proxy records, including sea ice indices and documentary sources, Ogilvie and Jónsson (2001) suggest that the Icelandic climate was relatively mild during the early LIA (AD 1430-1560) with colder periods in the late sixteenth century, between AD 1630 and 1640, and the late seventeenth century. Between these cold periods, there were milder and more variable spells of climate. Tephrochronological dating of glacial moraines suggests the LIA glacial maximum in Iceland occurred during the later eighteenth century (Kirkbride and Dugmore, 2001: 163). This compares well with analysis of sediments from the south-western Icelandic Shelf by Jennings *et al.* (2001). Carbon and sediment magnetic material was used as a proxy record of soil erosion, and stable isotope ratios and foraminiferal analysis were used as proxies for oceanographic conditions. Approximate synchronous changes in these proxies occurred from *c.* AD 1780-1920, indicating colder conditions (*ibid.*: 94). Lichenometric dating of glacial moraines points to an even later maximum in Iceland, around the late nineteenth century. However, as we have previously discussed, lichenometric dating is fraught with problems. The tephrochronological dating for Icelandic moraines shows a much more complex picture, with at least five cool periods since the later seventeenth century (Kirkbride and Dugmore, 2001: 165). Changes in Icelandic beetle fauna assemblages are consistent with this finding, indicating that the coldest period of the Holocene in Iceland was after AD 1500 (Buckland and Wagner, 2001: 141).

Evidence from ice cores

Greenland Ice core records from central Greenland provide a large variety of environmental data within a well-dated high-resolution chronology. In fact the oxygen isotope records from the Greenland ice cores are considered one of the most reliable passive climate archives for the northern hemisphere (Fischer *et al.,* 1998: 1749). Most proxy climate records tend to provide an estimate of a particular seasonal value (for example, mean summer or winter temperature, or precipitation) and may miss important seasonal events or fluctuations. As ice cores record oxygen isotope levels at intervals throughout the year, they are less likely to miss important seasonal variations in climate (Morgan and van Omman, 1997: 351). However, the climatic signal for the LIA is lower than would be expected. From the GRIP and the GISP2 cores, it has been extrapolated that the 1490s to 1500 were considerably mild, followed by a highly variable climate throughout most of the sixteenth century, with particularly low temperatures around the 1590s. The beginning of the seventeenth century was mild, with temperatures decreasing during the 1620s to a colder spell from 1630 to 1640. There was a short warm spell during the 1660s, but temperatures deteriorated again in the 1670s to 1700s, with the coldest decade being the 1690s (Barlow, 2001: 106). The DYE3 ice core shows a similar pattern of climatic fluctuations, although with a 50% higher amplitude due to its location close to the centre of highest atmospheric variability (Dahl-Jensen *et al.,* 1998: 271). Four further cores taken from along the North-Greenland Traverse in 1993-95 exhibited oxygen isotope anomalies consistent with extended cooling during the seventeenth century, with core B21 indicating a cooler period at the end of the sixteenth century (Fischer *et al.,* 1998: 1750). All these cores show the LIA as a variable period with short alternating periods of warm or cooler conditions. The increased sea salt concentration in the GISP2 record also points to colder meteorological conditions, including enhanced meridional circulation and expansion of the polar vortex (O'Brien *et al.*, 1995: 1962).

Sub-Arctic Islands Ice cores, taken from the sub-Arctic islands of Svalbard and Severnaya Zemlya in 1992, show previous ice surface conditions through analysis of ice stratigraphy and average isotopic and chemical composition. The core from Svalbard displays cooling consistent with the LIA between AD 1550 and 1920, with the coldest summer during 1630. A similar, but weaker, signal is apparent from Severnaya Zemlya (Tarussov, 1992: 515).

Antarctica Although not close to our study area, it is important to note that many of the LIA fluctuations recorded in the Greenland ice cores are also reflected in ice cores from Antarctica. During the period AD 1680-1730, sodium concentrations are high in both the Siple Dome (Antarctic) ice core record and the GISP2 core indicating a colder, or at least more stormy, climate. Low CO^2 (a reduction of six parts per billion) during this period in the Siple Dome adds further evidence for this cooling (Kreutz *et al.,* 1997: 1295). This suggests that, although most evidence is associated with the northern hemisphere, the LIA may have had profound effects on other parts of the world.

Evidence from speleothems

Speleothems, or cave dripstones, are important sources of climate proxies including stable isotope records, annual growth laminae, pollen, and organic matter. A speleothem from a cave (Søylegrotta SG93) near Mo i Rana, northern Norway, has recently been examined in order to provide an oxygen isotope profile for the Holocene. This record gives mean annual temperatures that relate to both the cave temperature at the surface of the speleothem and the average air temperature (Lauritzen and Lundberg, 1999: 663). From this record, it was found that the coolest decades of the LIA were the mid to late 1600s. It is important to note that the dating of speleothems may be of a higher resolution than many proxy records, as they can be dated in calendar years using Uranium-series dating (although, of course, this still has a standard deviation and thus an error margin).

Evidence from chironomids and diatoms

Chironomids and diatoms are found in many lake core samples from northern Scandinavia. Both yield important climatic information as well as being records of the existing lake characteristics and those of the surrounding area (Bigler *et al.*, 2001). A research project carried out in Åbisko, in northern Sweden, has attempted to combine pollen analyses, chironomid and diatom analyses to provide a multi-proxy record of climatic change in the Holocene. Although this study has a long time depth, therefore low resolution and limited application in this thesis, there are a number of characteristics in the data worth noting. Firstly, all records show the period from 6000 BP until present as one of decreasing temperature (to the order of 0.8 to 1.5°C), and a decrease in precipitation is shown in the pollen records, which tallies well with the orbital data. Most interestingly, the chironomid records show the appearance of a cold indicator species *Abiskomyia* after 1000 BP, which is absent throughout earlier periods of the Holocene. This also occurs with various warmth indicating species (Bigler *et al.,* 2002: 489). Although not explicit, this may indicate the variability of the last 1000 years of climate: a period that includes the medieval warm period and the LIA. A similar multiproxy reconstruction has been produced from cores in Lake Sjuodjijaure (67°22'N, 18°04'E, 826m a.s.l.), using chironomids, diatoms, pollen analysis, and near-infrared spectroscopy (NIRS). During the late Holocene (*c.*3900±300 BP to present), both chironomid and diatom assemblages show the appearance of 'cold' species that may coincide with the LIA. The diatom *Fragilaria pinnata var. pinnata,* which is almost absent since 7300 BP, appears from *c.*500 cal BP until the late twentieth century. *Corynocera oliveri* type, a cold-indicating chironomid, also increases towards the recent period; with a peak of 18% at *c.*250 cal BP (Rosén *et al.,* 2001: 554). Cooling is also evident from the pollen and NIRS temperature reconstructions, but this is a more general and long-term trend. Pine gives way to a more open and shrubby vegetation from 800 cal BP and the NIRS record suggests a gradual decrease in temperatures since 900 cal BP (*ibid.*).

Evidence from dendroclimatology

The first biological research into tree-rings began in the mid-nineteenth century, under Theodor Hartig (and later Robert Hartig), although it had been previously recognised that climate and weather influenced growth characteristics of trees (Schweingruber, 1996: 537). The study of past climates through tree-rings is now a well-developed research area, through which a wide variety of environmental information can be extracted. There are a number of detailed dendroclimatic records from northern Fennoscandia and it remains one of the most important proxies for Holocene climate change in this region. Trees in Arctic environments are slow-growing, with pines from areas such as Lake Torneträsk living to over 600 years old (Bartholin, 1984: 261). However, the interpretation of these records is not without problems. Firstly, the relationship between climate, or weather, and tree-ring growth is not fully understood and is often difficult to establish. Different parts of the tree may react to climatic stimulus in different ways and often on different timescales. For example, climatic factors in one year may affect plant processes involved in tree-ring growth for several years. The climatic condition that has the strongest influence on tree-ring growth is widely accepted as being summer temperature: '...winter conditions appear to influence the low frequency variability of pine growth, while year-to-year variability is determined by summer temperatures' (Kirchhefer, 2001: 47). In fact, summer temperature may account for 80% of yearly ring variations (Karlén, 1990: 18). In addition to temperature, tree rings are also influenced by the timing and duration of the growing season, precipitation, and the trees' own efficiency in utilising water, nutrients, CO^2 and UV radiation (Briffa, 2000: 101).

As most tree-ring profiles are calibrated by cross-referencing with instrumental observations from the recent period, the reliability of the calibration will depend on qualitative aspects of the instrumental data (Schweingruber, 1996: 440). It should be of high quality, ideally from a site near to and with similar ecological conditions to the tree-ring sample site. For tree-ring chronologies from remote areas, this may pose problems. However, tree-ring chronologies from high latitudes also have characteristics that make them more reliable. As the trees often come from the limits of their distribution, and have little competition from other species, there is a much higher probability of a strong relationship between climate and tree-ring growth. Similarly the lower temperatures and consequent slower growth rates mean that much longer chronologies may be found than in temperate or tropical latitudes (Briffa, 2000: 88).

Scandinavia From a combination of 10 ring-width and 4 latewood-density chronologies from northern Fennoscandia, Briffa and Schweingruber (1992) have presented a reconstruction of mean summer (July/August) temperatures for the northern hemisphere back to just before AD 1600. Warm periods were evident in the 1650s, 1660s, 1680s and 1690s, whilst colder conditions prevailed during 1590-1609, the 1670s and from 1700-1720. The coldest years were 1601 and 1580; during the latter year the temperature fell to 2.5°C lower than the base period mean (Briffa and Schweingruber, 1992: 377-378). A separate profile from Torneträsk,presented by Briffa (2000: 89), shows a different pattern, with cooling predominately in the latter half of the seventeenth century. Pines from northern Sweden have been used to create a ring-width chronology from AD 436 until the present. Since ring-width is largely a result of prevailing July temperatures in this area, this chronology indicates that periods of lower summer temperatures persisted around AD 550, 800, 860, 910, 1140, 1240, and 1570-1750 (Karlén, 1984: 265). These dates compare well with lichenometric dates of glacial moraines from the same area (see earlier section). A separate study of pines from Lake Torneträsk has shown that, of the 1546 years studied, the narrowest ring widths, and therefore lowest temperatures, prevailed during AD 1601, 1642 and 1645 (Bartholin, 1984: 261).

Three sites in northern Norway (Vikran, Stonglandseidet, and Forfjorddalen) have been used to produce a chronology of average July temperatures from AD 1358-1994. The results showed that the first half of the sixteenth century was generally warm, with a shift to a severe cold period around 1540. Temperatures were stable and around the average between 1550 and 1600, before another cold event, the most severe of the whole reconstruction, between 1601 and 1620 (Kirchhefer, 2001: 48).

In a later study Karlén (1990: 18) calibrated a reconstruction of summer temperatures from trees in the Torneträsk area with recorded temperatures from northern Fennoscandia (1876 to present). It was found that the coldest 50-year periods occurred during 1108-1157 and 1576-1625, the latter period correlating well with estimates for the LIA. Aniol and Eckstein (1984),again using *Pinus sylvestrus* L. from four sites in the Torneträsk area, found a slightly later colder period. Using calibrations with Kiruna weather records (1901-1979), they found below-average summer temperatures during the periods 1608-1690, 1700-1710 and *c.*1720-1735 (*ibid.*: 278).

Documentary sources

Proxy records such as those described above have provided a range of information on past climate. However, each method has its own limitations. Many proxy records for the last 500 years do not have a very high resolution because of problems with dating and response times to climatic stimuli, most being restricted to decadal or at best yearly parameter averages.[14] It is not until the late seventeenth and early eighteenth century, when the first instrumental observations begin in Europe, that we have detailed monthly information about climate. Even so, these records are highly variable, especially during earlier periods, both in geographical coverage and the methods and instruments used for collecting observations (Ingram *et al.*, 1985: 200). A source of information, which can both complement these early observations and calibrate proxy records, is the reference to meteorological phenomena in documentary sources. Information about climate and weather has been extracted from a number of sources, ranging from governmental and parish records, weather logs, personal papers (such as journals, diaries and biographies), myths and legends, and even pictorial art (Pfister, 1992: 120). However, documentary sources are not without their own specific problems. Although extremely time-specific ,these records do not tend to be very scientific and need to be carefully and critically scrutinised before use. The principle problems are contemporaneity, propinquity, and faithful transmission. Firstly, it must be verified that the person writing the account actually witnessed or lived during the period they are describing. Secondly, the events should be reported

[14] The main exception to this is dendroclimatology, as this has good but seasonal time resolution at an annual level.

as soon as possible after their occurrence to increase accuracy. Finally, if the source has been transcribed, efforts should be made to ensure this is done correctly using good quality sources; many chronicles include compilations of more remote events (Ingram *et al.*, 1985: 195). Until the eighteenth century, both the Julian and Gregorian calendars were in use, therefore care must be taken to convert all dates before this period to the same calendar; this reduces the possibility of events being amplified or duplicated due to differences in calendars (Pfister, 1992: 122).

The Northern Hemisphere Monthly mean pressure calculations have been made for the late Maunder Minimum (1675-1715AD), for the northern hemisphere in general, using documentary sources calibrated with recent meteorological observations. This period is characterised by low sunspot activity and represents the coldest period of the LIA (Luterbacher *et al.,* 2000: 1050). The documentary data used are mainly drawn from the CLIMHIST[15] databank and are calibrated and statistically tested using the reference periods 1901-60, and 1961-90 respectively. The reconstruction showed that during the winters of 1675-76, 1679-80, 1695-96, and 1696-97 there was strong anti-cyclonic pressure over Scandinavia, leading to cold air advection from an easterly direction. This correlates well with independent, but as yet untested Russian data ,suggesting cold winters between 1675-79 and 1695-97 (*ibid.*: 1062).

The British Isles Anecdotal sources indicate that Inuit were recorded arriving in Kayaks in the Orkney Islands several times between 1690 and 1728. These coincide with a failure in the cod fisheries from 1675-1704 when no cod was found in this area (Lamb, 1995: 219). In England, the temperature between 1550-1700 has been calculated from diary and other literary sources to have been 0.7-0.8°C colder than the average for 1900-1950. Extreme winter events are well recorded in England with ice on the river Thames 22 times between 1564/5 and 1813/4, and several feet thick during 1608 (Lamb, 1984: 46). Numerous famines are recorded from Scotland and England, during which harvests or fisheries failed due to harsh weather conditions. In particular, wheat

[15] The CLIMHIST database has been developed through a number of projects and is hosted at http://www.wsu.hist.unibe.ch/index.php?id=190 . It contains data on climate from AD 750 to the late nineteenth century.

harvests in England were poor during the 1550s, the 1560s, 1594-97, and 1692-98 (Lamb, 1995: 228).

Central Europe Pfister has presented extremely careful and detailed reconstructions of LIA temperature from documentary sources from Switzerland in numerous publications. Documentary sources used include personal papers, such as journals and diaries, governmental documents, and early meteorological observations made in weather logs. Monthly estimates of precipitation and temperature have been given in these for central Europe from 1525 to 1979, and were used to create the CLIMHIST data bank. He found that winter and spring months during this period tended to be colder and drier than at present with March being the coldest month. The climate was considerably more variable than at present with the least stable period at *c.*1600 AD (Pfister, 1992: 135). The main problems with the data used for this analysis were that, prior to 1659, accounts for every month were not available, although between 1550 and 1657 there were few gaps in the sources. Also, between 1583 and the end of the eighteenth century, both the Gregorian and Julian calendars were in use in Switzerland (Pfister, 1985: 217). The data showed favourable autumns, springs and summers from 1530 to1560, followed by decades of colder and wetter conditions: the winter of 1572/73 was the most severe during the last half millennium in Switzerland. Variability was high during the last decades of the sixteenth century, with the seventeenth century not as cold as suggested in previous reconstructions. Wetter conditions prevailed from 1600 to 1630, but 1645 to 1684 was a period of moderate summers. Towards the end of the seventeenth century, there is a decrease in temperature in all seasons with the 1690s being a particularly cold decade (Pfister, 1992: 137). Between 1683 and 1700, winter temperatures recorded in Zurich were 1.5°C colder than the 1900-60 average, whilst March temperatures for this period were 2.2-2.7°C colder than the twentieth century (Lamb, 1995: 216).

The first written weather report from Poland dates to AD 940/941, detailing an extremely cold winter. However, regular written accounts of the weather do not appear until much later, into the fifteenth and sixteenth centuries. One of the earliest of these is the daily weather notes recorded by Marcin Beim (*c.*1470-1540); an astronomer and theologian at the Jagiellonian University in Cracow (Bokwa *et al.*, 2001: 15). He started recording daily weather observations in 1487 and produced one of the longest series of this kind known from this period, with almost continuous notes between 1502-07, 1524-31 and 1535-1540. These notes show that, during the first half of the sixteenth century, there was a higher incidence of summer versus spring floods in Cracow, which were particularly destructive in 1505, 1515 and 1528. Using these data, the number of days with certain phenomena has been calculated and compared. This has shown that the highest incidence of frost was between 1527 and 1531; the period between 1535 and 1540 had the most days with thunderstorms. In general the notes showed that the sixteenth century had a higher frequency of summer precipitation than the twentieth century (*ibid.*: 16-19). Another, more general, source from Poland is the diary of Jan Antoni Chrapowicki, a weather enthusiast who sometimes made several notes on conditions throughout the day. Although the diaries stretch from 1656 to 1685, originals are only present from 1656 to 1667. Copies exist of later diaries, but these were made in the late eighteenth century. Chrapowicki travelled considerably so the diaries can only be used to refer to north-eastern Poland rather than a specific place. However, they can reveal much about temperature and precipitation in this region at that time. The earliest frost occurred on the 19th October 1665 and the latest frost on 24th April 1665. 1666/1667 had the most days with frost (109 days), and 1661/1662 had the least (42 days): indicating great variability during this decade. The average for this period was considerably more than the present day, with 75.3 days of frost compared with a modern day average of 63 days a year (*ibid.*: 22). In general the winters from 1656-1667 were of greater severity than today, with colder springs (especially during 1663-1667). A greater variability of weather was also evident in the summers, especially during 1660. Between 1656 and 1667, there were more days with precipitation in summer than winter, indicating drier winters and wetter summers, whilst heavy rains and floods were recorded in June 1658, August 1660, June 1664, and September 1667. Rains also destroyed rye crops in August 1661 (*ibid.*:24-25).

The Baltic A 500 year temperature sequence for the port of Tallinn has been constructed, by considering dates of ice break up in the port and Estonian rivers from documentary sources. In the instrumental period (since 1774), this has been calibrated with temperature observations so that estimates may be made for earlier periods. The sources may not be wholly accurate, as there are possible discrepancies between the date the first boats registered with the port and the breakup of ice. However, the error margin for this is not thought to be more than a couple of days so relatively accurate data can be extrapolated. The results show severe winters centred around AD 1600 and one winter (AD 1541) when the mean temperature was below -10°C (Tarand and Nordli, 2001: 194-197). The variability of climate during the LIA is well represented at the port of Riga, where the most severe winter of 1658-9 occurred in the same decade as the least severe (1652-3), when the port opened (*i.e.* became ice free) as early as the first week of February (Lamb, 1984: 48).

Scandinavia Documentary sources also yield a range of information on LIA glacier expansion. Grove (1988) has looked closely at documentary reports concerning glaciers in Scandinavia, particularly Jostedalsbreen in south central Norway. This glacier was close to settlements and farmland, therefore fluctuations in its size directly affected the local population. The sources suggest it began to expand during the mid-seventeenth century, with ice extending down into high valleys by the 1680s (*ibid.*: 73). This expansion resulted in claims for tax relief, due to loss of upland pasture or other damage caused by landslides, rockfalls, avalanches and floods. These reports increased greatly between 1680 and 1690, with the highest frequency of claims from the period AD 1690-1710 (Lamb, 1995: 226). Although there is some evidence for earlier cooling (the failure of fisheries during 1600, 1601, 1602, 1632, and 1634), it is unlikely that glaciers were growing during this time, as this is when the area was resettled following a post-Black Death desertion. People would be unlikely to settle where pasture or livestock were threatened by glacier activity (Grove, 1988: 69). In fact during 1665 there were fewer farms in Norway than there were *c.*AD 1300 (Lamb, 1995: 224). Documents from Sweden indicate that, whilst the period between 1520 and 1560 was relatively free of extremely poor harvests, this period was followed with a period of famine (Utterström, 1955: 23). Grain harvests in the Lule valley declined between 1559 and 1640, and there are numerous records of natural disasters, failing harvests and famine from Scandinavia for the hundred years following the 1590s. In particular 1596-1603, 1649-52, 1675-77, and the 1690s were years when crops failed in Sweden.

Decade	Collated Evidence for colder/more variable climate
1500's	Destructive floods in Cracow 1505 (5)
1510's	Destructive floods in Cracow 1515 (5)
1520's	Destructive floods in Cracow 1528 (5) High incidence of frost in Cracow 1527-1529(5)
1530's	High incidence of frost in Cracow 1531-1531 (5) High incidence of thunderstorms in Cracow 1535-1540 (5)
1540's	Average temperature below –10°C at Tallinn winter 1541 (6)
1550's	Poor wheat harvests recorded in the British Isles (2)
1560'S	Poor wheat harvests recorded in the British Isles (2)
1570's	Most severe winter in the last 500 years in Switzerland 1572-73 (4)
1580's	
1590's	Poor wheat harvests recorded in the British Isles from 1594-97 (2) Harvest failure in Sweden 1596-1603 (7) Account from Kålland of poor weather affecting crops, animals, and people 1596 (7) Severe floods in Småland and Östergötland 1596 (7) Extreme cold weather in Sweden 1597 causing crop and animal losses and famine (7) Hot year in Sweden 1599 (7)
1600's	Ice several feet thick on the Thames in 1608 (3) Least stable climatic period around 1600 from CLIMHIST databank (4) Wetter conditions in central Europe (4) Severe winters centred around 1600 at Tallinn (6) Extreme cold weather in Sweden 1601 causing crop and animal losses and famine (7) Good harvests in Ålem 1604-1606 (7) 1601 mild winter in Ålem but poor winter in Norrland (7)
1610's	Wetter conditions in central Europe (4)
1620's	Wetter conditions in central Europe (4)
1630's	
1640's	Harvest failure in Sweden 1649-1652 (7)
1650's	Very severe winters in northeastern Poland 1656-1660 (5) Drier winters and wetter summers in northeastern Poland 1656-1667, heavy rains and floods June 1658 (5) Very severe winter in Riga, 1658-9, and very mild winter 1652-3 (3)
1660's	Early autumn frost (19.10.1665) and late spring frost (24.04.1665) in northeastern Poland (5) Drier winters and wetter summers in northeastern Poland 1656-1667, heavy rains and floods August 1660, June 1664, Sept 1667, rains destroyed crops 1661 (5) 109 days with frost in northeastern Poland 1666/1667 (5) Especially cold springs 1663-1667, very severe winters 1660-1667 (5)
1670's	Strong anticyclones during the winters of 1675-76 and 1679-80 (1) Failure in British Isles cod fisheries from 1675 to 1704 (2) Harvest failure in Sweden 1675-1677 (7)
1680's	Failure in British Isles cod fisheries from 1675 to 1704 (2) Winter temperatures in Zurich 1.5°C colder than 1900-60 average, March temperatures 2.2-2.7°C colder than the twentieth century (2)
1690's	Strong anticyclones during the winters of 1695-96 and 1696-97 (1) Poor wheat harvests recorded in the British Isles from 1692-98(2) Records of Eskimos in Kayaks arriving in the Orkney Islands several times 1690-1728 (2) Failure in British Isles cod fisheries from 1675 to 1704 (2) Particularly cold decade in central Europe (4) Harvest failure in Sweden (7)
1700's	Records of Eskimos in Kayaks arriving in the Orkney Islands several times 1690-1728 (2) Failure in British Isles cod fisheries from 1675 to 1704 (2)
1710's	Records of Inuit in Kayaks arriving in the Orkney Islands several times 1690-1728 (2)
1720's	Records of Inuit in Kayaks arriving in the Orkney Islands several times 1690-1728 (2)

Table 5. Summary of documentary evidence discussed in the text for the period AD 1500-1730

Source : (1) Luterbacher *et al.*, 2000. (2) Lamb, 1995. (3) Lamb, 1984. (4) Pfister 1992. (5) Bokwa *et al.*, 2001. (6) Tarand and Nordli, 2001. (7) Utterström, 1955.

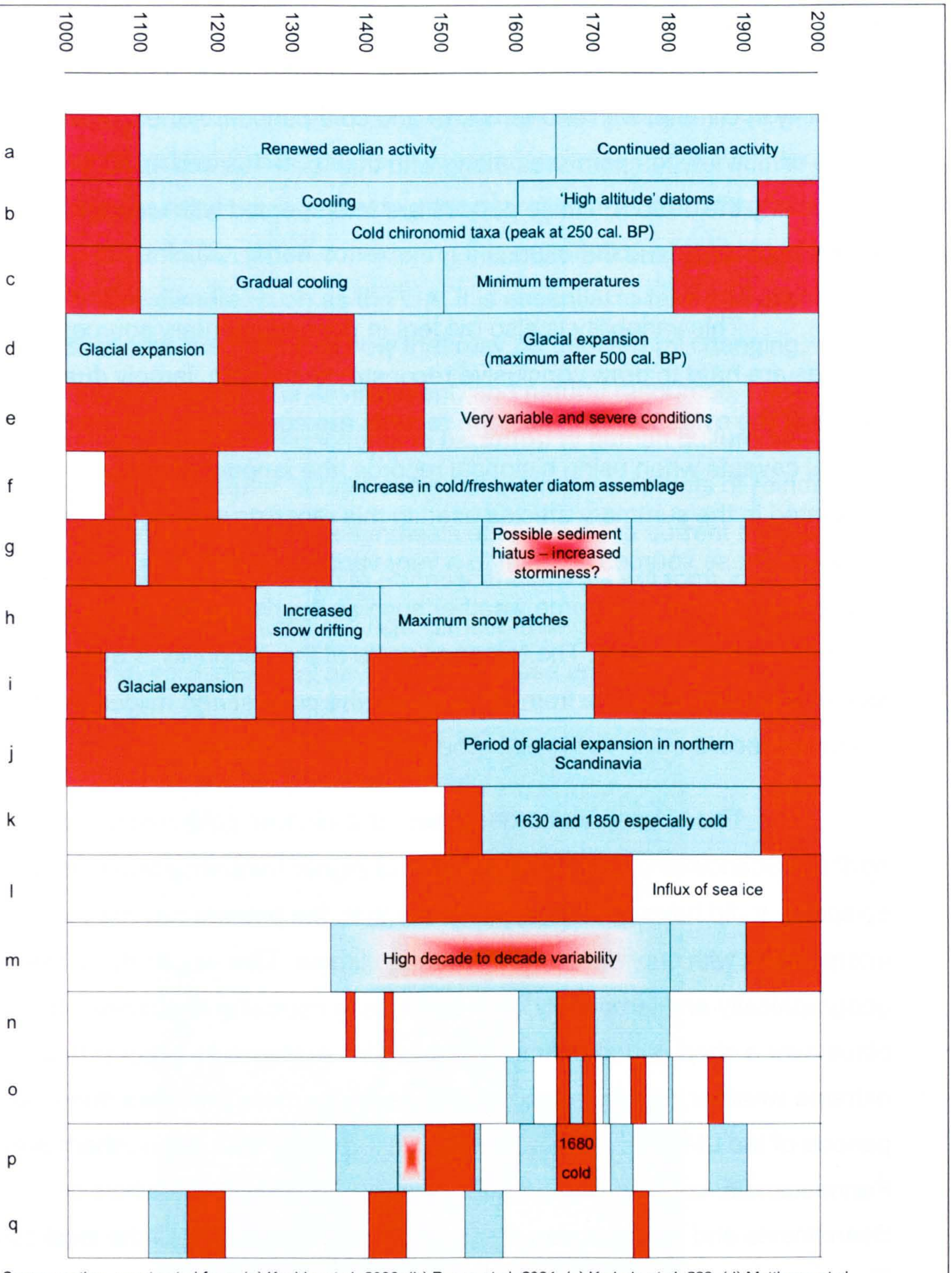
There were also many years of very poor crop yield during this period (*ibid.*: 26). This failure was not limited to Sweden, with comparable reports from Denmark and Norway. Utterström presents a summary of an account from a parish register from Kålland, western Sweden, detailing the impact of the poor weather conditions during 1596 on crops, animals and people. Floods destroyed crops and grass, there was little winter fodder for animals, which became ill and died over the winter. The soil was described as being 'sick for three years' implying the impact of these events was long-lived. People were driven to other means to sustain themselves: eating bark, chaff and hay, and as the price of grain was high, there was increased theft. Many people died of hunger, and there were increased levels of diseases, such as dysentery (*ibid.*: 27-28). Similar accounts exist from other parts of Sweden, for example, severe floods are reported from Småland and Östergötland in 1596, and extreme cold weather in 1597 and 1601, devastating crops and livestock and causing famine (*ibid.*: 29). There is also a suggestion of extremely variable conditions. 1599 is described as a very hot year, good harvests are reported from 1604-1606 from Ålem, and 1601 is reported to have been a mild winter in Ålem, but very severe in Norrland (*ibid.*: 30).

Summary

A diagram containing a synthesis of the evidence for the climate of northern Europe over the last 1000 years has been compiled from the proxies (figure 11). Although not a precise representation, this semi-qualitative diagram does allow the recognition of the general patterns of climate during this period. This can be compared with the summary table of documentary sources already presented (table 5). Particular emphasis is placed on the period between AD 1500 and 1700, as this provides the broader context for the transition to reindeer herding. In order to give a more focussed reconstruction of climate for the specific area of northern Sweden, only proxy sources from Fennoscandia are discussed here, although all relevant proxies are included in the diagram.

What is apparent from looking at figure 10 is that the majority of sources show episodes of cooling during the sixteenth and seventeenth centuries. Some of the proxies are drawn from long records, therefore do not have the high level of resolution necessary to determine exactly what climatic changes were taking place during this period. However, all of these records indicate episodes of cooling consistent with the LIA. For example, aeolian activity is observed to increase during the period AD 1100 to 1650, with a continuation of this activity until the present day. Chironomids and diatoms from lakes in the north of Sweden point to cold-indicator species becoming present after 1000 BP and 500 BP respectively. Slightly higher resolution records are presented from glacialfluvial sediments and glacial landforms. These suggest an increase in glacier expansion around AD 1600 to 1700, with some lichenometric dates suggesting earlier, late-sixteenth century, and later advances as well. This increase in glacier size has been associated with an increase in wetness for the period AD 1500 to1700 in Norway. Analysis of sediments from the nearby Baltic ocean, have shown a shift to cold-water taxa in the microfossil assemblages *c.*800 BP. The coldest period from the osxygen isotope profile is between AD 1500 and 1600, with a hiatus in sedimentation between AD 1550 and1750; indicating possible increased storminess during this period. Speleothems from Norway point to the mid to late 1600s as the coldest decades of the LIA.

The dendroclimatological evidence used in this reconstruction is particularly important. Not only does it come from areas within Sapmí, but it also is a high resolution record of climate during the period in question. Although not all records are the same length, considerable research has gone into producing composite records of a long timescale. These records do not always show temporal agreement with respect to climate episodes, but all show the variable nature of climate change during this period. Many records show the period around AD 1600 as one of severe cooling (Briffa and Schweingruber, 1992). In particular, Bartholin (1983; Bartholin and Karlén, 1984) states that 1601 was a very severe year; Karlén (1990) points to a 50-year cold period in 1576-1625, and Kirchhefer (2001) states that 1601-1620 was the most severe cold period of the reconstruction. Although not explicitly stated in the text, closer examination of tree-ring and temperature profiles provided by other authors show a similar trend. A diagram from Karlén (1984) shows cooling around the late sixteenth to mid eighteenth centuries, and a drop in temperatures immediately prior to 1600 is evident from graphs in Briffa (2000).



Source: author, constructed from: (a) Kayhko et al, 2000; (b) Rosen et al, 2001; (c) Korhola et al, 200; (d) Matthews et al, 2000; (e) Jennings and Weiner, 1996; (f) Andren et al, 2000; (g) Hass, 1996; (h) Christiansen, 1998; (i) Geirsdottir et al, 2000; (j) Grove, 1988; (k) Tarrusov, 1992; (l) Jennings et al, 2001; (m) Barlow, 2001; (n) Lauritzen and Lundberg, 1999; (o) Briffa and Schweinengruber, 1992; (p) Kirchefer, 2001; (q) Karlen, 1990.

Figure 10. Qualitative representation of the Little Ice Age climate in northern Europe from climate proxies.

What is evident in all the tree-ring profiles used is that there was a high degree of inter-annual variability within the LIA. The period AD 1500-1700 is marked by short periods of temperatures being colder, and sometimes warmer, than the recent calibration data averages, with rapid changes between these extremes. A similar high level of variability is evident in the Greenland ice core records. Throughout, the period in question they show a high decadal variability in climate, with shorter warm and cold periods. For example, the 1590s exhibit low temperatures along with the 1630-40s and 1670-1700 (particularly the 1690s). These periods are interspersed with warmer intervals during 1600-1620 and the 1660s.

This variability is also evident in the documentary sources. These sources are hard to draw conclusive reconstructions from, largely due to the nature of the evidence. Not all of the records are continuous and, apart from the normal caveats when using historical records, the amount of information presented in the summary articles used in this reconstruction is limited. However, these sources do point to a very variable period of climate with frequent examples of extreme weather such as floods, severe frosts and failure of fishing and agriculture. The temporal scale of the variability is evident if we look at a specific example from Riga, where the coldest and mildest winters of the entire record occur in the same decade (the 1650s).

The LIA cannot be described as a uniform cold period across northern Scandinavia, but it was a period of higher frequency and intensity cold episodes. It did have periods much colder than the present day but these were interspersed with short intervals of warmer climate. This variability existed both geographically and temporally, with changes to opposing conditions often taking place over a short period of time. There is also evidence to suggest that extreme weather conditions and storminess were more prevalent during some periods of the LIA. The dendroclimatological records from the northern areas of Fennoscandia, coupled with broader scale evidence from the whole of Scandinavia and neighbouring areas, allow a good estimate of the local climate. These records show extreme cold conditions around AD 1600, accompanied by high decadal and inter-annual variability in climate during the sixteenth and seventeenth centuries.

Chapter 5. Reindeer in Fennoscandia

Reindeer have been an important natural resource for humans since the middle Pleistocene, and their exploitation has a long and complex history. When considering how past and present societies may have interacted with and exploited reindeer, it is vital to understand something of the animals themselves. In particular, when considering the exploitation of reindeer during a period of variable climate, such as the LIA, it is essential to take into account the animals' normal life-cycle and how that may be affected by changing environmental conditions. The environment, and natural resources, should not be perceived as a stable and unchanging backdrop to human culture and development. In this chapter, a brief outline of the main elements of reindeer ecology is presented along with a synthesis of some of the current theories of reindeer evolution and their origin in Fennoscandia. This will form the basis for the exploration of how the Little Ice Age climate change during the sixteenth and seventeenth centuries may have affected these animals.

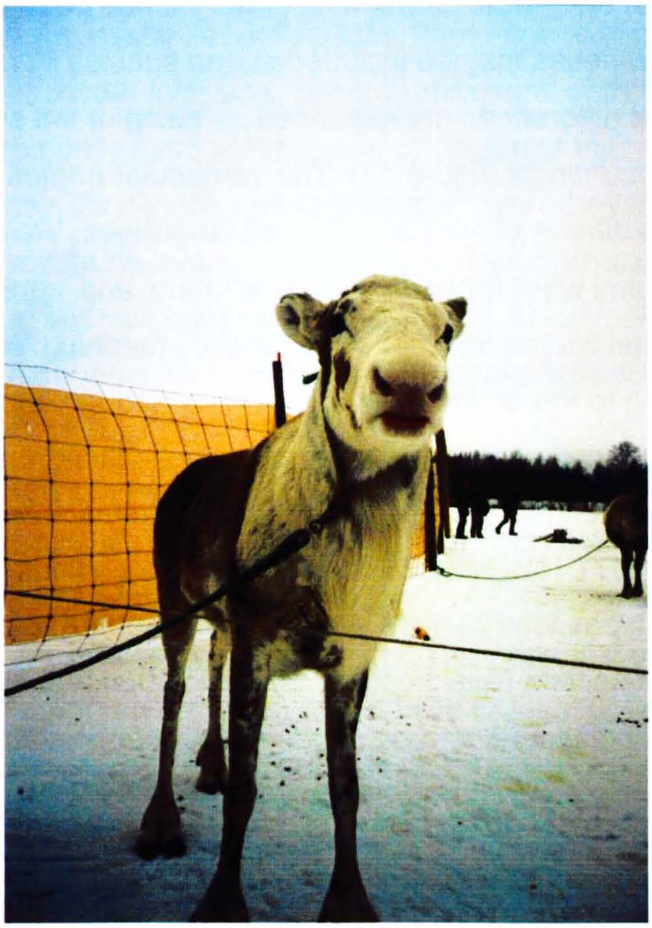


Figure 11. Reindeer in Umeå (author's photograph)

Reindeer taxonomy and distribution

Collectively, all extant forms of reindeer and caribou make up the subfamily Rangiferae within the family Cervidae (which includes all species of deer). Cervidae are one of the nine families of the order Artiodactyla, comprising all even-toed ungulates. All Cervidae are ruminants: having a four-chambered stomach (Walker, 1964: 1355). This characteristic allows ruminants to graze in the open but to continue masticating and digesting the food in other locations, affording them some protection from predators (Nieminen, 1980: 384). The males of all Cervidae species possess antlers, which they shed annually. *Rangiferae* may be further distinguished by the fact that both males and females have antlers (although female antlers are generally smaller), and that new-born calves do not have a dappled or spotted coat (Leader-Williams, 1988: 4,9).

Originally, the diverse extant forms of reindeer and caribou were thought to be representatives of different species; however, as a result of an influential review of the genus by Banfield (1961), it has been generally accepted that all varieties may be included in one species *Rangifer tarandus.* Within this species differences are explained as being of the sub-species level and are named accordingly (figure 12). The vernacular names of reindeer and caribou stem from different variations on local languages. 'Reindeer' probably comes from the Sami word for young reindeer 'reino' and 'caribou' from the north American First Nation Mi'kmaq word 'xalibu', meaning 'pawer' or 'shoveler', referring to the animals habit of digging through snow for forage material. The classification of the species into two distinct groups is largely a result of behavioural differences dependent on the animals' environment (Thomson, 1980: 547). However, there are some morphological differences. Tundra/mountain types tend to have antler beams that are rounded or cylindrical in cross-section (described as Cylindricornis) and distally flattened nasals. The forest types tend to have arched nasals and flatter, more elliptical, antler beam cross-sections (Compressicornis) (Banfield, 1961: 43)

Latin Name	Common Name
Type species: Rangifer tarandus	Reindeer/caribou
Group Cylindricornis	
R. t. tarandus	Mountain/tundra reindeer
R. t. platyrhynchus	Spitzbergen reindeer
R. t. groenlandicus	Barren-ground caribou
R. t. granti	Alaskan caribou
R. t. pearyi	Peary caribou
R. t. eogroenlandicus (extinct since *c.*1900)	East Greenland caribou
Group Compressicornis	
R. t. fennicus	Forest reindeer
R. t. caribou	Woodland caribou
R. t. dawsoni (extinct since *c.*1935)	Queen Charlotte Island caribou

Table 6. Taxonomy of extant and recent reindeer and caribou sub-species. After Leader-Williams (1988: 4)

The present distribution of reindeer and caribou exhibits the great niche-breadth of the species. It is present at latitudes from 45°N to 90°N in a range of alpine and Arctic/sub-Arctic habitats; from taiga to High Arctic Islands such as Greenland (Leader-Williams, 1988: 7). Because of this predominately Arctic distribution reindeer have a number of adaptations that enable them to thrive in cold climates. Firstly, they have a double-layered coat consisting of a woolly under-fur overlain by longer, straight guard hairs (Walker, 1964: 1402). The longer hairs are hollow fibres which trap air in their core and are the main source of insulation during winter. Reindeer often have little subcutaneous fat and this is used for nutritional purposes rather than insulation. In fact, studies on Svalbard reindeer have concluded that the high melting point of the reindeer's subcutaneous fat precludes it having any insulatory purpose (Ringberg *et al.*, 1980: 392). The hooves of reindeer are deeply cleft, broad and flat, enabling easy travel over snow and boggy ground. The hoof edge is well defined and sharp, and the soft pads are insulated with a thick coarse mat of hair in winter. This allows the reindeer to dig 'craters' in the snow to expose suitable forage. The quantity of forage available in winter is limited, so reindeer exhibit a marked drop in metabolic rate. Speiss (1979) describes how an average domesticated reindeer of 100kg requires 5000-6000 calories a day in summer compared with 3000-3500 calories in winter. This lowering of metabolic rate is also seen in the temporary cessation of growth of young over the winter season. Heat is also conserved in the body cavity by means of a vascular counter-current heat exchange mechanism in the legs. The lower melting point of fat in reindeer legs means that they can function well at relatively low temperatures. Reindeer have longer legs than other Arctic ungulates, such as Musk Oxen, enabling them to move through deep snow and thus a wider range of Arctic and sub-Arctic environments (Suttie and Webster, 1998: 100). The major adaptation, that makes reindeer so successful in these environments, is the ability to digest a largely lichenous diet. Reindeer diet will be discussed in more detail later, but in many areas the principal winter food source is lichen. Many lichens are acidic and would be indigestible to most cervids[16] because of the low tolerance of the symbiotic intestinal bacteria. The ability of reindeer to survive on this diet indicates either a more tolerant intestinal flora or a stomach capable of balancing the pH (Speiss, 1979: 62). Even with these adaptations to cold environments, reindeer typically lose up to 20% of their body weight over the difficult winter period (Nickul, 1977: 20).

The origin of reindeer in Fennoscandia

The earliest European reindeer remains are from Sussenborn, Germany, and date to 440,000 BP, although the evolutionary origins of the species are probably much earlier. Where the species initially evolved is unclear, as there is no fossil evidence, but the most likely scenario is that they originated from north-east Asia or the near-Arctic in the earlier Pleistocene (Nieminen, 1980: 379). By 120,000 years ago, reindeer were increasingly common and were an important, if not continuous, part of the European biota of the later Pleistocene. The distinct forest and mountain types probably differentiated around this time (Banfield, 1961: 41). They are virtually absent in temperate Europe during interglacials, but have outlived many other components of the Pleistocene fauna such as woolly mammoth and cave-bears (Speiss, 1979: 32). It is therefore assumed that, during warmer periods, reindeer were able to respond rapidly to climate change by altering distribution patterns.

[16] With the exception of the Musk deer (*Moschus moschiferus*) which also consumes lichens but not in the same quantity (Suttie and Webster, 1998: 114).

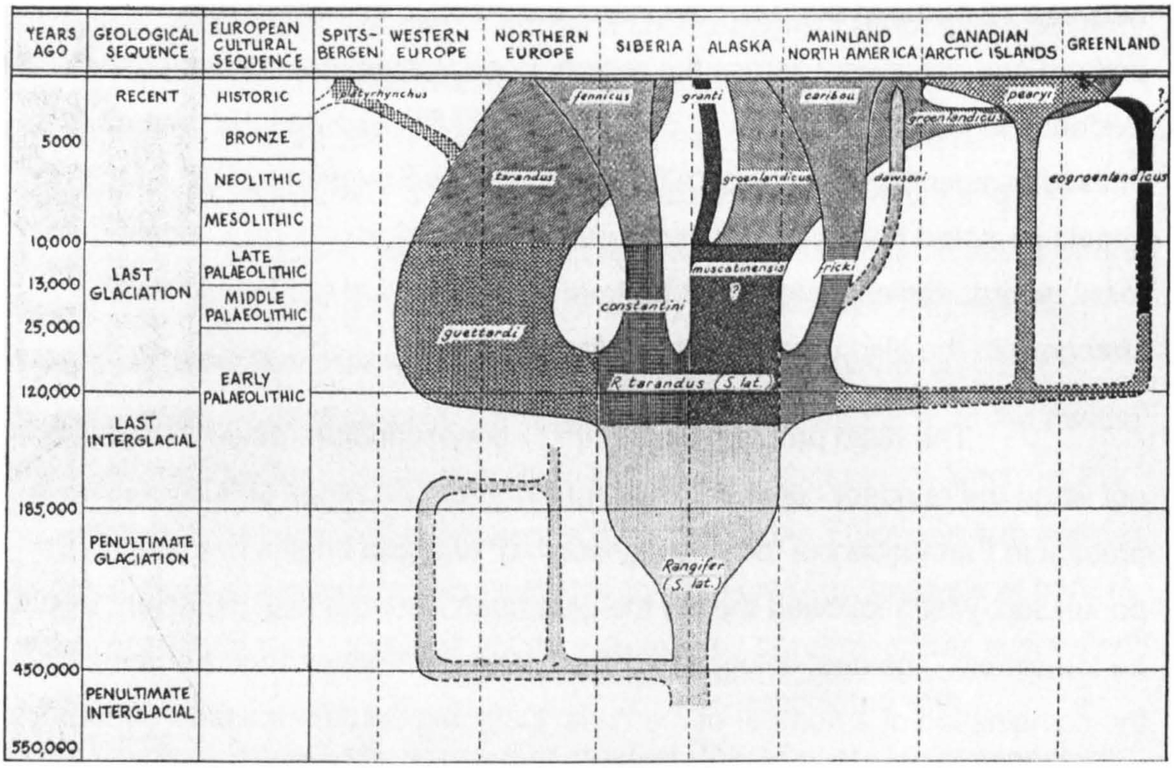


Figure 12. Chronology and distribution of reindeer Rangifer tarandus in the Quaternary Period. After Banfield (1961: 41)

Reindeer remains found on the western coast of Norway have been dated to 34,000 BP and have led to the suggestion that reindeer may have colonised Scandinavia in a warmer interstadial of the last glaciation, and survived the later cold period on the Norwegian coast (Nieminen, 1980: 384). This hypothesis is questionable if we consider that, during the last glacial maximum (*c.*22,000 BP), virtually all of Fennoscandia was covered in an ice sheet, the western extent of which was marked by the Egga Moraines on the continental shelf off the coast of Norway (Lowe and Walker, 1997:28). It is implausible to suggest that a viable population of reindeer could have survived for several thousand years on the sparse *nunataks* and marginal strips of land which were not beneath ice. It is much more likely that these remains represent an earlier colonisation of Fennoscandia, during the Ålesund Interstadial (35,000-29,000 BP; *ibid.*: 388), which was either wiped out or forced to relocate as the ice sheets re-advanced. Similar evidence is available from Greenland, with reindeer colonising the island during interglacial-like climate 40,000 BP, then no evidence until the early Holocene (8800-8000 BP; Forman *et al.*, 2000: 763).

The post-glacial colonisation of Fennoscandia by reindeer occurred alongside a number of other species; including wolf, wolverine, and elk, between 12,500 and 9000 BP. As is to be expected, this colonisation was not uniform and dates vary across the region. For example, the earliest post-glacial evidence for reindeer in Norway dates to 12,500 BP whereas the date from Finland is much later at *c.* 8,000-7,5000 BP (Aaris-Sørenson, 2000: 41). It should be noted that, with any interpretation of species occurrence based on a fossil record, earliest dates must be treated with caution (and could easily change with the discovery of a single fossil).

The main problem concerning Fennoscandian reindeer origins is not when the reindeer colonised, but from where. The range of sub-species present in Fennoscandia today suggests that, to argue origins from a single population, which followed the ice margins north after the last glaciation, would be too simple. The best solution to the problem of reindeer origins comes from the combination of a number of methods. Osteological comparisons within archaeological and geological reindeer remains may help find similarities or differences between sub-species, which may indicate common ancestry. Zoogeographical studies of present ecology and distribution of reindeer, and the use of molecular genetics may assist in highlighting suitable refugia locations. Osteological study of reindeer remains from archaeological deposits in Finland, by Rankama and Ukkonen (2001), has suggested a two-stage migration of reindeer. Mountain reindeer migrated from Europe via the west coast of Norway (before 7750 BP), followed by a later migration of forest reindeer from a glacial refuge in Siberia (*c.*7500 BP). This second migration was probably via the south and south-east of Finland, although the possibility of a route through the Kola Peninsula remains. It is likely that the two sub-species were able to mix during the early Holocene climatic optimum and thus created the variety of types seen today (Rankama and Ukkonen, 2001: 142-143). By looking at the DNA, both of chloroplast for plants and mitochondria (mt) for animals, Godfrey Hewitt has suggested migration routes and locations of refugia for a number of European species. For example, looking at mtDNA of brown bears (*Ursus arctos*) he noted two distinct eastern and western lineages explained by two refuge areas; one Iberian and the other Caucasian/Carpathian (Hewitt, 2000: 909). He highlighted Sweden as an area where these lineages met, and puts forward the late melting of the Fennoscandian ice sheet in central Sweden as a possible reason for this (*ibid.*: 910). Similarly, the examination of chloroplast DNA from

Finnish oak has led to the suggestion of complex origins. Although an eastern origin, from Russia via the Karelian Isthmus, is most likely, there is also evidence for a southern and western input from Estonia and Sweden respectively (Ferris *et al.,* 1998: 591). A summary of osteological and zoogeographical results for the origin of reindeer in all of Scandinavia is offered by Aaris-Sørenson (2000), giving four possible refuge areas; a former North Sea Continent, Denmark, and to the south and east of Finland. Banfield suggested that in Scandinavia, woodland reindeer descended from the middle Palaeolithic Siberian sub-species *Rangifer tarandus constantini,* whereas the ancestor of tundra/mountain reindeer is the Palaeolithic European sub-species *Rangifer tarandus guettardi* (Banfield, 1961: 41). However, analysis of mtDNA sequence variation amongst all extant sub-species of reindeer has suggested that the current species designation may be more associated with morphological differences, as a result of adaptation to post-glacial conditions, rather than indicating evolution in distinct glacial refugia (Flagstad and Røed, 2003: 669). From their analysis, they suggest that both woodland (*R. t. fennicus*) and tundra/mountain (*R. t. tarandus*) types share a common diphyletic origin in Fennoscandia, with a large glacial population from

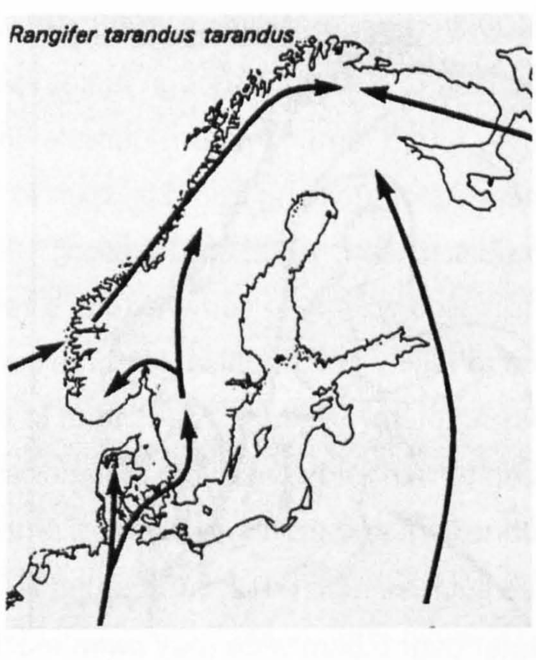


Figure 13. Immigration routes into Fennoscandia in Late Glacial and Holocene for Rangifer tarandus. After Aaris-Sørenson (2000: 37)

central Europe to Beringia and a smaller more isolated refugia possibly in Western Europe (*ibid.*: 665-666). In order to get a clear picture of how and when these distinct forms of reindeer colonised Fennoscandia, geographical and hydrological barriers that may have prevented the use of certain immigration routes need to be considered, as well as the fossil record. For example, the sea level in Finland was 30 to 70m higher than today before 7000 years ago, which would mean that the sea distances to be crossed at this time will be much greater (Ferris *et al.,* 1998: 591).

Reindeer ecology

Migrations

The life cycle of *Rangifer tarandus* is strongly marked by biannual or seasonal migrations. In most populations, these consist of a movement to the calving areas in the spring or early summer and a return to the winter range in the forest in autumn (Burch, 1972: 345). There is considerable variation in these migrations, both between and within sub-species, and it is likely that the distance and direction of migrations is governed by a range of factors; including access to suitable calving grounds and forage areas as well as local topography and biogeography. In general, woodland/forest types tend to migrate small distances, whilst the migrations of tundra types can be extensive. For example, the distance covered by Canadian barren ground caribou during their annual cycle can be 2000-2400km (Leader-Williams, 1988: 10). During migrations, animals travel at speeds of *c.* 10km/hr although faster speeds of *c.* 40km/hr may be maintained over rough terrain for considerable distances. The distances travelled vary but estimates of anything from 25-30km to 160km per day are suggested in the literature (Burch, 1972: 345; Walker, 1964: 1402). Clearly, the speed and distance travelled will be, to some extent, a result of the terrain. For example, caribou tend to follow geographical features such as rivers for some distances before crossing them. Similarly, herds tend to travel in a narrower profile in areas of steep terrain and spread out in flatter areas (Speiss, 1979: 38). This results in funnelling, and therefore slowing, of the herd around distinct topographical features such as high passes. Although *R. tarandus* is capable of crossing bodies of water over 6.5km wide they swim much slower than they trot (*c.* 6.5km/hr), therefore open water on migration routes will slow progress down considerably (Burch, 1972: 345).

Migrations can be both elevational and cross-country in nature. In Bloomfield's (1980a) study of mountain caribou in British Columbia, he described a pattern of biannual migrations which were primarily elevational. Caribou foraged on lowland meadows and in forests over spring. Throughout summer they moved progressively higher as the snow receded and vegetation was exposed, spending the autumn in the wet timberline. In early winter a movement down-slope occurred, to graze in the mature dense forests where the snow was shallower and arboreal lichens could be eaten. In late winter, once the snows had compacted and were safe to travel over, the caribou moved above the timberline again (Bloomfield, 1980a: 16-17). Cross-country, or rather inter-island, migrations have been observed among Peary caribou on the central Canadian archipelago by Miller and Gunn. By recording tracks and trails of caribou on sea ice, they were able to show that the caribou migrate westwards from Somerset Island and the Boothia Peninsula, across the Peel Sound and Franklin Strait, to the Prince of Wales Island for summer forage (Miller and Gunn, 1980: 112). This gives an idea of the amount of variety in types of migration. However, what is consistent here is the pattern of relocation of herds in response to forage availability which, although not the only factor in migrations, exerts a strong driving force.

Reproduction

Like many temperate ungulates the reproductive activity of reindeer and caribou is associated with day length (or photoperiod; van Oort *et al.*, 2000: 102). Reproduction usually takes place in autumn: generally late September to early October. Reindeer live for on average 15 years, and females are fertile from age 2 to 10 years, with males reaching maturity earlier but also becoming impotent earlier. Although caribou have a similar lifespan, they have slightly lower reproductive rates than reindeer. They begin breeding later, between 3-4 years old, and produce fewer follicles during ovulation (Leader-Williams, 1988: 67-73). Although this difference is thought to be genetic, no explanations of how this may affect ecology are present in the literature. This author speculates that this may be related to the increased level of domestication of reindeer versus caribou, and therefore the selection of animals with higher reproductive success. In terms of ecology, it is assumed that this difference does not affect the general lifecycle or behaviour of reindeer greatly.

Before the mating period, dominant males become more aggressive towards younger, or lower-ranking males and spend less time foraging and more time herding and guarding their 'harem' of females. This period may begin up to a month before the rutting season. During the rut, the males exhibit a number of dominance-related behaviours such as stamping, urinating over their hind legs, sham fighting tussocks and shrubs, driving individual females, and making characteristic rutting sounds; typically low-voiced, husky rattles (Espmark, 1964a: 160-162). The female is receptive for only two days of her cycle, and will cycle again that season if breeding is unsuccessful. The gestation period lasts for 208-240 days, over the difficult winter months (Leader-Williams, 1988: 55). It is interesting to note that males lose their antlers immediately after the rut, whereas females keep them until after the calving in spring. Mature females have also been observed to exhibit dominant and aggressive behaviour towards other herd members during winter (Espmark, 1964b: 425). This has led to the suggestion that females remain antlered to ensure dominance, and therefore have a greater chance of access to essential winter forage during pregnancy (Ingold, 1988:21; Schaeffer and Mahoney, 2001: 3559).

Males and females tend to segregate at the end of the winter period, in time for calving, and spend most of the summer apart until coming together for the rut in late summer (van Wieren and de Bie, 1980: 552). Females calve in spring, usually from May to mid-June, after the migration to the spring calving areas. The calves weigh *c.*4kg and, unlike other cervids, do not have a dappled coat at birth. They are extremely precocious, are capable of regulating their own temperature, and are quickly mobile after birth. Since reindeer and caribou often calve in open areas, these characteristics offer good protection from predators (Blix, 1980: 361; Leader-Williams, 1988: 89).

Diet

The diet of reindeer and caribou varies seasonally and, although they show a marked preference for particular plants, it is strongly influenced by climate. During spring and summer, animals tend to select forage in terms of preference and high nutrient content. The range of plants obviously reflects local conditions, but may include forbs, grasses, sedges, willow and birch leaves, berries and shrubs (Ingold, 1988: 20; Skjenneberg, 1984: 129). During winter, diet is restricted by relative availability; *i.e.* not only how much forage is present in total but also how accessible that forage is. For example, the structure of reindeer hooves allows them to crater through snow for forage but they are unable to dig through depths of over 50-70cm, and may not be able to break through hard snow crusts (Leader-Williams, 1988: 97). The main component of reindeer and caribou winter diet is lichen, which makes up 60-80% of the winter food intake, especially *Cladonia* sp. in the form of lichen mats or arboreal lichens in forest environments (see figure 14).

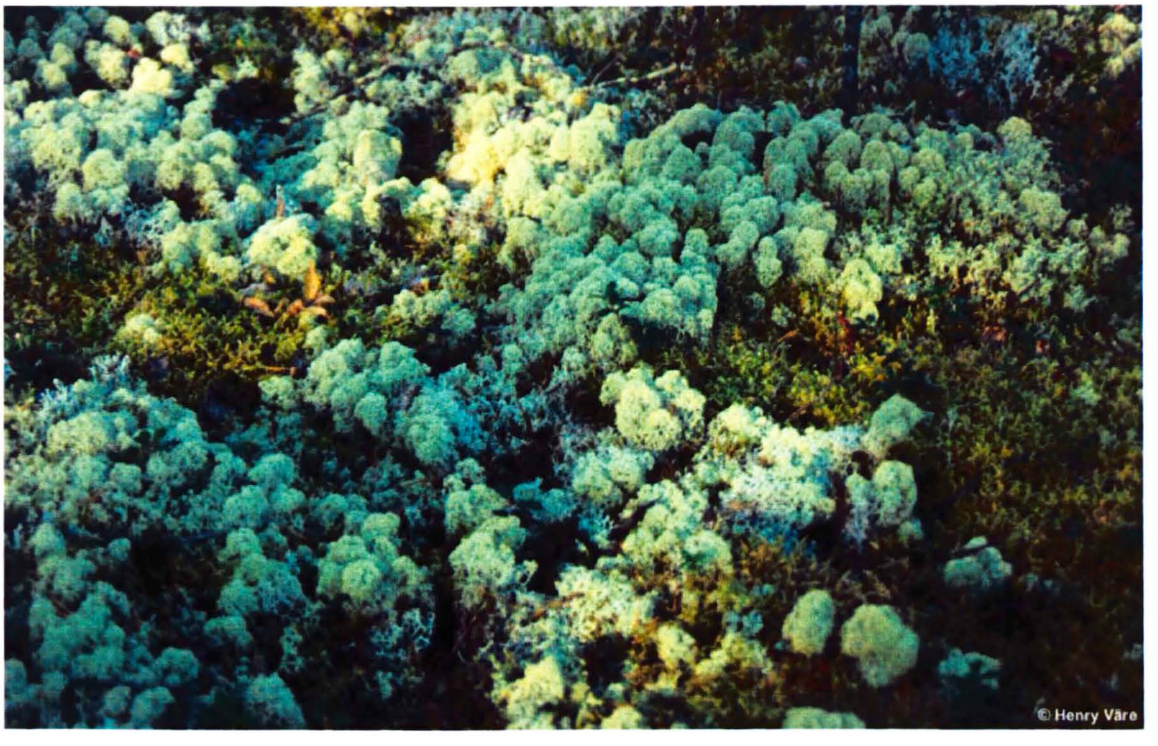


Figure 14. Reindeer lichen (Cladonia stellaris). Image by Henry Väre, available from the Encyclopaedia of Sami Culture (SENC) hosted by the University of Helsinki.

Lichen is a symbiotic organism, composed of fungi which obtain nutrition from unicellular or filamentous algae or cyanobacteria through a mutually beneficial relationship. They usually grow on oligotrophic sandy soils or well drained podzols, where the opportunity for vascular plant growth is low (Crittenden, 2000: 131). Lichen is very poor in nutrients and reindeer often sustain a negative nitrogen balance for the winter period. However, lichen is a good source of carbohydrate (Klein, 1980: 6), and if supplemented with small amounts of vascular plants, or bodily reserves built up over the preceding summer, can sustain the animals throughout the winter.

Overgrazing of lichen mats

One problem, which has been the subject of many studies, is the recovery rate of lichens to overgrazing and trampling (*e.g.* Garre and Skogland, 1980). Damage to lichen mats occurs in summer, through trampling on summer migrations, and in winter, through overgrazing; in particular cratering is very destructive and wastes between two and ten times the amount of lichen actually consumed (Crittenden, 2000: 133). Lichen mats are slow-developing, long-living but are also sensitive vegetation types, and it is estimated that, to prevent overgrazing, there should be *c.*25-30 acres per animal. In modern contexts, where animals are often restricted from natural migrations by perimeter fences, this is not always possible. If lichen mats are overgrazed or trampled, it can take many years for them to recover and be usable as a grazing area again (Ingold, 1988: 20). An experimental study in northern Finland indicated that the impact of reindeer grazing on vegetation composition was variable: depending on specific context and the responses of individual plant groups (Pajunen *et al.*, 2008: 1233). However, the impact on preferred lichen species was profound and no significant regrowth was seen over the 8 year period of study (*ibid.*:1242). Crittenden (2000: 132) suggests that overgrazed woodland lichens in Fennoscandia could grow from 300kgha^{-1} to 1000kgha^{-1} within nine years and to 2000kg ha^{-1} in sixteen years. However, this recovery requires lichen mats to be undisturbed for this period. This will obviously be an extremely important issue to modern reindeer herding/farming populations and is already posing problems in some areas. For example, reindeer fences between Finland and Norway at Kvijärvi are causing serious overgrazing on the Finnish side, which has lead to subsequent erosion and establishment of more impoverished grassy landscapes. This may be the first sub-Arctic environment where such erosion has been recorded (Evans: 1996: 11-12). At current stocking levels, this erosion is likely to continue but even more alarming is the fact that reindeer numbers have actually increased in this area.

Box 2. The problem of overgrazing of lichen mats in reindeer herding areas.

Predators

The most significant predators of reindeer and caribou are humans. Humans have been exploiting reindeer and caribou since the middle

Pleistocene (Burch, 1972: 339) and they are still an important resource for many societies. The way in which the resource is utilised varies widely from hunting groups, such as the Inuit, to pastoral societies, such as the Russian/Siberian Evenk who keep reindeer for milk, riding, and use as pack animals as well as for meat (Ingold, 1988: 97).

Other predators include wolves (*Canis lupis*), Lynx (*Felix lynx*), Wolverine (*Gulo gulo*), and brown bear (*Ursus arctos*), although golden and white-tailed eagles, and Arctic foxes may also take fawns. In general, wolves tend to be opportunistic and select vulnerable animals, which may actually maintain the health of the herd to a certain extent as these may be animals that are diseased or not contributing to the reproduction of the herd. Recent research on predation on wild forest reindeer by wolves indicates that wolves were responsible for 50% of reindeer mortality in the study area between 1998 and 2000, and reduced the scale of annual population increases (Kojola *et al.*, 2004: 229). The effect of predators on populations depends very much on local situations: for example, reindeer on the islands of South Georgia and Svalbard have no predators (Klein, 1999: 98). In other regions, humans have reduced predators, such as wolves, down to minimal numbers in order to protect their own interests in the reindeer/caribou herds. However, recent commitments by governments to protect and conserve certain predatory species may change this. For instance, in Sweden it is estimated that wolves now reduce the surplus available for harvesting by humans by one third (Danell, 2000: 112).

Parasites

The main parasites of reindeer and caribou are the nasal botfly and warble fly. The warble fly (*Oedemagena tarandi* Linn.) causes considerable discomfort and damage to reindeer. The female lays between 300 and 800 eggs, firmly attaching them to the reindeer's coat. Once hatched, the larvae penetrate the skin of the host, migrating through subcutaneous tissue and intermuscular connective tissues to lie under the skin of the animals back. The larvae form a fibrous encapsulation under the skin which is visible externally as a warble, and may contain up to 1487 individual larvae (Minář, 2000: 483-484). Eventually the larvae break out of the host's skin and pupate on the ground. These flies are thought to infest over 80% of continental reindeer and caribou in the northern hemisphere (Leader-Williams, 1988: 163). The female nasal botfly (*Cephenemyia trompe*) ejects fluid, containing hatched larvae, into the nostrils of a host species. These attach to the mucous membrane of the nasal conchae, or may settle on the pharynx, and grow in size until maturation, or are snorted out by the host. One reindeer may be infested with up to 230 larvae (Minář, 2000: 469-471). A number of other parasites are present including liver flukes, lungworms and several species of nematodes; however, the effect of these is less evident on the ecology of the animals (Leader-Williams, 1988: 164). Again, parasites and flies vary with the local environment, although some have been introduced with reindeer populations, such as the introduction of the Tungus fly to Canada alongside European reindeer (Paul Buckland, pers. comm.)

Although not technically parasites, harassment from mosquitoes and black flies can have a profound effect on reindeer/caribou behaviour. In summer, large concentrations of insects can cause animals to stop foraging and relocate, causing both a reduction in the amount of forage consumed and an additional expenditure of energy in the movement associated with relocation, which may affect general body condition. A study on semi-domesticated reindeer on the Seward Peninsula (Wright, 1980) showed how harassment by insects may also influence the type of vegetation that reindeer select for forage. In the spring and early summer, reindeer chose forage material in terms of availability and preference, grazing on shrub-tundra then on low to medium willows. However, in late summer they chose to graze on coastal plains, on salt-grass meadows principally, because this was the only area they could get relief from insect harassment (Wright, 1980: 172).

Summary

The ancestor of all extant forms of reindeer probably existed in the early Pleistocene in the near Arctic or north-east Asia. By 440,000 BP there is evidence for reindeer in Europe and, by 120,000 BP, the distinct groups comprising mountain and forest sub-species had begun to develop. Today, there are at least seven sub-species of reindeer all belonging to the single species *Rangifer tarandus*, making up one of the four families of ruminants within the order of Artiodactyla. The two extant sub-species in Scandinavia are the mountain reindeer (*Rangifer tarandus tarandus)* and the forest reindeer

(*Rangifer tarandus fennicus*). Scandinavia was first colonised by mountain reindeer in the early post-glacial (between 12,000 and 9,000 BP) from refugia in Europe, via the west coast of Norway or Denmark. The forest reindeer colonised later, about 7,000 BP, from refugia in Siberia via the south and east of Finland (Aaris-Sørenson, 2000; Rankama and Ukkonen, 2001). It must be stressed that these proposed routes and dates are based on current evidence but do not rule out earlier colonisation or different immigration routes.

Reindeer ecology is strongly marked by their adaptation to Arctic/sub-Arctic or Alpine environments. They have a number of physiological adaptations which make survival in these environments easier, such as the ability to digest lichens and the lowering of metabolic rate during winter. The annual lifecycle of reindeer is punctuated by biannual or seasonal migrations, which are principally driven by response to forage availability. Reproduction takes place in autumn with the calving period the following spring. A number of predators prey on reindeer, the most prevalent being humans, wolves, lynx and bears. Whilst reindeer are well adapted to living in higher latitudes, both physiologically and behaviourally, they are not immune to changes in these environmental conditions. Nor is the Arctic/sub-Arctic an area of stable and unfluctuating climate. Therefore, the next chapter will focus on how reindeer respond to changes in climatic parameters both through changes in aspects of their physiological condition and behaviour.

Chapter 6. The impact of environmental conditions on reindeer physiology and behaviour

The climate changes explored in chapter four have shown the LIA climate to be one of variability; with periods of temperatures higher and lower than the recent average and rapid changes between these conditions. There is also evidence for increased precipitation during the LIA, and a higher incidence of extreme weather conditions, including storms, flooding and severe frosts. It is with these aspects of the reconstruction in mind that the impact of changes in climate on reindeer is approached. In order to do this, studies of how reindeer and caribou have responded to recent and historical climate change will be considered as well as accounts of indigenous knowledge of reindeer and caribou behaviour from societies with long histories of interaction with these animals.

Evidence from biological and ecological Studies

Most recent studies concerned with climatic change and reindeer/caribou ecology have focussed on how an *increase* in temperature would affect populations. This is principally because of very real and current concerns with global warming. It is thought that global warming will impact earliest on Arctic ecosystems, as they are extremely sensitive to changes in climatic parameters, and the impact of change tends to be amplified. Arctic ecosystems are characterised by a low taxonomic diversity of species, often living in relatively high densities at the limits of their adaptability (Klein, 1999: 96). Mammals are represented by only 75 species (including both aquatic and terrestrial ones) comprising only 1.8% of the world's mammalian fauna (Chernov, 1995: 83). The few mammals that are present are very important for ecosystem functioning and are regarded as good biological monitors of matters of global concern such as climate change (Moen, 1980: 289). The ratio of carnivore to herbivore species increases with latitude, and large herbivores are particularly under-represented with moose/elk, reindeer/caribou, and Musk Ox being the most important. Since the Musk Ox is extinct in northern Europe (Vibe, 1967: 153), and elk is less numerous and not suitable for domestication (Skjenneberg, 1984: 131), reindeer are the most important large herbivore resource for human exploitation. Therefore, any impacts of climate change on reindeer populations are going to be of paramount importance to human populations who exploit them. It should be noted that stable or normal environments do not naturally exist in the Arctic, and conditions tend to oscillate between those perceived to be 'good' or 'bad'. 'The capacity to recover quickly and shift habitats periodically make Arctic ecosystems resilient to the impact of external change' (Krupnik, 1993: 156-157).

The bottom-up approach taken in this thesis, to understanding how climate change affects human populations, involves first considering the direct and indirect consequences of climate change on aspects of reindeer ecology. Direct effects include the impact of weather changes, for example, in temperature and snow cover, on the animals themselves. Indirect effects include changes at other trophic levels of the ecosystem, ranging from changes in existing vegetation cover to major shifts in regional species distribution. Since no two reindeer populations have identical habitat relationships (Klein, 2000: 96), and the current research position requires that examples are drawn from a wide variety of contexts, behavioural and physiological responses of reindeer to climatic change will be given in general terms.

Direct effects

Changes in snow cover can have a profound effect on reindeer ecology, not only in terms of depth and type of snow, but also in the timing of spring melt and winter freeze. An increase in temperature in the Arctic would lead to an increase in precipitation and cloud cover, due to factors such as increased evaporation from unfrozen seas. This means that, although winters may be warmer, they would also be wetter and, if interspersed with colder spells, could lead to the formation of hard compacted ice layers or crusts within the snow. 'Rain on snow' incidences are particularly prevalent during high phases of the North Atlantic Oscillation: a few days of these conditions is enough to form crusts that can persist throughout winter (Ravilious, 2003: 24). Reindeer 'crater' for forage through snow in winter, which normally entails an additional energy expenditure of 30% when compared with browsing/grazing (Gunn and Skogland, 1997: 191). If the snow is compact or deep, this can increase that expenditure or even make the forage inaccessible. In fact, the 'survival of all Arctic animals is threatened far more by winter-thaws and subsequent crust-ice formation than by extreme cold' (Krupnik, 1993: 40).One possible benefit of deeper snow is that it may give overgrazed lichen mats time to recover, as they would be well protected from damage through trampling. However, this is unlikely to be of benefit to the reindeer if alternative food sources are not found (Crittenden, 2000: 133). Access to winter forage is essential to enable animals to survive until the spring melt and, in the case of pregnant females, it affects the biology of calves as well as their own body condition. For instance, studies on domestic reindeer in Finland have indicated that, in warm and wet winters, a lower number of calves survive until spring round-up (Lee *et al.,* 2000: 100,105). Similarly, studies on another cervid (red deer), have shown that the last two months of nutrition before calving may affect the calf's birth weight, its age at first reproduction, and even the reproductive success and birth weight of the next generation (Gunn and Skogland, 1997: 193). Investigation of the impact of winter weather on reindeer calf weight and growth rates has shown that impacts can be long-lasting, affecting both the mother and calves weight, and the birth-weight of the next generation (Weladji and Holand, 2003: 320-321). Experimental investigations on 20 reindeer at the Norwegian State Reindeer Research Station have shown that maternal under-nutrition in winter may cause behavioural disturbances. These may lead to low motivation to tend the calves (through suckling, washing *etc.*) and, in extreme cases, desertion of the calf (Espmark, 1980: 486). Within other sections of the herd, poor winter forage may cause dispersion of the animals into smaller groups weakening behavioural bonds between animals (Roby, 1980: 542).

Season length may also affect reindeer condition: during warmer periods there would be shorter winters and therefore an earlier snow ablation period, which would acutely influence migratory patterns. Firstly, travelling through deep snow with an unstable surface can increase the energy cost of walking by 570% at a time when the animals are in their poorest condition. This could have an additional effect of allowing lighter-bodied predators, such as wolves, which would be supported by the weak snow surface, facilitated access to the struggling animals (Gunn and Skogland, 1997: 194). An earlier melting period, or later freezing period, could also create geographic barriers to reindeer movement. Lakes may have thinner ice and therefore be more hazardous to cross, or sea ice may fail to form, preventing inter-island migrations. This may result in later arrival, or failure to reach, spring calving grounds or winter forage areas (*ibid.*: 195). If this occurs on migrations to calving grounds, it may result in more calves being born in exposed areas, which lack suitable forage for females to obtain nutrition to lactate, and increase vulnerability to predators. Clearly, the increase in snow cover and change in freezing/thawing times will have varied impact depending on local conditions. It will have more intense impacts on high density populations, where grazing pressure is already high, and areas where snow cover is already deep. For example, the extinction of *Rangifer tarandus eogroenlandicus* Dergebøl in central eastern Greenland has been correlated with a shift to warmer and wetter winter climate around AD 1900 (Vibe, 1967: 153).

The best winter conditions for reindeer are stable and cold temperatures with relatively low precipitation. However, a shift to colder, drier climates may not be beneficial. For example, reindeer can dig for forage much better in shallow powdery snow consistent with a colder, dry climatic regime (Lee *et al.,* 2000: 100) but, if this was associated with an extension of the winter period, it may lead to earlier freeze-ups and later melting periods. This may result in poorer body condition, due to extended reliance on winter forage, and later access to essential spring forage on the calving grounds. A study of caribou of the Porcupine herd in north-east Alaska has shown how choice of calving grounds is strongly determined by snow cover ablation patterns (Lent, 1980: 74). Changes in these will have profound effects on location and quality of forage on calving grounds. Shorter summers may also mean that the animals do not have sufficient time to raise their young to an independent level before the onset of winter (Danell *et al.,* 1999: 11). Observations of a population of Svalbard Reindeer in the high Arctic have shown that annual variations in population growth are related to winter, rather than summer, climate, possibly due to the fact that variations in winter precipitation restrict the winter food supply (Aanes *et al.,* 2000: 440). Nonetheless, this study showed that the effects of precipitation in different seasons can have varied effects with regard to the actual area of study.

Changes in temperature and precipitation may also affect reindeer's capacity to regulate body temperature. As discussed earlier, the reindeer's coat provides the principal insulation from external temperatures.

However, in conditions of strong cold winds, or if the coat is wet, heat transfer away from the body may be more than doubled. This means that, in colder, windier, and wetter winters, animals will have higher energy expenditure on thermoregulation, which may reduce body condition and increase mortality rates, especially in calves (Blix, 1980: 361). However, extreme high temperatures may also cause weight loss through seasonal inappetence, and therefore weaken the animals (Krupnik, 1993: 167). One of the strategies for coping with high temperatures is to aggregate on snow patches, where they can accelerate heat loss without having to use energetically costly strategies such as panting. Reindeer are often observed biting at the snow and lying down in it to increase heat loss (Anderson and Nilsson, 1998: 14). Until recently, it was thought that animals rested on snow patches to avoid insect harassment. However, a study using observations and infra-red video of reindeer activity showed that time spent on snow patches coincided more with warmest periods of the day than increased insect activity. Therefore, the relief from insect harassment is coincidental rather than the purpose of using snow patches (*ibid.*: 13).

Indirect effects

<u>Insect harassment</u>

A decrease in summer temperatures is likely to prevent insect populations reproducing and therefore decrease insect harassment of reindeer. It has been observed that mosquito activity is greatest at 18°C and at wind speeds of less than 6m/s. Insect harassment causes herds to spend less time foraging and may also lead to relocation to areas of lower quality forage but less harassment (Wright, 1980). An increase of 2-4°C in average summer temperatures has been calculated to result in a 7% reduction in forage time (Gunn and Skogland: 1997: 194). Although this does not seem like a large reduction, it would have an impact on the ability of reindeer to gain sufficient bodily reserves for winter. For example, since the introduction of parasitic flies with domestic reindeer to Greenland, in 1952, noticeable reductions in body condition of the native caribou sub-species have occurred. Extended population lows have been noted to coincide with periods of increased insect harassment (Klein, 1999: 100). In areas where insect harassment is not a problem, an amelioration of climate may allow their establishment and survival, although in high Arctic islands (*e.g.* Svalbard) the sea presents a substantial barrier to initial colonisation (*ibid.*). If increased insect harassment was coupled with warmer/wetter winters, and therefore reduced access to forage, animal body condition may be seen to deteriorate significantly.

Internal parasite numbers are also seen to increase with temperature, although it is unclear whether this is due to an independent growth in parasite numbers or increased vulnerability of animals due to poorer body condition (Gunn and Skogland, 1997: 196). Obviously, the individual parasite's life cycle will determine the effects of temperature increase. For example, a study of infection of Norwegian domestic reindeer by the nematode *Elaphostrongylus rangiferi* showed that an increase in temperature allowed development of the parasite's infectious stage in gastropods and an increase in the time reindeer spent on common gastropod ranges in the summer, resulting in increased levels of infection. A cold period, between 1975 and 1978, was seen to coincide with reduced infection levels (Halvorsen *et al.,* 1980: 454).

Forage material

Arctic vegetation covers only 5% of the world's terrestrial surface and varies in composition from boreal forests, through shrub tundra, to graminoid-dominated tundra. As with animal species, biodiversity decreases polewards, with high Arctic ecosystems having fewer species. In fact, all vascular plants in the Circumpolar Arctic are accounted for by just twenty genera (Chapin and Körner, 1995: 313). Growth of plants in the Arctic is limited by temperature, moisture availability, and soil nutrient levels (Klein, 1999: 101), and therefore any changes in these parameters will affect species distribution, reproduction and quality as a forage material.

With a long-term increase in temperature, a northwards expansion of species ranges would be expected, with a general pattern of increased areas of shrub-tundra and a restriction of graminoid dominated tundra to the far north. This may not be to the benefit of large herbivore grazers such as reindeer and caribou (Jeffries and Bryant, 1995: 272-273). A reduction in areas of graminoid species may result in high selection of these areas and increased grazing pressure. If they become overgrazed or trampled, this may actually assist the development and encroachment of shrub vegetation. Woody shrub species are less suitable as a forage material for reindeer, as they are more chemically defended against grazing, meaning that they are not as readily accessible sources of nutrients as simpler graminoid species. This is particularly important for animals after winter (when they are at their poorest condition) and during the calving season (*ibid.*: 275). The notion that vegetation change can affect herbivore distribution has been developed by Jeffries and Bryant (*ibid.*) to give a possible explanation for the extinction of many mega-herbivore species at the terminal Pleistocene/early Holocene boundary. Here, a switch from tundra-steppe to birch shrub in Beringia, caused by climatic amelioration, is suggested as the cause of extinction (*ibid.*: 273). However, such explanations are probably too simplistic, as the relationship between animal and plant species in ecosystems is not simply one of cause and effect. It is more likely that species operate in a dynamic system, and that changes in composition and distribution are initiated by other complex feedback mechanisms as well as the direct effects of climate change. For example, Zimov *et al.* (1995) have proposed that the extinction of mega-herbivores at the terminal Pleistocene facilitated the spread of shrub over tundra-steppe vegetation, through a number of feedback mechanisms. The initial impetus for imbalance is the reduction in mega-herbivore numbers through human hunting and climate change. Furthermore, not all winter weight loss is due to the availability of forage but can also be linked to seasonal inappetence, particularly amongst female reindeer (Tyler *et al.*, 1999: 114)

The level of nutrients in soils, and therefore those available for plants, is lower in the Arctic because of slower soil biochemical processes (Klein, 1999: 101). An increase in temperature would quicken these processes allowing increased decomposition rates, and therefore greater nutrient availability and higher levels of primary production (Nadelhoffer *et al.*, 1997: 361). Animal dung would also be broken down faster in grazing areas, increasing the nutrient-richness of soils. However, since reindeer tend to wander over wide grazing areas, and exercise a range of forage searching patterns, this is unlikely to have a large impact (Gunn and Skogland, 1997: 196; Mårell *et al.*, 2002: 864). Increased soil nitrogen levels would allow greater lichen growth in the high Arctic, where its growth and use as forage material is limited at present. However, it would also be beneficial to rooted vascular plants, and so competition would be increased. Either way, in the high Arctic an increase in soil nutrients would increase quantity of suitable forage in both summer and winter (Klein, 1999: 102). In southern Arctic areas, the increased levels of soil nutrients may favour growth of shrubs and mosses over graminoids and further reduce the area of graminoid-dominated tundra (Nadelhoffer *et al.,* 1997: 362).

In the high Arctic, where snow-melt is the principal source of water, increased winter precipitation levels, and thus heavier snow fall, would allow more extensive vegetation cover and therefore more year-round availability of forage (Klein, 1999: 103). In the southern Arctic, a warmer climate with drier summers may have detrimental effects on forage quality. For example, in drier summers lichen growth is reduced, resulting in poorer quality winter forage. Since drier sites are likely to have shallower snow cover in winter, this means that the most easily accessible forage may be of the poorest quality (Gunn and Skogland, 1997: 194). Poorer quality winter forage will reduce the survival of animals over winter and adversely affect calf mortality in spring.

Changes in the length of plant growing seasons will have an effect both on the availability and quality of forage material. The timing of thaw in spring is the trigger for new growth in many plants and, as this is when they are at their peak nutritive value, its timing is very important. In colder periods the thaw will be delayed, resulting in later spring growth and later access to forage, which may result in increased mortality of young or weak individuals after the winter period (Lee *et al.,* 2000: 100). In warmer periods, with earlier springs, the growing season will be longer but the peak in nutrient levels may not coincide with times of need: for example, if the spring growth precedes the calving period (Gunn and Skogland, 1997: 190). It is important to note that the relationship between increased temperature and growing season length is not completely understood. For example, increased winter precipitation as a result of warming would mean deeper snow cover, which may take longer to melt in spring. This would cause a displacement of the snow-free season rather than an actual lengthening of it (Heal *et al.,* 1998: 38). In the high Arctic, an extended growth season would be beneficial, as animals will have longer summers in which to build up reserves for winter, although potential water deficiency might then become a limiting factor. In addition, any benefits may be tempered by a reduction in the quality of winter forage. At present the short summers mean that many graminoid species do not flower every year, leaving an extremely high nutrient 'winter-green' resource for winter forage. If these species flowered more often, their nutrient status in winter would be lower, to the detriment of the animals grazing on them (Klein, 1999: 102).

Competition

At present, reindeer are without direct competitors in the Arctic. They occupy a specific niche in that they exploit lichen and crater for food over winter. Also, the reduction in species richness with latitude reduces the actual potential for competition (Klein, 1999: 100). Reindeer/caribou, elk and Musk Ox are the principal large herbivores in the Arctic but smaller animals such as birds (ptarmigan, grouse and geese), lagomorphs (hares) and rodents (voles, squirrels and lemmings) have overlapping distributions (Ingold, 1988: 22). The amount of dietary overlap between these species varies widely. For example, there is little overlap between reindeer and Musk Oxen. Local conditions are also relevant, since not all possible competitors will be present; for instance, the Musk Ox is extinct in Eurasia (Vibe, 1967: 153). Hares show the most dietary overlap with reindeer, although evidence suggests that they may exploit different parts of plants or different plants seasonally compared with reindeer (Klein, 1999: 101). In periods when lemmings are present in high numbers, they may also compete with reindeer for forage (Roger Engelmark, pers. comm.). Clearly, when forage resources are limited or grazing pressure is high, competition will be increased. A long-term increase in temperatures will expand the northwards range of many species, and may introduce unfamiliar competitors or increase the range overlap of existing ones. In the short term, the impact of this is only likely to be felt in marginal areas between species distribution ranges. There is also evidence that, as well as competing for food resources, an increase in number of animals on reindeer ranges may indirectly affect reindeer. Experiments in feeding reindeer with fodder mixed with faecal matter showed that reindeer avoided eating food contaminated with urine or faeces. Although the animals became habituated to feeding on food with dry faecal matter, they consistently avoided wet matter thus implying that a recent presence, or rain on old faeces, would deter reindeer from grazing on land used by other animals (Moe *et al.,* 1999: 58). In the context of reduced forage availability due to increased snow cover, the concentration of animals on grazing areas could increase the incidence of this.

Interactions with predators

Ingold (1988: 53) suggests that wolf populations are limited mainly by the amount of accessible and vulnerable prey available. As discussed above, an increase in temperature may result in poorer animal condition for a number of reasons, which may result in an initial increase in wolf numbers. However, if reindeer populations decline, wolf populations would either mirror that decline or switch to alternative prey sources. For instance, on Banks Island in the Canadian Arctic, wolves prey primarily on Musk Oxen, which outnumber caribou 20:1 (Klein, 1999: 99). Animals may also be more vulnerable to predators because of inability to use existing predator avoidance strategies. Reindeer often rest on frozen lakes or sea ice as this allows them a good vantage of approaching predators in order to escape. If the ice fails to form then the animals are left without this strategy, and may be less vigilant (Pulliainen, 1980: 679). Increase in predator numbers may not influence foraging time, as animals have been seen to show the same levels of vigilance with or without the presence of predators (Bøving and Post, 1997: 61). However, we would expect that, if forage material was limited, activity would be focussed on food procurement, and therefore the amount of time available for vigilant behaviour would be reduced.

Summary – reindeer responses to changes in climate/weather

It is clear, from the above discussion, that extremes of cold and warm conditions both have detrimental effects on reindeer/caribou populations. From the biological evidence, it is shown that reindeer have a range of physiological and behavioural adaptations for dealing with the natural variability of Arctic environments. The most effective behavioural adaptation is their high mobility; the annual migrations undertaken by wild reindeer/caribou are thought to be primarily driven by desire for suitable forage material. It is not unlikely that, in times when environmental conditions restrict access to forage, animals will adapt by seeking alternative forage areas, altering normal migration patterns.

Impacts on reindeer ecology are seldom isolated: it is this combination and conjunction of impacts that can be most detrimental to animal condition.

Overall, the weather conditions most detrimental to animal condition are erratic ones characterised by switches between cold and warm extremes (Krupnik, 1993: 40). The most devastating effect of these conditions is the formation of ice crusts within the snow, compromising both animal mobility and access to forage material. Erratic weather would also increase the variability and unpredictability of aspects of the climate such as season length, precipitation, and timing of melting and freezing periods.

Local knowledge: problems with definition and explanation of usage

The cultural knowledge of indigenous people is variously described in the literature as indigenous knowledge, aboriginal knowledge, local knowledge, and traditional knowledge (Dybbroe, 1999: 13). The use of the word 'traditional' raises problems because there are two ways in which it may be interpreted. In many contexts it is taken to have negative connotations, referring to a static and ancient way of doing things often associated with an ancestral or pre-colonial condition (Ingold and Kurttila, 2000: 186). However, tradition may also be seen as a way of doing things in the present but with reference to, and acknowledgement of, the past (Kalstad and Viken, 1996: 33). The term indigenous knowledge is used more widely but also is problematic, not least as it tends to result in the cultural capital of indigenous peoples being commoditised and presented as free-standing, independent of context (Cruikshank, 1998: 49). For this reason, the term 'local knowledge' is used throughout this thesis to emphasise the contextual nature of the perspectives discussed.

Local knowledge (LK) is set within, and reflects the worldview of, the culture and community it belongs to. Within many cultures this means LK is holistic in nature, and as such it involves, and is incorporated within, the spiritual, practical and social aspects of society (Dybbroe, 1999: 16; Berkes *et al.*, 1993: 4). Whilst some LK is shared by the whole community, this sharing is not even. Individuals have different types of knowledge according to their role and status within a group, and knowledge is used in different ways by different people. LK is socially constructed and therefore differences will exist according to social factors such as gender, age, occupation and personal choices (Sillitoe, 1998: 232). For example, Alaskan native women are acknowledged as having a greater knowledge of medicinal herbs and plants than native men (Cochran, 2003). LK is also socially interpreted: understandings and implications are filtered through the experiences of the individual sharing or using the knowledge in practice at a specific point in time (Thorpe *et al.*, 2002: 4). LK does not exist within a vacuum; it is constantly changing, being revised and updated and integrated with other forms of knowledge (Semali and Kincheloe, 1999: 5-6). Therefore, it is hard to document or describe this knowledge in a way which represents its complexity and interconnectedness, it is better demonstrated or 'acquired through experience' (Thorpe *et al.*, 2002; 5). It is the dynamic and highly contextual nature of LK that creates the most difficulties in using it within a western research paradigm. Once researchers attempt to define and document indigenous knowledge, it changes the meaning of that knowledge. Within its highly personalised, contextual and oral context LK is better framed as a relational concept; more about social processes than products (Cruikshank, 1998: 70). Cruikshank (1998) provides an excellent example of how the same oral narrative was used by the Yukon Elder, Angela Sidney, at particular points in her life to negotiate and provide insight to specific experiences. In this way 'what appears to be the same story, even in the repertoire of one individual, has multiple meanings depending on location, circumstance, and stage of life of narrator and listener' (*ibid.*: 44).

One of the main issues in the definition of LK is that it is usually categorised in terms of how it differs from western scientific knowledge. This is not surprising when it is considered that the drive to identify and list LK has come from western academic quarters. Therefore, LK is typified as empirical rather than theoretical, qualitative rather than quantitative, consisting of diachronic rather than synchronic data, and holistic rather than reductionist (Dybbroe, 1999: 16; Berkes *et al.*, 1993: 4). These and other differences are summarised in table 7.

How indigenous people themselves see local knowledge is not so linked to western scientific concepts; some definitions from Cochran (2003), detailing the opinions of individuals within Alaskan first nations, are listed below;

- 'It is practical common sense based on teachings and experiences passed on from generation to generation.
- It is knowing the country. It covers knowledge of the environment – snow, ice, weather, resources and the relationships between things.
- It is holistic. It cannot be compartmentalised and cannot be separated from the people who hold it. It is rooted in the spiritual health, culture and language of the people who hold it. It is rooted in the spiritual heart, culture and language of the people. It is a way of life.
- Traditional knowledge is an authority system. It sets out the rules governing the use of resources – respect, an obligation to share. It is dynamic, cumulative and stable. It is truth.
- Traditional knowledge is a way of life – wisdom is using traditional knowledge in good ways. It is using the heart and head together. It comes from the spirit in order to survive.
- It gives credibility to the people' (Cochran, 2003)

Local Knowledge	**Scientific Knowledge**
Assumed to be the truth	Assumed to be a best approximation
Sacred and secular together	Secular only
Teaching through storytelling	Didactic
Learning by doing and experiencing	Learning by formal education
Oral or visual	Written
Integrated, based on a whole system	Analytical, based on subsets of the whole
Intuitive	Model or hypothesis based
Holistic	Reductionist
Subjective	Objective
Experiential	Positivist

Table 7. Comparisons between local and scientific knowledge styles. After Cochran, 2003. The term traditional knowledge, from Cochran's original table, has been replaced by local knowledge.

Drawing on a collaborative study of LK, about mainland caribou with a Qitirimiut (Inuit) community, Thorpe (2002: 4) describes their LK as 'infused with spirituality'; focussing on relationships between people, the land, weather, wildlife and the spiritual world; including local observations, experiential knowledge and skills that have 'passed the test of time'.

Comparisons of LK with western science have lead to LK being treated as simply an alternative type of science. Many native people feel that this trivialises LK and does not take into account its true breadth or value (Cochran, 2003). One of the main drawbacks in comparing LK and western science is its holistic nature. Since it is contextual, inextricably linked to the wider cultural matrix, extracting simply one part of that matrix is difficult and also dangerous. Taking LK out of its context means that it is often misrepresented or misinterpreted (Sillitoe, 1998: 228).

The transmission of LK generally takes place between generations and, since it is usually unwritten, is passed on orally; often in the form of story and song, and through demonstration in practice. However, this is not to say that LK is simply a fixed body of knowledge carried by passive human vessels. Knowledge is also generated and developed through an individual's own experience of the world. This is described by Ingold (2000: 21) as a 'perceptual engagement' within the environment. The perceptual skills required for this are developed both through teaching from other members of the community, usually elders, and through experience of the environment itself. Described this way, LK is less a collection of empirical observations and more '...a set of processes for discovering the nature of the world and then modifying it in ways to make it more useful' (Roy Ellen's comments to Sillitoe, 1998: 239) or a set of tools to think with (Cruikshank, 1998). The dynamic nature of LK means that it is both difficult to define and compromised by attempts to do so (Sillitoe, 1998: 239). It is with that caveat in mind that the ethnographic accounts detailing LK should be viewed: as the knowledge of a particular person, or group of people, at a specific point in time, rather than a definitive account of knowledge on a subject.

One area of indigenous knowledge that has created particular interest among western researchers is indigenous perspectives concerning environmental issues: relating to weather, plants, and animal physiology and behaviour. Researchers have begun to appreciate the value of an indigenous perspective on issues such as wildlife management, medicine, agriculture and climate change studies. Through their long association with particular areas, indigenous peoples have accumulated rich in-depth knowledge about their local environment, including resources such as animals, plants, and water as well as climate and weather patterns. The incorporation of this knowledge into western scientific research and the role of indigenous people in this research are highly contentious areas, and cannot be explored in sufficient detail here. However, attention should be drawn to some important points. LK is of a highly personal nature and is indivisible from a person's biography; therefore such knowledge should be considered personal intellectual property rather than a body of information available to all. Indigenous people have been reluctant to share their personal knowledge, because of concerns about rights to that knowledge and how it may be used (Cochran, 2003). Within indigenous societies this knowledge is not neatly compartmentalised and is woven into and inextricably linked with the particular culture's worldview. However, in a western scientific paradigm this area of local knowledge has been separated out and defined as Traditional Ecological Knowledge (TEK). Whilst some indigenous societies have successfully entered into collaborative programmes based around a model of TEK, this has not been without cost. Although this has enabled indigenous groups (for example the Canadian Inuit) to have a voice within the activities of the nation states in which they live, it often results in a commoditisation of LK and constricts that knowledge within western bureaucratic models, such as resource management systems (Cruikshank, 1998: 65). In recent years the role of indigenous peoples in research projects has improved somewhat, especially in self governing areas, such as Nunavut, where indigenous people have control over research projects and rights to their knowledge.

The differences between LK and the western scientific research paradigm, and the socio-political context of research activity make any combination of the two bodies of knowledge problematic. Some differences in the uses of traditional versus western scientific knowledge are explored in table 8. The main problem is that the western perspective is usually privileged within the nation states in which collaborative work is conducted, and LK is often reframed to fit within a western paradigm, and expected to meet similar criteria as scientific findings. Clearly there is enormous potential in establishing a true dialogue between these two knowledge systems, as they offer complementary information on many issues. To enable that dialogue, both partners need to be open to alternative perspectives, and different approaches to framing and judging the value of knowledge need to be explored. There is still some way to go but, the increasing number of projects carried out with both native and western researchers mean that progress is beginning to be made.

Local Knowledge	Scientific Knowledge
Lengthy acquisition	Rapid acquisition
Long-term wisdom	Short-term prediction
Powerful prediction in local areas	Powerful predictability in natural principles
Weak in predictive principles in distant areas	Weak in areas of local knowledge
Models based on cycles	Linear modelling as first approximation
Explanations based on examples, anecdotes, parables	Explanations based on hypothesis, theories, laws
Classification • a mix of ecological and use • non-hierarchical differentiation • includes everything natural and supernatural	Classification • based on phylogenetic relationships • hierarchical differentiation • excludes the supernatural

Table 8. Comparison between local and scientific knowledge in use. From Cochran, 2003.

Local knowledge about reindeer/caribou ecology

Existing published material regarding reindeer/caribou responses to changes in weather conditions and climate change is limited and is mainly within the context of TEK. Much of this is the product of ethnographic and anthropological fieldwork by western researchers to 'collect' and utilise TEK from communities exploiting caribou in the northern USA and Canada. For Sami reindeer herders, the majority of material used here comes from comments about reindeer ecology from books written by Sami authors or published anthropological fieldwork with Sami with a broader focus. In addition to the problems articulated above, it should be noted that, for many northern indigenous societies, local knowledge is rooted in a worldview that frames the relationship with reindeer/caribou as a complex social relationship and contracts between human and non-human persons, rather than a subsistence relationship between humans and animals.

Indigenous people in the circumpolar regions are acknowledged as having considerable local knowledge and understanding of patterns and cycles in the natural environment. For example, Krupnik (1993: 143) explains how short-term climatic cycles, which occur within an individual's lifetime, are well known to native Russian/Siberian groups. Longer-term climatic cycles have been described as 'encoded' through oral traditions, such as stories about extreme weather events. Similarly, native groups in the northern United States and Canada perceive patterns and cycles in the populations of mammalian species which they exploit. Ferguson (Ferguson *et al.,* 1998) carried out an important survey of TEK about long-term changes in caribou abundance, distribution and movements in the southern Baffin Island area, through interviews with 43 Inuit elders and hunters over a period of five years. The level of detail in the observations passed down through Inuit oral traditions was found to be 'remarkable'; with information on the seasonal migrations of caribou over long periods including details such as the particular movements of groups of males, females and females with calves (Ferguson *et al.,* 1998: 205, 216). The information given by Inuit was cross-referenced with aerial surveys, and early sporadic written records, and found to be accurate, in some cases giving better estimations of population size (*ibid.*: 205; Ferguson and Messier, 1997: 22). The written records also support Inuit assertions that cyclical changes in caribou populations exist, with a periodicity of 60-80 years, and these could be used to predict animal behaviour regarding future movement and abundance. In contrast to the view of some wildlife biologists, Inuit suggested that these cycles were not necessarily due to decreases in caribou numbers, but represented movement away from a particular area. This suggests that caribou are not as loyal to geographical ranges, and specifically calving grounds, as previously thought (Ferguson and Messier, 1997: 216). This knowledge of long-term changes in caribou populations is only possible because of the way in which Inuit knowledge was passed down through oral traditions and between generations. Elders are able to teach young Inuit about their own experience of being on the land, along with the information and experiences passed down to them by their parents and elders when they were younger. The teaching of such knowledge in an elder-youth camp in the Bathurst Inlet region has proved an excellent environment for Thorpe (1997; 1998) to draw together Inuit knowledge on the caribou of that area. The camp also provided a valuable opportunity to observe the exact way this knowledge is passed on, and gave both Thorpe and younger Inuit the opportunity to ask questions and explore different aspects of this knowledge. From long-term observations about caribou distribution and movement, Kitikmeot elders understand that these are affected by a number of factors including: wind direction; insect harassment; disturbance from industry and traffic; the quality of tundra vegetation; and, ice and snow conditions (Thorpe *et al.*, 2002: 100-112). Recent climate change, however, has changed the relationship between the people, the land and wildlife, and made animal behaviour less predictable.

'In addition to noticing warmer temperatures in the 1990s, Qitirmiut find it more difficult to plan for the weather because it has been so unpredictable and variable. Today, people understand the weather less, as they are not outside and living in it as much. Still, weather events seem beyond the realm of expectation or what people consider normal (Thorpe *et al.*, 2002: 167).

The impact of variable snow conditions on reindeer and caribou is well understood by the populations who exploit them. As Paine noted from his experience working with Sami reindeer herders in Norway;

'Not only does snow put new dimensions on the physical landscape, it affects relations between the animals, between them and their herder, and, in consequence, between the pastoralists themselves' (Paine, 1994a: 67).

The best snow conditions for reindeer are associated with a dry, cold winter, and dry powdery snow of a moderate depth. If the snow is too deep, there may be problems with access to the underlying forage material (Paine, 1994a) and increased susceptibility to predators such as wolf and wolverine (Turi, 1931: 48). The worst snow conditions for reindeer are the formation of ice crusts within the snow pack. Early snow in autumn is particularly bad as this may thaw and be re-frozen before the winter, resulting in the formation of patches of bottom crust (*bodneskarden* in Sami). This may lie under the snow throughout the winter preventing reindeer access to lichens (Turi, 1931: 53). Thawing and freezing episodes after significant snowfall may cause ice crusts to be formed on top of the snow, and reindeer may break through these, making movement slow and even cutting the animals' legs (*ibid.*: 84). On the Guovdageaidnu winter pastures, northern Norway, irregular winter weather in 1917/18 and 1967/68 caused considerable reindeer losses. Ice crusts formed as a result of early winter rainfall, followed by alternating frosts and thaws, preventing reindeer access to forage. In 1918 this reduced the local reindeer population by one third (Bjørklund, 1990: 79). In spring, thawing of snow into deep slush makes movement slow again for the animals, particularly calves, and it may refreeze preventing access to forage material again (Paine, 1994a: 91) (Turi, 1931: 81). In a bad winter, when access to forage material is thus restricted, reindeer cows are observed to lose considerable weight. This can have long-term effects, such as delaying the timing of menstruation and calving, resulting in calves being younger and lighter the following winter (Paine, 1994a: 40). Paine's informants go on to say that poor snow conditions can lead to '...years of catastrophe' (*ibid.*: 68).

Although cold, stable winters are accepted as the best condition for reindeer, extreme cold may be observed to have a detrimental effect. Turi (1931: 78) observes that, in very cold weather, there is often increased wolf predation (whether this is because of hunger caused by the cold or increased wolf population is not clear). If cold weather is accompanied by strong winds, reindeer may be blown over and thin calves may freeze to death (*ibid.*: 40, 99). Reindeer have been observed by herders to try to move against the wind, and the direction of herd movement may be changed by prevailing conditions (Paine, 1994a: 45).

Conditions during the calving period are perceived to be particularly important. Slow movement and delayed arrival of animals in the calving area can have serious consequences. The reindeer require the new spring growth of green plants on these pastures to compensate for the lean winter period. However, the transition to this new diet needs to be gradual. Without a transitional period, the reindeer's intestinal flora will not become accustomed to the new forage material and they may experience digestive problems and illness (Kuhmunen, 2000: 125). It is essential, therefore, that herders select both suitable calving pastures and migration routes which allow early exposure of green plants. Many of the causes of calf abandonment (poor maternal instincts, restlessness, sickness) can be linked to poor pasture, and therefore animal condition. As calving grounds tend to be in open terrain, they also offer little protection from weather or predators. Reindeer mortality has been observed as highest amongst calves, with an old rule of thumb that only two thirds of calves will survive through the winter to the following spring (*ibid.*: 102). In particularly bad conditions, calf mortality can result from sleet (making it impossible for the mother to lick the calf dry resulting in it freezing to death), snow and wind (which can drift over small calves) and nocturnal frost (which freezes green vegetation: if this is subsequently eaten by calves it can cause diarrhoea and deterioration of animal condition) (*ibid.*: 103-104).

Precipitation has also been observed to have a significant impact on reindeer condition. Rain, snowstorms, damp ground, and fog are all observed to make animals restless and listless (Paine, 1994a: 70; Vokov, 1996: 29; Turi and Turi, 1921: 224). The effect of this restlessness is considered particularly important in calving grounds, where rest is essential for the well-being of cows and their calves. Precipitation may also affect river and lake levels; swollen rivers are treacherous for animals to cross and calves may drown or refuse to cross completely, usually accompanied by their mother (Turi, 1931: 93). If precipitation, and the consequent river and lake levels, are reduced during autumn then lakes and rivers may develop multiple layers of ice with gaps in between: caribou have been known to fall through higher levels getting stuck in the resulting hole (Henriksen, 1988: 19). From a more recent context, damming and re-direction of water courses for hydroelectric power has led to a drop in lake levels in Sapmí, causing variability in ice thickness and the disruption of reindeer migration patterns (Bäck, 1996: 194).

Warmer than average conditions at anytime through the year can be seen to be deleterious to reindeer health. Calves, in particular, can suffer high levels of insect infestation in warm years, leading to weakening (Kuhmunen, 2000: 21). Turi (1931: 49) notes that diseases and insects have a greater effect on animals in warmer summers. This compares well with data from reindeer herders in Russia, where the effects of anthrax and hoof-and-mouth disease are more devastating in hot, dry summers (Krupnik, 1993: 153). Warmer spring temperatures in the 1990s caused increased caribou mortality in the Kitikmeot region of Nunavut, as a result of drowning, heat exhaustion, and starvation (Thorpe *et al.*, 2002: 91). Experience of Norwegian reindeer herders suggests that hot, dry summers may lead to lower reproduction rates because of deleterious effects on the animals' health.

'Yes, there can be many rodno [calfless cows]...but the number varies with the year. This year was bad because we had such a hot summer the year before, but we have hopes for next year because this summer was cooler' (Sami pastoralist quoted in Paine, 1994a: 37).

Summary

It is clear that the indigenous communities who exploit reindeer and caribou have reached many of the same conclusions that scientific studies have about the type of weather/climatic conditions that are beneficial for wild and domestic reindeer herds. Erratic weather, with frequent shifts between cold frosty and warm thawing conditions are the worst for the animals, not only because they reduce access to forage, but also because they hinder migrations through the formation of snow crusts which are difficult to travel over, and the unpredictability of ice on rivers and lakes occurring on migration routes. Furthermore, the impact of poor weather conditions can have long-term impacts at the levels of both the individual animal and herd, affecting: individual fertility and mortality; the genetic health of the herd; and, choice of migration routes, pasture and calving grounds. It is just these kinds of unpredictable and variable conditions that have been demonstrated as prevailing during the sixteenth and seventeenth centuries in the climatic reconstructions presented in chapter four. How the response of reindeer to these variable conditions affected the human societies who exploit them is complex and varies according to whether the animals were domesticated or wild. These are issues which will be developed through the next two chapters.

Chapter 7. Impact of climate change on human populations

There is no doubt that external environmental conditions, such as climate and weather, are perceived by and exert influence on human populations. However, the nature of that influence and human responses to external conditions are complex and difficult to isolate for analysis. An alteration in climatic parameters may have a range of effects, and the ensuing human response will vary according to particular situations and individual choices (Anderson, 1985: 339). When looking at historical examples of climate change, establishing links between those changes and human behaviour becomes very difficult. Firstly, there are questions concerning the reliability of climate reconstructions. Each proxy data set has its own inherent assumptions and limitations, and instrumental and documentary data for early periods is not continuous either temporally or geographically (Ingram *et al.*, 1985: 6-7). The most reliable reconstructions, therefore, come from a combination of proxy records and careful analysis of documentary sources (Jones *et al.*, 2001: 2), as presented in chapter four. Secondly, identifying whether climate played a significant role in social or economic change within a society is fraught with problems of establishing causality. Historical events and changes have multiple causes, and the temporal correlation of climatic and socio-economic change is not sufficient evidence to suggest the two are related (Anderson, 1985: 339). Therefore, to understand how social change comes about, a range of factors must be considered, including the prevailing social climate as well as environmental conditions. Only by approaching problems in this way can the role of climate be established. For long-term socio-economic change, the role of climate is harder to establish; as changes tend to be gradual and the influence of other factors is often great. Long-term climatic change of a weak amplitude is also less likely to be perceived by human populations, and therefore less likely to be responded to. However, on smaller geographical and temporal scales, where the number of variables which may influence social change is limited, more detailed studies can be carried out and the role of climate in social change may be possible to establish (Ingram *et al.*, 1985: 25). Short-term high amplitude changes in climate are easily perceived by populations and, if dramatic, can cause rapid change. In fact '[t]here is good evidence to suggest that northern peoples notice and respond more to *extreme events* than to changes in *mean conditions*' (Fast and Berkes, 1999: 10). For instance, extreme events such as floods, storms and droughts during the Little Ice Age may have dramatic short-term consequences which can then lead to socio-economic change.

'*These alterations of extreme seasons may have been the most damaging aspects of the behaviour of the climate to the economies of those times, with severe effects on farming routines and harvests and on the health of people and animals*' (Lamb, 1985: 305).

In this case, the regional study of the transition to reindeer pastoralism in northern Sweden should be a suitable study area. Furthermore, since the reindeer economy in northern Sweden would be considered marginal in socio-economic terms as it is '...heavily dependent on agriculture or other economic activities conducted in conditions close to the climatic limits beyond which such activities are physically inviable' (*ibid.*), the impact of climate change should be more visible here. The sensitivity of Arctic ecosystems to environmental change has already been discussed in chapter six.

Before going on to assess the indirect impact of climate change on human populations, *i.e.* through impacts on resources and subsistence strategy, it is worthwhile to consider some of the impacts that climatic change may have directly on human physiology.

Direct impacts of climatic change on humans

The impact of climatic change on human health

Extremes of both cold and warm temperatures can lead to death through exposure. In recent periods, hospital admissions and mortality rates have been seen to rise during 'heatwaves'. For extremes of cold temperatures, an increase in mortality is also seen but the correlation is not as high. This may be due to adaptive human behaviour, such as cold avoidance and the influence of seasonal respiratory infections on mortality figures. 'Some evidence exists however that, in extreme climates, stormy rather than very cold weather is responsible for some wintertime excess mortality' (Diaz *et al.*, 2001: 283). Possible causes of increased mortality include drowning or exposure, during storms and floods, or the indirect impacts of climate variability on disease incidence. An additional point of interest regarding northern populations, is the impact of external conditions on clothing. In northern Scandinavia, Eurasia and North America, many indigenous inhabitants traditionally used reindeer and caribou skins as the principle material for making clothes. However, recent observations by Inuit have indicated that, in periods of increased precipitation or humidity, the hairs of the skins can become clogged with ice (Armstrong, 2001: 37), garments become heavier and their insulating properties may decrease. As chapter four indicates increased precipitation and storminess may have been a feature of the variable LIA climate, this may have been an issue for Sami in the past.

Climate change also affects human health through its impact on the lifecycles of disease vectors; allowing colonisation of new areas and changes in the length of the virus or parasite incubation period (Diaz *et al.*, 2001: 279). In the Arctic, cold temperatures mean fewer disease vectors are present than in temperate zones, but the warmer periods during the Little Ice Age may have increased disease ranges. Increased precipitation and extreme weather phenomena, such as floods and storms, may also increase the incidence of waterborne diseases, including cholera, diarrhoeal diseases and typhoid, through the contamination of water and food sources with waste matter. Linneaus reports that a type of colic, known locally as '*ullem*' was common among Sami he met during his travels in the mid-eighteenth century, as a consequence of drinking polluted water (Blunt, 1971: 52). Any increase in open water may also create suitable habitats for water-breeding disease vectors such as mosquitoes (Diaz *et al.*, 2001: 279). Although difficult to measure, studies also suggest that extreme weather events often result in psychological stress, such as post-traumatic stress disorder, which may increase vulnerability to infections and poor health (*ibid.*: 284).

Whilst all these factors should be considered, the prospect of establishing the occurrence of disease in historical periods is difficult. Little documentary information on Sami populations in northern Sweden exists for the sixteenth and early seventeenth centuries, and the probability of finding detailed descriptions of diseases and mortality of the Sami is negligible. The Swedish state only started compiling mortality statistics for the whole country in 1749, and even in 1781 there was only one doctor assigned to the whole of the counties of Västerbotten and Norrbotten (Sköld, 1996: 95,107). Further problems arise because of the variability of human responses to both extreme events and disease occurrence. For example, increased population density and overcrowding following recent floods has exacerbated the effects of disease (Diaz *et al.*, 2001: 279). During the smallpox epidemics of the eighteenth and nineteenth centuries in Sweden, the reaction of Swedish and Sami people to outbreaks of the disease was very different, due to cultural differences in the perception of disease within the context of each society's religious beliefs. In the context of Sami religious beliefs, action could be taken to appease or battle these spirits causing disease and ill health. Ordinary Swedes, on the other hand, thought disease was an inevitable act of God, and did not believe their personal actions could hinder its progress (Sköld, 1997: 17). This led to the Sami using a strategy of avoidance of people with smallpox, reducing its spread. This, and the fact that the Sami population was more dispersed than the Swedish population, may be responsible for the late arrival of smallpox in Sapmi, and the limited impact of epidemics (Sköld, 1996: 109). In periods without such detailed historical information, it is difficult to ascertain the impact of disease, it remains a possibility that changes in disease cycles may have impacted local Sami populations earlier than the eighteenth century. The impact of this on the Sami population as a whole was probably small; in fact it has already been shown that the Sami population of some areas actually grew during the late sixteenth and early seventeenth centuries, indicating population losses to disease were not substantial.

Increased accidental mortality during extreme weather events may have occurred during the sixteenth and seventeenth centuries, but this would depend on individual response to the perceived danger. Indigenous peoples in northern environments carrying out subsistence activities are accustomed to variable environmental conditions, and therefore it is probable that they would have good skills in predicting potential hazards. In poor conditions, extra precautions could be taken, such as taking extra provisions and clothing if a hunting expedition may be extended, or avoiding making trips at all. However, there may have been conditions that were outside the scope of predictability within their local knowledge framework. These '*unpredictable* changes are more important and potentially damaging than predictable extreme events' (Fast and

Berkes, 1999: 10). Although local knowledge is dynamic and cumulative, unpredictable climate changes can cause confusion, and reduce the value placed on that knowledge. For instance, in recent years the Chisasibi Cree have found that their traditional use of the colour of ice as an indicator of ice thickness on the La Grange River has become unreliable (*ibid.*: 14). This has implications both for human safety and social stability. Unpredictable weather patterns may have lessened the reliability and credibility of local knowledge around climate change and impacts on resources, which has potential to undermine the position of those holding that knowledge and perhaps other aspects of social organisation and cohesion.

Extreme weather events will also impact on the choice of areas used for reindeer pasture. High levels of precipitation can make some areas unusable, through deep snow cover and flooding. In fact Linnaeus (1971: 173) reported that, on the 6th of June 1732, rain had made river levels so high that the nearby herders' pastures were in real danger of being flooded.

The impact of climatic change on human mobility

Just as environmental conditions have an impact on animal mobility, they also impact human mobility over land and water. Firstly, certain types of weather associated with increased precipitation and storminess can make visibility poor and thus travel difficult, *e.g.* heavy rain and snowstorms, and fog and mist. Secondly, snow conditions and the timing of freeze and thaw events can influence the timing, direction and means by which humans may travel. As with reindeer, the reliability of ice on lakes and rivers can be a barrier to human movement. When snow conditions are deep and loose, the Naskapi have noted that the narrow runners of their sleds sink, the only remedy for this situation is for people to flatten a path by walking ahead of the sled in snowshoes. Clearly, this makes the journeys with sleds longer and more arduous (Henriksen, 1988: 19). Turi (1931: 81-83) noted that soft snow conditions in spring make travel very difficult, with people resorting to travelling during the night when the cold forms crusts on the snow surface. Even on crusted snow, travel may be hindered by surface instability, allowing sleds to break through the crust. Clearly, populations living in such environments have a wealth of local knowledge about snow and weather to enable them to plan travel in variable conditions. For example, consider the wealth of native language terms for snow in many northern groups. Manker (1964: 9) points out Sami herders are careful to time their spring migrations whilst there is sufficient snow to enable them to travel by sled. Similarly, snow conditions influenced the choice of migration route taken by Sami groups that Paine (1994a: 87) worked with. Again, the greatest dangers occur when conditions are outside the realms of previous experience and predictability. Canadian Inuit are already experiencing this unpredictability due to recent warming trends, noting that 'the ice is thinning and people are falling through it' (Armstrong, 2001: 37).

Indirect impacts of climatic change on humans

Impacts on neighbouring populations

Interaction between Sami and neighbouring Nordic populations has been ongoing for several hundred years, through trade, taxation and other forms of social and economic relationships. Therefore, the impact that climatic variability had on these neighbouring populations may have also affected how they interacted with Sami. Throughout the sixteenth and seventeenth centuries, there were numerous crop failures and poor harvests across Europe. In Sweden, crop failures occurred in 1596-1603, 1649-52, 1675-77 and the 1690s, and poor harvests were recorded in the late 1620s, early 1630s, 1640s and mid 1660s (Utterström, 1955: 26). Extreme weather events, such as floods, storms, and droughts, are detailed in documentary evidence from this period as having a particularly severe impact on agricultural harvests, stored goods, and livestock. All of this led to increased incidence of famine and disease around the turn of the seventeenth century, with graphic descriptions provided in parish records. For example, plague epidemics were most common during the late sixteenth and seventeenth century, with 1602-3 recorded as one of the worst years, and poor harvests and extreme weather were often blamed for outbreaks of dysentery (*ibid.*: 30; 33).

The way climatic variability affected Nordic populations raises many questions as to how this will have consequently affected Sami. It will have affected agricultural harvests, and the ability to sustain Nordic populations in northern environments and, therefore, may have had impacts on how they related with the indigenous Sami population. The fact that many settlers would have found it difficult to support themselves may have led to some settlers abandoning their farms, or could have affected trade and possible triggered conflict with neighbouring Sami communities. Utterström (1955, 27) describes records detailing an increase in theft and raiding in times of shortage; it is possible that the Sami could have been targets for theft. On the broader scale, economic difficulty and possible political unrest in the population may have led to political interventions by Nordic states (*ibid.*: 5). For example, in Sweden, this may have affected state controlled trade with, or taxation of, the Sami. Some of these questions may be answered through further analysis of documentary sources from this period.

This is particularly pertinent to some of the theories of the transition to pastoralism in northern Sweden, which indicate taxation as a principal influence in that transition. If political interventions such as taxation and trade can be linked to the indirect impacts of environmental conditions (*i.e.* that climatic variability is seen to influence the cultural behaviour of the Swedish population and state), then that variability could also have indirectly influenced the Sami through taxation and trade. This reinforces the assertion that the best way to understand such transitions is through a holistic approach, and that the separation of the natural and social environmental factors may not be possible or appropriate. Climate and social influence are often placed in opposition, as competing influences over cultural change. However, in reality these two spheres are inextricably linked. The variable climate of the LIA could have had indirect impacts on the Sami through the way the Swedish state responded to the impact of environmental instability on its socio-political interests.

Impacts on important resources

Chapter six explored in detail, using both the results of scientific investigations and ethnographic material, the possible impacts that LIA climatic variability may have had on reindeer behaviour and condition. These impacts would have had indirect implications for the human populations exploiting these animals. The nature of these implications depends on the way in which the animals are exploited. Therefore, the impact of LIA climatic variability on how populations were able to exploit both wild and domestic reindeer will be considered in the following section.

Interruption of normal behaviour patterns of wild reindeer

A change in timing of seasonal events, such as thaw and freezing periods, has been shown to influence both migratory patterns (*i.e.* failure or lateness in reaching destinations) and choice of forage areas. These interruptions in normal behaviour patterns would have serious implications for the societies which exploit reindeer. For societies exploiting wild reindeer, the main issue would be the unpredictability of reindeer populations. In order to predict how reindeer respond to difficult weather conditions, the human groups would need a detailed understanding of both the animals' ecology and local weather patterns. Krupnik (1993: 136, 156) notes that many indigenous northern Eurasian groups have a rich local knowledge of these, drawing on experience of cyclical weather patterns and animal responses. However, predictions are not always correct and some climatic changes would have had unfamiliar outcomes. For example, the long period of climatic instability during the LIA may have made migratory patterns of wild reindeer extremely variable from one year to the next. In this context, irregular local reductions in reindeer numbers may have occurred as reindeer used areas of better forage. For example, in 1965/66 Naskapi reported that mild weather, followed by frost, created a layer of ice over lichen, leading caribou to leave the interior and head for the coast and offshore islands where forage was more accessible (Henrikson, 1988: 1) Similarly, during favourable conditions, reindeer numbers may have grown in particular areas. The high amplitude of climatic change during the LIA may indicate that these periods of high and low reindeer numbers were both rapid and short-lived, meaning that wild reindeer could not be relied on as a regular resource.

Historical research has suggested that wild reindeer numbers in Sweden dropped dramatically (almost to extinction) in the seventeenth century, coinciding with the transition to herding (Lundmark, 1982:38). Krupnik (1993: 145) describes the natural cycles in reindeer and caribou populations as being between 65 and 115 years; with a 10 year increase in numbers followed by a period of 10-15 years of high reindeer numbers, then a rapid decrease and between 35 and 70 years of very low reindeer numbers. During this extended period of low numbers, the range of wild reindeer often shrinks and migratory patterns are disturbed (*ibid.*: 146). If the variable climate of the Little Ice Age coincided with this cycle, the impact of the very low numbers could be exacerbated. For example, Krupnik goes on to describe Nenet and Koni estimations of reindeer mortality rates: 10-15% of herds in 'normal' years, rising to 30-50% during periods of variable and extreme weather and epizootics (*ibid.*: 153).

As well as influencing reindeer numbers in particular areas, alterations in reindeer behaviour may have affected the prevailing hunting techniques. Throughout Swedish Sapmí, a number of hunting techniques have been used including hunting with decoys, using battues and pit-falls set along migratory routes, and utilising natural features of the terrain over migratory routes to ambush and trap animals (Sammallahti, 1982: 104). Clearly, if the migratory routes of reindeer are dramatically altered, the value of maintaining features such as pits and battues would be decreased. Furthermore, if routes are rapidly changing then the building of new features along alternative routes will have to be weighed against the probability of reindeer regularly using that route. Another technique, used by many reindeer hunters, is to take animals while they are resting on frozen lakes. Reindeer and caribou use open spaces, such as frozen lakes, as resting areas as they allow good vantage and vigilance of approaching predators such as wolves. However, human hunters, able to hunt from a distance and co-operatively, can use this as a good opportunity to take several animals at once. If the freeze and break-up times of lake-ice become unpredictable, as a result of climatic instability, this method could not be relied on. For example, in recent years, warmer temperatures have meant tundra lakes are not frozen in periods they would normally be expected to be (Burmeister, 1997: 68).

Once a hunted animal has been caught, weather conditions may also have an impact on how the carcass is butchered. Henrikson (1988: 29) describes how Naskapi value the ability to skin a carcass swiftly in poor weather, both because the cold makes hands numb and, in poor conditions, other predators may take carcasses without being observed.

Change in species distribution patterns

It has already been stated that species distribution may be affected by the prevailing climatic regime: for example, an increase in temperature in the Arctic would facilitate the northwards expansion of more southerly species. This expansion not only refers to animals and plants, but also includes humans. Increases in temperature would allow agricultural land to be developed further north. In fact, it has been suggested that agriculture in Scandinavia stands to gain more from global warming than any other area in the world, because of an increase in both yields and land suitable for agricultural use (Parry, 1992: 81). Clearly, this is a predominately modern problem with large scale agriculture being relatively recent. However, any increase of agricultural land use in the north in the past would have reduced the range available for wild reindeer. If mixed farming economies are allowed to penetrate further north, we may also see the introduction of other herbivores into reindeer territories, such as goats, cattle, and sheep, which may compete for and reduce the amount of available pasture.

A predominately modern consequence of the northwards expansion of human populations is the increased urbanisation and industrialisation of northern areas. The destruction and fragmentation of reindeer habitats, by logging companies, hydroelectric power stations and pipeline constructions. has been a contentious issue for several decades (Bloomfield, 1980b: 706). Some of this industrialisation also creates physical barriers to reindeer and caribou movement by, for example, the construction of transport networks through reindeer ranges. The urbanisation of Sweden has already put pressure on grazing lands and reduced the area available for animal pasture (Nordkvist, 1980: 792). Increased traffic through industrialisation, tourism, and recreational hunting has led to compacted roads and tracks through reindeer territories, which may make it easier for predators, such as wolves, to access reindeer grounds (Pulliainen, 1980: 680). There may also be wide-reaching effects on other aspects of the ecosystem by alteration of local conditions by industry, such as the modification of irrigation patterns caused by construction of hydroelectric power stations (Young and Chapin, 1995: 185). Increased urbanisation also creates more opportunity for conflict between different groups. Since the construction of the Kiruna-Narvik road in the late 1970s, increased conflicts have arisen between native Sami reindeer herders and Swedish industry. There have been increased reindeer fatalities from car and train accidents, changes in migration tracks to avoid built up areas, reduction of arboreal lichens through forestry activity, and flooding of pastures by dams (Bäck, 1993: 72-75). In many cases, the Sami communities feel they have not been consulted and the effects on their lifestyle and animals have not been considered in the planning processes.

The consequences of higher density human populations in the north are likely only to have had a drastic impact in recent times. However, in the more distant past, we must consider that any increase in the human population in these areas is likely to have increased the incidence of human-reindeer encounters. These encounters disturb reindeer and caribou and can result in a reduction of foraging or resting time, as well as future avoidance of areas of disturbance. If animals are repeatedly disturbed in regularly visited areas (*e.g.* calving grounds), avoidance of these areas could have profound repercussions on animal behaviour and condition (Aastrup, 2000: 88; Mahoney and Schaefer, 2002: 152). It must also be noted that, in the context of the unstable climate of the LIA, any advance of agriculture into northern areas may have been unsuccessful, as the climatic variability would have made agricultural harvests vary too.

Impact on reindeer herding activities

Just as the variable climate impacted on wild reindeer populations, it is expected that similar impacts were felt by domestic reindeer herds. These would have consequences for the way in which herding activities were carried out, and the level of workload required of reindeer owners. The actual work activities associated with herding require great physical effort and in-depth knowledge of the animals. However, as with wild reindeer, even with in-depth knowledge herding plans may be altered by factors such as disturbances (by humans and other animals) and bad weather conditions (Paine, 1994a: 15). In the following section, some of the principal herding activities are presented along with the hazards that particular weather conditions may present to the herder.

Migrating with animals

Chapter six explored how climatic instability can create snow and ice conditions which affect reindeer migration, with mobility requiring additional energy expenditure (for both herders and reindeer) and unpredictable freeze and thaw cycles presenting barriers along normal migration routes. Paine (1994a: 91) notes that in 1962 slush made migration to the calving areas very arduous. Turi (1931: 85) pointed out that the stress of migration can cause the death of many draught animals in bad snow conditions, a high price to pay considering the effort invested in taming these animals. In early spring, February to March, pasture quality is of utmost importance to reindeer herds. Following winter, animals are often in poor conditions and must be provided with access to sufficient forage. In addition, pregnant females are especially sensitive to overexertion and stress around the end of March, therefore, herders must be sensitive when relocating the herd. Overstress, through exertion or unnecessary use of herding dogs, may lead to miscarriages, still births or the death of cows before calving begins. Reindeer mortality tends to be high during this period and herders must strategically consider relocating herds, to both maximise forage access and limit possible complications during the calving period (Kuhmunen, 2000: 15, 85).

Kuhmumen (2000: 71) states that reindeer become accustomed to regular migration routes (after 2-3 years) and, as a consequence, require less intensive herding (*ibid.*: 71). However, in unstable climatic conditions, particular migration routes or pasture areas may not be suitable every year and thus have to be changed periodically. If reindeer are herded along unfamiliar routes, or are taken to unfamiliar calving areas, the labour required to keep the herd together will be increased (*ibid.*: 109).

Watching the herd

The number of herders required to watch the herd is related to herd size and composition, terrain, pasture quality, and animal behaviour (*ibid.*: 69). For example, particular vigilance is required when watching the borders of calving areas as reindeer cow tend to try to seek fresh pasture. If reindeer are pastured in unfamiliar areas, they may need to be watched closely for a number of years before they become accustomed to the area (*ibid.*: 71). In the unstable

LIA climate, movement to unfamiliar pasture areas may have been common, increasing the labour involved in watching animals. The prevailing weather conditions were also important, as reindeer tend to be more restless on damp ground and will disperse overnight if not watched closely (Paine, 1994a: 45). Similarly, gathering herds after rest periods is harder in bad weather, and therefore herders tend to take advantage of good conditions, when they occurred, to allow animals to rest (Turi, 1931: 49). Some herders use bells to identify the location and activity of reindeer, however, in bad weather these can become clogged and heavy with ice, or may rub on the reindeer's coat in warm summers (Kuhmunen, 2001: 118), so it is unlikely these would have been used all year round. In winter, the shortened day-length and reduced visibility, herders rely more on herding bells and reindeer calls to locate animals (Paine, 1994a: 70). In stormy weather, the chance of hearing these sounds is reduced and vigilance must be increased.

Smaller herds, such as those kept by Sami during the sixteenth century, would be kept closer to the settlements, in order to make them available for milking, traction, and possible emergency slaughter (Kuhmunen, 2000: 155). Whilst, this may have made vigilance easier, keeping herds close results in habituation to human contact and makes animals hard to drive during migrations (*ibid.*: 108).

Overall, the climatic variability during the LIA has been suggested (in chapter four) to have had significant deleterious impacts on reindeer physiology. This has important implications for herders, as weaker animals would need higher vigilance, because of increased vulnerability to accidents and predators in bad weather (Turi, 1931: 48).

During warmer summers, when fly populations are higher, herders may have also had to work harder to prevent damage to animal condition from insects. Kuhmunen (2000, 151) describes how herders are able to kill hundreds of flies, by laying reindeer skins on snow drifts and killing the flies which settle on it. It is possible that these and other strategies, for example lighting 'smudge' fires to drive away insects, were used by herders in the past.

Calving

The success of the calving period is largely influenced by the prevailing pasture and weather conditions, and herders must make careful and informed choices about moving animals and herding strategies. In good conditions, herders may only need to watch at the borders of the calving area. However, in bad weather or poor pasture conditions, more vigilance is required (Kuhmunen, 2000: 17). Both herding during migration and watching whilst on pastures involve a higher workload in unstable climatic conditions. The composition of the herd also influences the labour involved: if male and female animals are herded together during the calving period, they require closer herding as the bulls are often keener to move on to fresh pastures (*ibid.*: 70). Clearly, small-scale herders would have to choose between dividing the herd or closer vigilance during this period: both of which would require additional labour. In recent years, bulls and cows have been separated during the calving period, both to prevent the bulls disturbing calves and to prevent the females, which are still antlered, harming the bulls. The week following calving is considered crucial in the establishment of bonds between calf and mother. If the animals are disturbed, by herders, other animals or bad weather, females may become restless, and if the calf cannot keep up it may be abandoned (*ibid.*: 90-91).

Gathering and catching animals

There are numerous points in the herding year when animals are gathered, including for ear-marking, slaughter, castration, and for monitoring purposes. If herders have combined their animals into larger herds at certain times of the year, they will also need to gather and separate the reindeer back into individual herds (figure 15). To catch individual animals, herders traditionally used a lasso, with hemp rope and an eyelet made of bone (although plastic and metal have been used in recent times). The weather conditions can also impact here, as lassos with hemp rope lose their strength when damp (Kuhmunen, 2000: 23).

Even in good conditions, gathering and separating herds in autumn can require considerable labour. Particularly poor conditions for these activities are: mist; heavy snow; and, storms. In recent periods, herders used skis to move around the herd and gather animals together, therefore, snow conditions are particularly important (*ibid.*: 51). To identify and separate reindeer from combined herds, herders need sufficient light; for smaller herds this may be possible by firelight, but for larger herds this must be carried out in daylight (increasing labour intensity during shorter autumn and winter days). If reindeer are gathered into corrals, they need to be released temporarily both to graze and drink, as temperatures inside the corrals can be high (*ibid.*: 48). In spring, boggy ground is often used to gather and separate animals and smudge fires may be lit to encourage animals to stay together (as they congregate around the smudge fires to avoid insect harassment; *ibid.*: 72, 112). In winter, poor pasture conditions can make animals particularly difficult to gather (*ibid.*: 135). Once separated into smaller herds, increased vigilance to ensure animals do not disperse over too wide an area. As poor snow conditions can make it more difficult for animals to disperse, and therefore may actually facilitate vigilance (*ibid.*: 49).

Figure 15. Gathering and separating reindeer herds in the present day. Image by Mauri Nieminen, available from the Encyclopaedia of Sami Culture (SENC) hosted by the University of Helsinki.

Ear-marking

Ear-marking of calves usually occurs several times between June and early August, although exact timing is decided by weather conditions and reindeer condition (Beach, 1993: 62). If it is started prematurely, the calves may not be strong enough to stay with their mother in the marking corral, which makes driving the animals much harder. Animals may stay up to ten hours at a time in the corrals, but are held for shorter times when the calves are young or weather conditions are bad. The best weather for ear-marking is generally accepted as cool cloudy weather (Kuhmunen, 2000: 32, 122). In warmer weather, herders may ear-mark calves in the evening, when conditions are cooler and harassment from insects is not a problem (*ibid.*: 22). When visibility is impaired (*e.g.* during periods of poor weather) identifying and catching individual calves to mark will be harder work. Ear-marking tends to be conducted in summer because the blood dries quickly and speeds up the healing process. In colder autumn and winter weather, ice can accumulate on the cut; breaking down the wound and causing blood loss. In extreme cases, this can contribute to calf mortality. If calves are missed during the summer, the herder must decide whether to risk marking later in the year or leave the calf unmarked. In recent periods, temporary markers (*e.g.* tying a marker with symbols or initials representing the owner around the animals neck) have been used (*ibid.*: 34), and this cannot be dismissed from occurring in earlier periods. Generally, if herders must make ear-marks in winter, smaller cuts are used (*ibid.*: 33).

Slaughter

Traditionally, the majority of slaughter took place in winter, with meat prepared for the following spring and early summer. Turi (1931: 71) stresses the importance of having sufficient animals to be able to do this, as the reindeer will be too thin to warrant slaughtering in the spring, and meat cannot be preserved in the heat of summer (Paine, 1994a: 39). Thorpe *et al.*'s (2002: 42) Inuit informants indicated that caribou are less likely to be hunted and slaughtered in summer, as the worms from flies can spoil the meat. Clearly, in unstable climatic periods when animal condition may have been poor, the number of animals available for slaughter at this time would be limited. Burmeister (1997: 56) points out, that during bad years in the recent past, herders could not afford to sell any reindeer, slaughtering only for domestic needs. This would have had further implications for trade and taxation, during the sixteenth and seventeenth centuries, as little surplus may have been available. Conditions during the slaughter and butchering of animals may also have implications for meat preparation and quality. Qitirimiut elders suggest that dried meat is cut thinner to prevent flies getting into the meat, but in cold weather the hunter is unable to remove his mitts and the meat is cut thicker: this can be difficult for old and young members of the community to chew (Thorpe *et al.*, 2002: 67).

The timing of slaughter is also linked to the timing of the rut. If bulls are slaughtered during or after the rut, they tend to be in poorer condition and the meat often has an unpleasant bitter taste and strong smell: 'Den kund som en gång ätit kött av en ren som har brunstsmak will nog inte längre köpa renskött' (Kuhmunen, 2000: 37)[17]. Therefore, the timing of the rut (itself dependent on environmental conditions) will have an impact on when animals are slaughtered.

Castration

Decisions about which animals are to be castrated affect not only the breeding stock of the herd but which animals will be available to tame as draught animals, and which animals will be a possible source of meat during the winter. Castrated bulls do not lose weight over the rut period, like breeding bulls, therefore castration acts as a kind of conservation, allowing animals to keep body weight and provide meat if slaughtered (*ibid.*: 39). Reindeer are typically castrated in August and September, just prior to the rut, when they are in the best condition. To castrate animals once the rut has started is inadvisable, as, depending on the degree of castration, animals will still attempt to breed. Therefore, if the timing of the rut is altered the timing of castration will also have to be changed. Castration offers the herder more options for animal use, however, for smaller herders who need to maintain adequate breeding stock, these options will be limited (*ibid.*: 46). The method of castration and the prevailing weather conditions, will affect the impact of castration on animals. In cold weather, the glands harden and castration by biting would endanger the animals' health (Paine, 1994a:25). In more recent times, castration tongs have been used, with herders using sounds to indicate that the tubes have been severed (Kuhmunen, 2000: 42). In windy or stormy weather, it is possible this quiet sound may be missed and castration could be less precise.

Breeding

Controlling which bulls contribute to the reproduction of the herd would have been easier in smaller herds, than in larger or combined herds. Breeding bulls expend considerable energy during the rut so it is important that they are able to graze well between the rut and winter so that they may regain condition. Recent experiments have shown that, if bulls' antlers are removed before the rut they will still mate, but abstain from fighting, therefore using less energy (*ibid.*: 122). During the variable conditions of the LIA, when forage quality may not have been reliable, herders may have used techniques such as these to ensure animals were in as good condition as possible before the critical winter period.

Access to winter forage

Although not strictly a herding activity, winter conditions that reduced reindeer access to forage material may have created additional labour for reindeer herders. In extreme winter conditions, Turi (1931: 54) indicates that the best strategy is for herds to be allowed to roam free. Reindeer have a good sense of where suitable forage is and, if allowed to spread out, will find food. However, the implication of this for the herder is that it will then be more difficult to locate and gather up animals. Furthermore, relocation to alternative pastures may not have always been an option. In particularly deep snow, herders may need to be creative in providing sufficient food for their animals. The depth of the snow may be tested, using a ski or wooden staff, and herders can assist reindeer by digging craters themselves, to facilitate access to forage (Kuhmunen, 2000: 130; Paine, 1994a: 77). Alternative fodder may also be provided in the form of hanging tree lichens or hay. If the reindeer can be driven to forested areas, where herders can cut or pull down branches with hanging lichens to within the reindeer's reach (Kuhmunen, 2000: 77, 136).

Summary

Drawing on the reconstruction of the LIA climate from chapter four, and the exploration of how this increased variability may have affected reindeer

[17] Translated from Swedish by the author: 'The customer who has eaten reindeer meat with the taste of the rut won't want to buy reindeer meat again'.

behaviour and physiology in chapter six, this chapter has attempted to build a general picture of the impact this had on the mixed subsistence strategy practised by Sami populations in northern Sweden. A key theme in this picture is the profound impact of extreme weather events, and the unpredictability of climatic variability. The direct impacts on human health are hard to establish, but it is likely that the climate posed challenges of barriers to mobility and increased accidental mortality. Although Arctic environments have a high level of 'normal' variability, the extreme variability during periods of the LIA also resulted in increased labour required to pursue subsistence activities. What is of interest here is that this impacted upon both hunting and herding activities. Hunting required more labour as wild reindeer herds became unpredictable and local reductions in numbers may have been observed. The labour associated with herding increases in poor conditions, principally because of difficulties with moving, monitoring and ensuring good pasture for domestic herds; with the timing of many herding activities dependent on the predictability of annual freeze and thaw cycles. This is of particular importance for developing an understanding of the transition to herding, as prior to the expansion of herding many Sami practiced a mixed economy, hunting and herding small numbers of reindeer. In the context of variable climatic conditions, both of these subsistence activities required additional labour and herders faced difficult choices about where to focus their resources. How herders may have made those decisions, and what effect this had on social organisation and cultural transformation within Sami communities, is explored in the following chapter.

Chapter 8: Discussion: the Impact of the Little Ice Age on reindeer herding Sami populations in northern Sweden

The starting point of this thesis was the assertion that whilst there is evidence for a widely accepted shift in subsistence strategy amongst some Sami in northern Sweden during the sixteenth and seventeenth centuries, the nature and possible reasons behind this transition have not been sufficiently and robustly explored. This thesis aims to provide an extra dimension to the understanding of this transition, by exploring what research from across a range of disciplines elucidates about the nature of this transition, and a critical consideration of the current theories pertaining to the rise of reindeer pastoralism in northern Sweden. Previous research has provided in-depth studies of a number of internal and external factors which may have influenced this change, with considerable emphasis placed on interactions between the Sami and the Swedish state as a strong influencing factor. As chapter two indicated, in the majority of this previous research, environmental and climatic factors have been largely sidelined; with the environment framed as a static backdrop or, at best, exacerbating the impact of certain socio-political or internal factors. Since each of the previous accounts of the transition is set within the context of a specific discipline (*e.g.* history, anthropology), it is not surprising that they have focussed on the factors most appropriate to study within each discipline. In the preceding chapters, a picture of the environmental context has been provided, with a particular focus on climate (chapter four) and how that may have affected animal (chapters five and six) and human populations (chapter seven and this chapter). It is hoped that this additional perspective can be considered alongside the socio-political and internal societal organisational factors, to provide a more comprehensive and holistic understanding of subsistence activities amongst Sami communities during the sixteenth and seventeenth centuries.

In order to set the context for the discussion, a brief summary of the findings from the preceding chapters is necessary, focussing on how the questions posed in the introductory chapter have been answered and further questions that have arisen from the analysis.

Although framed as a transition from one subsistence strategy to another, the combined evidence does not support this characterisation of the nature of the Sami economy during the sixteenth and seventeenth century. This questions the usefulness of applying general terms such as hunting and pastoralism to populations such as the Sami. The terms themselves are ambiguous and contentious, with differing definitions and applications in previous research. There are particular problems with using these terms to describe 'reindeer herding' as it has characteristics in common with both hunting and pastoral economies: herded reindeer are morphologically wild, often kept within their natural range (and there is shared access to land consistent with hunting) but they are protected by herders; and selective slaughter (and often selective breeding) takes place consistent with pastoralism. This has led some authors to suggest a separate classification system for reindeer herding or, as suggested in this thesis, seeing these classificatory concepts as more fluid, representing points along a continuum, as opposed to mutually exclusive categories. Within this framework, the mixed economy of Sami reindeer herding can be better described as moving from a mixed economy, with the most emphasis on reindeer hunting, to one where the emphasis is on keeping domestic reindeer, but, in both scenarios a range of subsistence activities were employed.

This framing is consistent with the picture of Sami subsistence activities throughout the sixteenth and seventeenth centuries drawn from historical, archaeological and anthropological research, summarised in chapters two and three. Although there was a shift in balance within subsistence strategies for some Sami, this did not represent innovation in terms of developing new subsistence activities, and was highly variable across the broader Sami population. There is considerable continuity in the type of resources exploited between the sixteenth and seventeenth centuries represented in historical sources. The archaeological material indicates that there is little evidence for a radical transformation in terms of settlement patterns, technological innovation or ideology during this 200-year period; indicating that increased reliance on domestic animals toward the end of this period built upon existing cultural practices. Therefore, the 'transition to herding' is better framed as an intensification of one aspect of the Sami mixed economy.

This more complex picture still leaves the question of why this intensification of reliance on domestic reindeer took place, and why there was so much temporal and spatial variability in subsistence strategies during this period. The patchy nature of this subsistence activity is a topic which has not been adequately accounted for in previous research on the 'rise of reindeer pastoralism'. The starting point of this thesis was the recognition that this shift in subsistence activities coincided with part of a globally accepted period of climate change, the Little Ice Age (LIA), and aimed to explore what role, if any, this period of climate change may have played in this cultural change. Far from being a consistent cold period, the LIA was a variable climatic period driven by multiple and complex causes. The prevailing picture, with a particular focus on evidence from Fennoscandia, is that the sixteenth and seventeenth centuries were characterised by highly variable conditions. This manifested in high-frequency and intense cold periods, interspersed with shorter warm intervals, and a greater frequency of storminess and extreme conditions. These variable conditions would have varied geographically and temporally and it is tempting to suggest this may be the reason behind the variable extent of pastoralism during this period. However, the relationship between environmental conditions and cultural change is not so straight-forward. Human beings exercise individual choice when responding to environmental conditions, and do so within a broader communal and socio-political context. One factor may be the variability inherent within Sami culture. As stated in the introductory chapter, the Sami culture is not homogenous, nor would it have been in the past; therefore there may have been other cultural reasons for subsistence choices (for example, the symbolic role that reindeer played in Sami culture may not have been uniform across the whole of Sapmí). This reinforces the notion that, to fully understand the cultural changes occurring during this period, and the role climate may have played in that, detailed local level investigations could provide a richer contextualised picture. It is also possible that, whilst herding offered reduced uncertainty when compared with hunting the declining population of wild reindeer, it was not without its own risks and uncertainties and may not have always been a successful strategy. Returning to the scope of the thesis set out in chapter one, it is a more nuanced and holistic understanding of this period of cultural change that is sought, and to consider the impact of factors in isolation undermines that aim.

Nonetheless, the environmental change during the LIA is suggested as leading to profound consequences for reindeer and the societies that exploit them. Chapter 6 draws together scientific research and local knowledge from historical sources and extant indigenous societies, that exploit reindeer and caribou, to examine the physiological and behavioural consequences of variable conditions. These are consistent in describing erratic weather with rapid transitions between extreme cold and more temperate conditions as having detrimental impacts on individual reindeer mortality, health, foraging and breeding behaviour, as well as the genetic viability, mobility and collective behaviour of reindeer herds. Similarly, erratic and unpredictable conditions are likely to have resulted in direct and detrimental effects on human populations; particularly concerning mobility and increased accidental mortality. Furthermore, conditions would have resulted in indirect effects linked to the impacts on internal social stability (through the potential unreliability of local knowledge), neighbouring non-Sami groups, the broader socio-political context, and the impact on both hunting and herding activities. During this period, wild reindeer would have become a less predictable resource, some hunting strategies became less reliable and there was a dramatic long-term reduction in wild reindeer numbers. Domestic reindeer were not immune to the physiological and behavioural impacts of the LIA climate, posing challenges for many herding activities. For those societies exploiting reindeer, the challenge was to balance the needs for reindeer products within a mixed economy in which both wild reindeer hunting and the maintenance of domestic herds were becoming increasingly labour-intensive subsistence activities.

The scale of early reindeer pastoralism

Some authors emphasise the partial nature of pastoralism as a economic adaptation, arguing that it requires involvement in other activities (*e.g.* trade, alternative animal husbandry or agriculture, hunting and gathering, *etc.*) to be a sustainable subsistence strategy (Khazanov, 1984: 35). Therefore, it is likely that Sami reindeer herders in the seventeenth century did not rely solely on the products of this activity. This concurs with Krupnik's (1993:108) findings that reindeer herding only satisfied between 40% and 70% of the subsistence needs of the Nenet and Chukchi groups he studied. The question remains as to where the shift in the balance occurs. When does a mixed economy comprising reindeer hunting and a small number of domestic animals become a mixed economy of small-scale pastoralism supplemented by fishing, gathering and hunting? Using Krupnik's figures for extant and recent pastoralists, it is possible this balance lies around the point at which over 40% of subsistence needs are met directly from the products of pastoralism. To examine the scale of early reindeer pastoralism in northern Sweden, it is possible to look for the point at which herd size had the potential to fulfil this percentage of subsistence requirements.

One possible line of enquiry is to consider the recorded sizes of reindeer herds from northern Swedish taxation records, from the earliest seventeenth century. It is likely that these figures do not represent the full breadth of herding activities at this time, but do provide an indication of the range of herd sizes amongst some Sami communities. A 1605 reindeer census in the Uma Sami district indicates herds were between 5 and 27 animals, with occasional herds of between 30 and 40 belonging to the wealthiest herders (Wheelersburg, 1991: 342). Away from these extremes, Hansen calculated that the average size of herds in two reindeer herding areas in 1605 were 18.9 and 24.3 (Granqvist, 2004: 108). By using the estimate of the largest herd during this early period, it is possible to calculate the maximum contribution the products of reindeer herding made to Sami subsistence. Within a herd of 40 animals, for an average family size of five (Mulk, 1991), it is reasonable to estimate this contained 2 breeding bulls, and 5 castrated males for labour purposes (1 per member of the household to pull *pulkas*). This would leave a maximum of 33 breeding females. Considering that reindeer are able to breed between the ages of 2 and 10 years, this suggests that each female will produce a maximum of 8 offspring (of which 1 will be required to replace the mother). It is reasonable to expect that the female may not breed every year, or that not every pregnancy will be successful, so we could hypothetically reduce this estimate by another calf. This suggests each female could produce a maximum of 6 additional calves.

Using these figures, a herd containing 33 breeding females could theoretically produce 198 calves over a 10 year period: averaging out at a growth of 19.8 animals per year. This would be the maximum number of animals available for slaughter to maintain herd numbers. However, it should be noted that, during this period of extreme climatic variability, there will likely be good and bad years, so the actual number of animals available for slaughter (and the condition of those animals) would vary from year to year. This theoretical growth rate is at the upper end of those calculated for recent herding populations. Nenet and Chukchi groups estimate calving rates of between 35% and 55% depending on the size and sex structure of the herd (Krupnik, 1993: 103-104).

Taking into account dietary and other requirements of Nenet and Chukchi groups, and calculating the caloric and other contribution of the products of different activities (herding, hunting, trading, *etc.*), Krupnik (1993: 107) has estimated the subsistence balances for these groups. Although this example is based on Siberian and Russian reindeer herding groups from the 1920s and 1930s, and therefore is not directly comparable with the seventeenth century Sami experience. There are elements of Krupnik's methodology which can be legitimately transferred and used to explore a model of Sami reindeer pastoralism during this period. Krupnik calculates that individuals within these Arctic communities need on average 900,000 kcal per year, and that an average reindeer carcass provides 49,000 kcal from meat and edible internal organs. Using these figures, for reindeer meat to be the sole source of subsistence an individual would need to consume 18.5 reindeer each year, and a family of five would need to consume 92 reindeer.

Reindeer would also be required for non-food related requirements. For example, the Sami used products from reindeer in constructing dwellings, clothing, footwear and tools. The Nenet and Chukchi groups from Krupnik's example used reindeer in a similar way and, for the purpose of this model, Krupnik's estimation of the reindeer skin requirements of a family of 5 (a minimum of 40 skins a year) will be used (Krupnik, 1993: 106). This could obviously be incorporated into the overall requirement for dietary needs, although desire for particular types of reindeer skins for particular items of clothing may have influenced the time of slaughter.

The picture for Sami reindeer herding is further complicated as reindeer were also exploited for milk. This was one of the products of keeping small numbers of domestic reindeer prior to the transition to herding, and there is evidence that this continued to be exploited until the development of large-scale reindeer herding in the late nineteenth and early twentieth centuries. Reindeer milk is incredibly rich in energy, providing 8.7 kj/g (Gjøstein *et al.*, 2004: 649), which converts to 2,078 kcal per kilogram. Reindeer have been observed to provide between 57kg (during periods of poor nutrition) and 99.5kg (during healthy nutrition) of milk over a 24-26 week period (*ibid.*: 652). Using these estimates, reindeer milk could potentially provide anywhere between 13% and 23% of an individual annual caloric requirement. In reality, the contribution would be less as this does not take into account the volume of milk being consumed by the reindeer calf, and the possibility that the caloric content of the milk may vary with the physiological health of the animal. With one of the impacts of the variable LIA climate being less healthy animals, it is possible that milk yield and caloric content were low. However, this does indicate that for almost half of the year fresh milk would be a possible supplementary food source, and could be stored or made into cheese to be consumed at other times of the year. Archaeological evidence of milk storage in dams and pits has been described at sites in northern Sweden (Wennstedt Edvinger, 2002: 124) and, whilst these sites are not ascribed to a particular time period, it does not preclude the possibility that milk was stored in the past.

Applying Krupnik's (1993) calculation of the average caloric value of 1 reindeer as 49,000, these figures suggest that a family of 5, with a herd of 40 animals, could derive a maximum of 970,200 Kcals from reindeer meat, without significantly reducing herd size. This equates to 22% of the caloric requirements of the family. Taking the average of the two figures provided by Grankvist (2004: 108) of a herd of 22 animals (and fewer breeding and working males), the contribution made by herding is even less at 12.4%. Even supplemented by reindeer milk, this example indicates that, in the first decade of the seventeenth century, even the largest recorded Sami reindeer herds were insufficient to completely support a family. It is possible that the level of herding at this time may be comparable with the level of herding for much of the preceding century. The tentative interpretation of Magnus's (1998b: **3**: 869) account of herd size from the mid-sixteenth century, provided in chapter two, of between 10 and 60 animals may be indicative that reindeer herding already had the potential to make this level of contribution to subsistence requirements and that this represents a hunting society with small numbers of domestic animals for traction and milk, and as a reliable (but possibly rarely used) source of meat.

By the later seventeenth century, however, herd sizes had grown much larger. For example, Schefferus indicates herds of 120 animals (comprising 100 breeding females). Using these figures, the maximum number of available animals for consumption would be 60 animals a year, equating to provision of 65% of the caloric requirements of the family.

Working backward through Krupnik's method of calculation, it is possible to ascertain that in order for the products of carnivorous pastoralism to be able to contribute 40% of the caloric requirement of a typical Sami family, the herd would need to number between 65 and 70 animals (with 61 females and 4-9 males). Therefore, we can tentatively suggest that, when herd sizes reached 65 and above, the balance was tipped from hunting supplemented by small scale pastoralism, to herding supplemented by hunting, gathering and fishing. It is possible that slightly smaller herds may provide this level of contribution where the diet is also supplemented by reindeer milk. These exploratory calculations indicate that the balance within the mixed economy occurred in the mid-seventeenth century, when herd sizes grew to a level where over 40% of the caloric requirements of a family were able to be met through the products of carnivorous pastoralism. It should be noted, however, that the variable environmental conditions and the individual choices of herders mean that the growth of reindeer herds is unlikely to be linear and consistent. It is likely that some herd numbers may have stayed the same, and others fluctuated in size.

Possibilities for herd growth

The growth of some reindeer herds during the seventeenth century raises questions as to whether herders slaughtered all available animals, or took a more conservative approach in order to increase herd size. However, herd growth in pastoral societies is not simply a function of the reproductive potential of the animals but can also be social in nature: through co-operative and reciprocal herding relationships and more 'negative' social behaviours such as theft and taxation.

'Redistribution of [livestock] through kinship and friendship links and through raiding is common in pastoral societies and can be seen as a form of insurance or as a logical precaution against climatic uncertainty' (Dahl and Hjort, 1976: 260)

Taxation records from the Uma Sami district in the late-sixteenth and early-seventeenth centuries indicate that some Sami were employed to manage state owned reindeer herds, for which they were paid every third calf that was born in that herd (Wheelersburg, 1991: 339). This payment increases the chances of some Sami being able to accumulate their own herds. In fact, some records indicate that the herds these Sami looked after included their own animals (*ibid.*). This example of co-operative herding of state and Sami owned herds, with herders receiving stock in payment, may have also existed between different Sami herders. The records indicate considerable variability in herd numbers between different Sami (consider the Uma reindeer census citing herds of between 5 and 27 animals in one year). Furthermore, the social organisation for co-operative herding between Sami herders may also have existed in the form of early *siida*-like systems.

Increasing the size of reindeer herds would have to be balanced with the labour costs of maintaining them. For example, larger reindeer herds would require more investment in activities such as watching for predators, gathering and separating animals at certain times of the year, and foddering. Many sources indicate the need to separate bulls from females during the calving period. If a very small-scale herder only has 1 stud animal and 2 or 3 castrated male traction animals, this is relatively easy as these can be tethered or the females may be penned. However, in larger herds, males and females may have to be herded separately. In recent times, herders have supplemented the winter diet or reindeer through foddering (arboreal lichens or hay bought from settled farmers), and dug craters to assist reindeer to access forage beneath snow crusts. With larger herds, this obviously would have been a more labour intensive activity.

There must have been multiple models of co-operative herding employed, to attempt to balance the desire to accumulate more animals with the increased labour investment this required. For example, a number of extant and recent pastoralists have loaned animals to other herders to look after, have combined the herds of two or more families, or have employed poorer herders on an 'apprenticeship' model (that is, paid them in stock in return for herding labour; Krupnik, 1993: 91). In all of these ways, poorer herders were provided with the potential to develop their own, albeit smaller, herd. Within this context, it is easy to see how differential wealth was possible and that some herders would be more successful than others. This may go some way to explaining why not all Sami went on to specialise in reindeer pastoralism. It was a strategy with its own risks that not all were successful with.

Making subsistence choices

If the period of greatest transition took place in the mid-seventeenth century, we can return to the environmental reconstruction presented in chapter four to provide a more focussed picture of the context of this transition. The first half of the seventeenth century is characterised as extremely variable, with a number of proxies indicating extended periods of severe and cold weather conditions. With this environmental context in mind, there are a number of questions that remain. Given these variable climatic conditions, how did Sami make subsistence choices? And, why did only a section of the Sami community increase their emphasis on domesticated reindeer through those subsistence choices?

To answer both of these questions, it is useful to take a theoretical lens with which to examine the evidence. Much as Cruikshank (1998: 47) describes how stories are often used to 'think with' in cultures with strong narrative traditions, a good theory can be used to 'think with' when posed with a particular academic problem. The specific focus of the first question is to explore how Sami may have attempted to cope with this increased environmental variability and the impact this may have had on cultural development and change: particularly how that may have shifted the balance within the existing mixed subsistence strategy. To explore this question, a theoretical lens from Halstead and O'Shea's (1989) text *Bad Year Economics* will be employed. The principle underpinning this approach is that all cultures are subject to environmental variability, both spatially and temporally, and develop particular cultural behaviours and responses in order to flexibly cope with this variability. These behaviours and responses are referred to by Halstead and O'Shea (1989: 1) as 'buffering mechanisms' as they serve to buffer the impact of variability on human populations. The second question, as to why the decision-making processes of individual Sami varied, is less tangible and perhaps more complex, and outside of the scope of this thesis. It is not possible to second-guess the thought processes of individuals acting in familiar contexts in the present day, never mind those acting in unfamiliar contexts nearly 400 years ago. People do not always behave in rational and predictable ways, and individual skills, emotions and opinions play a large role. With that *caveat* articulated, it is possible that the application of theories relating to individual agency and decision making in the context of cultural change may offer additional insights. For example, one might draw upon sociological explorations of individual decision-making processes within a group context and how these are affected by perceived roles and status within those groups (Rogers, 2003). To better understand the role individual choices had in the shift toward reindeer herding, and to bridge 'the relationships between individual events and largescale processes' (Hodder, 2000: 21), a critical review of the evidence through the lens of individual agency may be a fruitful area for further investigation. This lens also has potential to change the way in which discourse around past cultural change is framed. In much of the research on the rise of reindeer pastoralism the individual proactive agency of the Sami is not acknowledged, and instead the implication is they have responded reactively to external stimuli. It is unlikely this is a deliberate attempt to present Sami as passive participants in cultural change, but, it is indicative of the way in which discourse about indigenous peoples has developed historically.

Buffering mechanisms

In order to explore the context of how Sami made subsistence choices, the buffering mechanisms approach (Halstead and O'Shea, 1989: 3) suggests that the variability that cultures are subject to has four aspects that require consideration: spatiality, temporality, intensity and predictability. Chapter four has shown that the LIA, and the seventeenth century particularly, comprised a complex and varied spatial and temporal pattern of climatic variability. The intensity also varied, with some events being particularly extreme (for example the increased incidence of floods and storms, and the evidence that extreme good and bad conditions were often in quick succession). The unpredictability of LIA climatic variability would have been an important factor influencing buffering mechanisms. Halstead and O'Shea assert that regular predictable variability is much more straightforward for societies to cope with than unpredictable variability.

'Variability, particularly that which results in severe and unpredictable scarcity of vital resources, exercises a powerful selective pressure on human behaviour' (Halstead and O'Shea, 1989: 2).

As previously discussed, many indigenous groups have a wealth of local knowledge to draw upon to cope with environmental variability. However, when that variability is rapid and outside the limits of historical experience (as the climate change during the LIA may have been), there may not be appropriate knowledge to cope with such changes (Fast and Berkes, 1999: 9).

There are four basic categories of buffering mechanisms that societies may use: mobility, diversification, physical storage and exchange (*ibid.*: 3). Each of these will be considered as a possible means of coping with LIA climatic variability and potential consequences for Sami will be discussed.

Mobility

Moving to an alternative location in times of resource scarcity is the simplest response to local variability. However, the actual possibilities for mobility may be restricted by social relationships with communities in other locations and flexibility of territorial boundaries (Halstead and O'Shea, 1989: 4).

Mobility is a difficult factor to address with respect to the Sami. The pre-herding hunting population was probably highly mobile, but archaeological evidence suggests that this mobility may have been structured through a number of regular semi-permanent dwellings (Forsberg, 1985: 272). Similarly, recent extensive pastoralists were also highly mobile, moving with herds along migration routes to seasonal pastures. But the possibilities for mobility of household with small numbers of tame reindeer may have been different. Keeping small herds of very tame reindeer for milking, traction, leading herds, or use as decoys requires frequent close contact and access to these animals (Aronsson, 1991: 30). Furthermore, smaller herds are less likely to deplete pastures as quickly so may not require the large-scale migrations practised by the extensive pastoralists. There may have also been cultural influences which encouraged Sami to have regular dwelling places. For example, parish churches, markets, and places where Sami paid their taxes or traded were in permanent locations. Keeping smaller domestic herds may have offered a compromise in that Sami were able to maintain a reliable source of subsistence whilst reducing the amount of travel required both to obtain resources, and comply with their new obligations to the Swedish state.

The *siida* system may have accommodated some mobility. Using the varied environments within each *siida's* territory may have provided a means for herders to buffer regular and predictable variability in seasonal pasture capacity, by dividing into individually owned herds and regrouping into larger *siida* herds as appropriate (Bjørklund, 1990: 80). This would imply in-depth local indigenous knowledge of animal behaviour, the environments within the *siida* territory and the impact of the seasonal variations in weather and climate. Bjørklund goes on to suggest that, when individual herds fell below the level that would be viable within the *siida*, this may have contributed to some herders leaving the *siida* to pursue other subsistence activities (1990, 82). This does question where those pursuing mixed subsistence strategies would be placed within the Sami economy as a whole after the transition to herding. For example, if small scale herders were obliged to participate in other economic activities such as farming, fishing, hunting or extensive trade, how did that impact their ability to be part of a particular *siida*? Was it possible to be a partial *siida* member and how was the relationship between reindeer herding and non-reindeer herding Sami within the *siida* territory configured?

The movement of Sami may also have been restricted by the Swedish, and other Nordic states. In recent times, Sami have been asked to pay in order to take their reindeer across national borders (Nordström, 1930: 229) or fences have been constructed to prevent migrations across these borders (Evans, 1996: 11). Whilst the Swedish state is unlikely to have had such complete control over national borders in the past, it is possible that some control over Sami movement may have been exerted. Perhaps closer examination of documentary sources may shed light on this issue.

Actual mobility may also have been impaired by environmental conditions (*e.g.* early melting periods may mean thawed lakes and rivers provided barriers to mobility, and poor snow conditions can make travel harder work or dangerous). There may have also been cultural factors which influenced willingness to relocate. Many landscape features in Sapmí have symbolic and spiritual importance (for example, *siejdde* and other locations considered to be sacred). This cultural attachment to particular areas may have discouraged relocation. Furthermore, any movement to distant areas would mean a new environment and location to become accustomed to. Whilst much local knowledge relating to reindeer must have been transferable in similar environments, some may have been locally specific. Furthermore, although this knowledge would have been cumulative and dynamic, rapid change could cause it to be unreliable. This could have both devalued existing knowledge and meant people would have to build up a new knowledge base in a new location. If people were contemplating relocating to an area, where resources were more plentiful, they would require information about this location in order to ensure it was a suitable choice; within the local area this may have come from their own knowledge but, in distant areas, this may have relied on communication with other communities.

Diversification

By exploiting a broad and varied range of resources, societies can buffer variability by taking advantage of the fact that it is unlikely to impact on all resources in the same way. So, when variability causes scarcity or loss of one resource, there are others to be exploited (Halstead and O'Shea, 1989: 4; Halstead, 1996: 24).

Prior to AD 1600, many Sami buffered the possibility of bad years through diversification; not only did they keep some domestic reindeer, they hunted reindeer and other smaller animals, and fished. There is also the possibility that small numbers of other domestic stock were kept for milk and labour. Evidence for keeping cattle and goats exists from the eighteenth and nineteenth centuries, and the survival of some herders during catastrophic reindeer losses in the late-nineteenth and early-twentieth centuries is attributed to the fact that they also kept cattle (Stoor, 1991: 86-89). These animals would have provided an extra source of subsistence products, during points in the year when reindeer products were not available (for example, keeping cattle for milk products outside the reindeer milking period), and to produce surplus for trade (*ibid.*: 86-88). They may have also provided an alternative source of material for non-subsistence products, for example Stoor (1991: 89) describes the use of cowhide for making summer shoes (*càzehat*).

Small stock, such as goats and sheep, can be effective buffers for short term variability: they have a shorter gestation period than reindeer; possibly larger milk yields; they can be slaughtered when meat is scarce or to satisfy a quick need (*i.e.* unanticipated guests) and thus avoid depleting the main herd; can be sold or traded; and, are easy to keep close to the dwelling (Dahl and Hjort, 1976: 237). However, keeping such stock is unlikely to have been entered into lightly as each type of animal has specific needs, it is perceived to be much more labour intensive than reindeer herding, and it inhibits the herder's freedom of movement. The increased workload mainly stems from the need to tend animals daily, and the need to house and fodder the animals over winter. In the recent historical period, some Sami have chosen to pay settlers to look after animals during the winter (usually at the cost of 2-3 reindeer per domestic animal; Stoor, 1991: 87). Alternatively, Sami groups split up over the winter, with women tending to domestic animals in timber or peat barns, and men herding the reindeer. If the animals were kept over winter in barns, fodder would need to be gathered during the previous summer. This increased labour costs as it typically coincided with a labour-intensive period in the herding cycle (*ibid.*: 88). Whilst the preceding description is based on research on keeping of stock animals during the eighteenth and nineteenth centuries, this does not preclude the keeping of these animals in earlier periods. This would require contact with settled farmers in order for Sami to obtain animals: as Sami were part of extensive trade networks at this time this is not impossible. However, the labour and logistical implications of keeping stock animals all year round imply that it is unlikely to have been a widely adopted strategy for non-settled Sami.

Wild reindeer were the main large animal resource hunted prior to the intensification of herding. In the southern areas of Sapmí, it may have also been possible to hunt elk, but in northern Sapmí there were no alternative large herbivore species. Therefore, in times of wild reindeer scarcity, other animals would need to be exploited. There were a number of other small mammals and birds which were hunted for fur and meat, and many Sami supplemented their subsistence with fishing. However, the consequences of climatic variability on these species would have to be considered, to ascertain if these could provide an alternative source of subsistence in bad reindeer years. Since reindeer are part of complex Arctic ecosystems, it is possible that climatic change would have had consequences on groups of species rather than individual species (Fienup-Riordan, 1986: 279). Head (2000: 115) suggests that species respond and migrate individually in response to climate change rather than as an ecological community. This reinforces the approach taken in this thesis, focussing on the responses to climate change of reindeer as a species (rather than considering impacts broadly on Arctic ecosystems) and then considering what the implications of those multiple responses would be for the human communities exploiting them. However, it also highlights the limited scope of the thesis. Reindeer are not the only species utilised by indigenous Sami populations now or in the past. Therefore to get a fuller understanding the impacts on all species exploited - or those it was possible to exploit - should be considered. This emphasises the complexity inherent in these kinds of studies, and the vast amount of work still to be drawn together to reach a more complete understanding. Each individual species will have multiple responses to different climatic conditions, and each of these will have impacts on other species within their community or ecosystem. As a result of this, there will be a range of contextual relationships between species which may affect the nature of their responses to climate change. It is clear that, in terms of understanding how species may have responded to the climatic variability of the LIA, there is still considerable work to be drawn together. However, this approach has potential to create more accurate and richer understandings of the impacts of climate change than generalisations about community or ecosystem-level responses.

Reliance on what species remained would not only have implications for diet and the time spent obtaining these resources, but also the possibilities for trade with other groups. In this way, scarcity of a group of resources may actually discourage the tendency to diversify and exploit a range of resources. This could be perceived as too costly and inappropriate for obtaining products for exchange. Therefore, specialisation in the procurement of a single resource efficiently may be a more attractive option (Fienup-Riordan, 1986: 304, 314). The specialised exploitation of domestic reindeer may, therefore, be seen as providing a known (but not risk-free), efficient means of producing subsistence and trade products which was more attractive than exploiting a broader range of resources (each with their own risks).

A considerable change in resources used, and therefore in diet, may also have indirect impacts on human health. In recent periods, a decrease in the dietary input of products of hunting and fishing has led to increased cardiovascular disease in some northern populations (Fast and Berkes, 1999: 15). Whilst this may be a particularly modern problem, with the availability of processed high-fat and sugar-rich foods, the changes in diet caused by a shift in resource utilisation may have had health impacts in the past.

Possibilities for diversification may have also been influenced by internal cultural values, in particular the role that reindeer play in other spheres of Sami life. Reindeer were incredibly important to the Sami way of life in a number of ways. Firstly, they supplied a wide range of raw materials used in everyday life (*e.g.* skins for clothing, bedding and tents, sinew for sewing, antler and bone for tools and jewellery). They also had a significant ideological importance, as evidenced by symbolic paintings of reindeer on shamanic drums, ritual deposition of reindeer remains, *etc.* described in chapter 3. In the event of a scarcity or disruption of wild reindeer populations, it is possible that Sami would have intensified efforts to obtain reindeer, to fulfil these varied needs, rather than pursue alternative resources.

Furthermore, diversification may not have been an appropriate indigenous response to resource scarcity. Although a logical solution to scarcity in western knowledge systems may be to cease hunting that resource, this may not have been so for indigenous knowledge systems. In the case of scarcity of wild reindeer, it is possible that hunting behaviour may have exacerbated the problem. Because of their close relationship with nature and their 'spiritual' views towards it, indigenous peoples tend to have been characterised as living in harmony with nature. Whilst recognising that native groups often have sustainable and environmentally sound approaches to nature, it would be wrong to describe them as 'original ecologists'. Conservation only occurs when it does not go against the grain of human survival and we must remember that hunters are, first and foremost, consumers (Krupnik, 1993: 238), therefore over-hunting is a possibility. For example, if we consider the role of 'ecologically aware' Native Americans in the post-contact game depletions of the nineteenth century, it is difficult to explain how they could have consented to take part in such an obvious overkill of animals. In his 1978 book, *Keepers of the Game,* Calvin Martin suggested that Algonkians only abandoned their traditional environmentally sound subsistence strategies because they felt that the animals had abandoned them. He suggests that they considered the epidemic diseases prevalent after Euro-American contact as evidence of the animals assaulting them, and therefore responded with, what may described as, a war against the animals (Brightman, 1993: 285). This conveniently side-steps the issue by allowing Algonkians to give up their values for a short time and then return to them. However, this ignores the fact that game shortages existed before white contact and that indigenous populations had a role in these shortages. For example, between 1850 and 1900 the Musk Ox was wiped out by native Inuit on Bank's Island without modern firearms. A similar Musk Ox extinction occurred on the Alaskan Brooks Range 200 years before any white contact (Krupnik, 1993: 235). Secondly, it suggests that the normal response of native societies to game shortage would be to kill less, whereas anthropological evidence points to the opposite; since hunting may be perceived to be an essential process in the regeneration of animals, then the obvious response to shortages would be to hunt more and therefore generate more animals. An interesting perspective on this is that Native Americans may have interpreted game shortage as a response of animals to the disrespectful way in which white men hunted.

'*The buffalo had, they believed, gone underground because whites had killed the animals with disrespect. The buffalo would return when Indians could ensure the animals would receive proper respect*' (White quoted in Nuttall, 1993: 155).

In this case, there was no reason for the natives to reduce their own slaughter of the buffalo as they were hunting in the correct way; all they could do was to continue to be respectful and wait for the animals to return. Whilst it is not the author's intention to draw direct parallels between the very different Native American and Sami belief systems, it is worth considering that ideology could have played a role in encouraging the slaughter of wild animals, even in times of scarcity.

Figure 16. Reindeer milking in the recent period. Image by Museovirasto, available from the Encyclopaedia of Sami Culture (SENC) hosted by the University of Helsinki.

It should also be noted that diversification does not necessarily imply that different species are exploited but may indicate that different subsistence strategies were used. By keeping small numbers of domestic reindeer, Sami were buffering by exploiting reindeer in a different way to hunting. Whilst alive, the animals provided products such as milk (see figure 16), cheese, antler for making tools, as well as being a source of labour or used as a decoy whilst hunting. They also served as an indirect means of storage 'on the hoof', and a readily accessible food source in times of need. Utilising live domestic stock for milk provides a number of advantages: essentially 'free' calories and a fat rich food source; relatively small pasture requirements; and the ability to store cheese to provide a fat rich food source at other times of the year. However, a focus on milk production has to be balanced with the fact that this requires considerable labour (gathering, tethering and milking animals), may result in weak calves if they are weaned very early, and that pregnancy and lactation place additional stress on females which may make them more vulnerable to disease and predators (Halstead, 2008: 246). However, it remains a cultural adaption that has been proposed as enabling survival within marginal environments (*ibid.*: 243).

Storage

Direct storage by the Sami is known to have taken place in recent periods, through the drying and freezing of meat and cheese, and cannot be ruled out as a possibility in the past. Rowley-Conwy and Zvelebil (1989: 54) have suggested that analysis of Mesolithic and Neolithic sites across Europe indicates that storage of meat, fish and plants was a part of some hunter-gatherer economies. In particular, the use of mass-capture hunting technology, such as the extensive hunting pit systems used in northern Scandinavia, may be taken as an indication of storage in that these must have resulted in a substantial surplus to store (*ibid.*). However, storing food is principally a buffering mechanism for temporal variability (Halstead and O'Shea, 1989: 4) and is therefore only possible if there are also periods when resources are plentiful as well as scarce. Therefore, the ability to store is also directly affected by climatic variability. When variability is regular and predictable, this would have been an appropriate and effective strategy but, in periods of unpredictable variability or prolonged shortage, it would be less effective. For example, in a year where wild reindeer were scarce, Sami may have used up many of their stored supplies over the winter. If the following spring and summer were also poor conditions for reindeer, they would be faced with fewer reindeer, in possibly poor condition, and therefore little surplus to be able to store for the coming year. It is, therefore, unlikely that storage alone would be used as a strategy to buffer the effects of unpredictable LIA climatic variability. Furthermore, the impact of climatic variability in the LIA has been shown to have long-term impacts on reindeer condition because of possible impacts on forage material. Therefore, there may be a considerable time delay between improved environmental conditions, re-growth of forage, recovery of reindeer condition and numbers and the ability to store meat.

Storage may have been a normal part of the Sami subsistence system used to buffer regular seasonal variability. For example, drying and storing reindeer meat slaughtered in summer and autumn in order would have provided food for the winter (see figure 17). However, there is always a risk that stores may spoil (Rowley-Conwy and Zvelebil, 1989: 48) and they tend to be used as a supplement to winter diet rather than the sole basis for it.

Decisions about storage need to be balanced with flexibility in mobility. A mobile population will need to return to the location of storage. This is not to say that mobility and storage are mutually exclusive buffering strategies but that there may have to be an element of compromise to use them together.

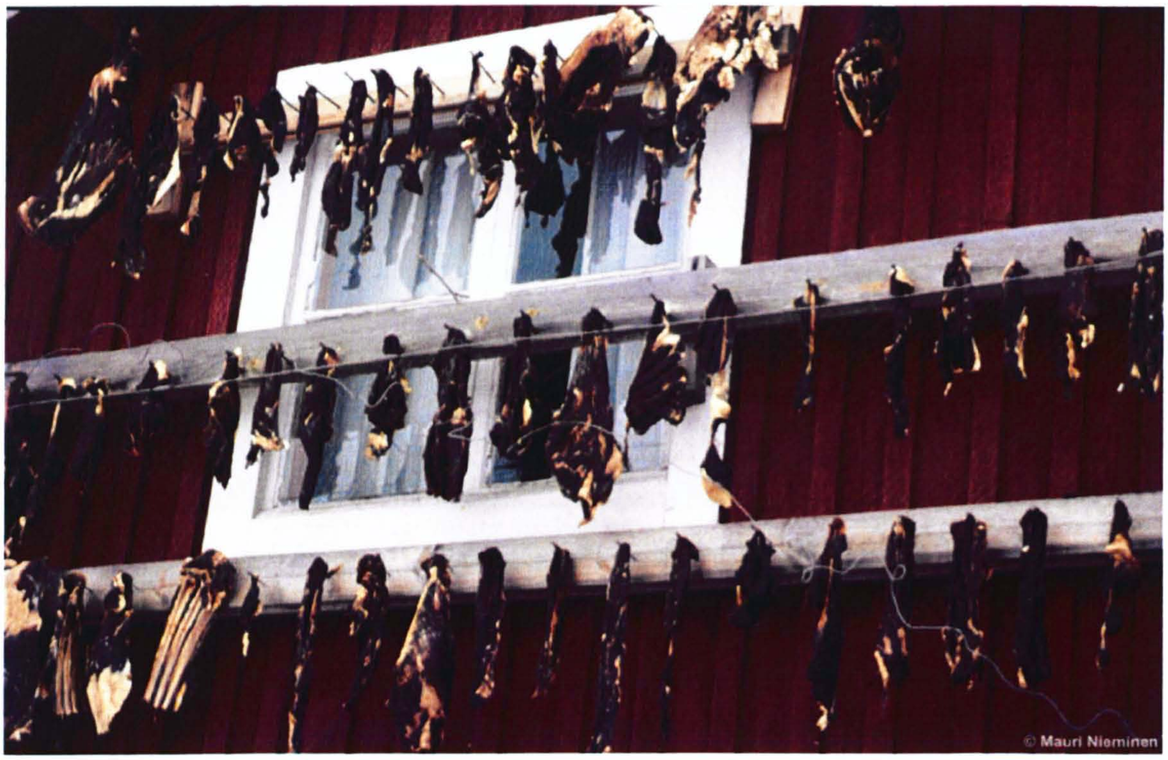


Figure 17. Drying reindeer meat. Image by Mauri Nieminen, available from the Encyclopaedia of Sami Culture (SENC) hosted by the University of Helsinki.

As climatic variability may have had different impacts in different locations, the ability to create surplus and store products may have also had a spatial pattern. If some areas had a regular surplus, this may have created wealth - and possibly social - differentiation. Furthermore, internal organisation (through the proto-*siida* system) may have identified certain Sami families with particular territories and prevented full mobility between these areas. This may have enabled greater differentiation of wealth, as some areas may have accommodated a greater surplus than others.

Exchange

Exchange can function at a number of levels, from reciprocal arrangements between individual households, to monetised trade within a market economy (Halstead and O'Shea, 1989: 4). The majority of mercantile trade in Sapmí took place under the control of the state. Connections between Sami and the state have a long history, they have been involved in trade with neighbouring Nordic populations for several hundred years and had been tied to the Swedish state since the 1300s though taxation payments. It is likely that small-scale household exchange may have gone on outside of this but large-scale trade for agricultural products, such as flour, would have been state-controlled. Therefore, the possibilities for increasing the amount of trade undertaken to ensure supplies throughout the year may have had external limitations. Furthermore, Sami would have needed to have a surplus in order to exchange. Obviously, this would not necessarily need to be a surplus of reindeer, but providing the surplus would add additional labour to economic activity. However, traded agricultural products which could be stored, such as flour, would have provided an important addition to the Sami diet. In fact, some authors have suggested pastoralism is an incomplete adaption and often requires exchange with other economic groups (Khazanov, 1984: 35).

Buffering techniques may have existed in the form of reciprocal sharing arrangements, where another Sami group or family may help another out *in lieu* of receiving help in the future. However, groups would need to ensure they could provide the help those other groups may require otherwise they could incur a large social debt. This form of exchange is not necessarily linked solely to subsistence-related resources; exchange of craft goods may have also been used to cement potential reciprocal relationships (especially between more distant groups; Halstead, 2008: 248). Interestingly, one of the impacts of resource scarcity may actually be the breakdown of some reciprocal arrangements. For example, in Yup'ik communities in the Yukon, one of the immediate impacts of a poor harvest was to restrict sharing to the extended family, rather than between households (Fienup-Riordan, 1986: 309).

Dahl and Hjort (1976: 234) provide an example of livestock loaning from the Murle (Lake Rudolf), where cattle pastoralists with small herds lend stud-males to owners of larger livestock herds in return for payment in live cattle. In this way, herders can substantially increase the size of their herd beyond its internal breeding capacity. Krupnik (1993) describes similar practices amongst Russian and Siberian groups. While these examples are drawn from a different context to the focus of this thesis, it does illustrate possible mechanisms for pastoral herd growth.

In addition to providing a buffer against times of hardship, the need for surplus for trade and taxation may have also driven the Sami toward more reliable resources. If they knew they could not avoid taxation, and needed surplus to trade for essential agricultural products, domestic reindeer would have provided a level of security that the increasingly unpredictable wild reindeer population could not. Taxation may have functioned as a form of negative reciprocity but its role in the transition to herding is difficult to establish. Since taxation could be partially, or completely, paid in reindeer products, it may have served to reinforce the importance of reindeer to the Sami. However, it is not clear whether method of taxation drove the choice of subsistence strategy, or whether it capitalised on an already extant specialised reindeer exploiting economy. It is unlikely that nation states would have requested tax to be paid in a currency the Sami could not acquire, nor would they ask for payment in a form they could not utilise. Doubtless, the existing subsistence strategy and taxation methods encouraged each other but it is hard to establish a causal relationship between the two.

Summary of possible buffering mechanisms used by the Sami during LIA climatic variability

There are numerous ways in which Sami may have buffered against the climatic variability of the LIA. Many of the responses described above are not mutually exclusive, and it is likely that a combination of buffering mechanisms were chosen according to particular situations, with different mechanisms chosen to cope with different kinds of variability. For example, both mobility and diversification are considered appropriate strategies for buffering spatial variability, whereas physical storage tends to be used to buffer temporal variability, and exchange can balance the impacts of spatial and temporal variability (Halstead and O'Shea, 1989: 4). It is likely that Sami made use of all these possible mechanisms. Exchange with neighbouring Nordic and Sami communities, diversification of resources exploited and the subsistence strategies employed, storage of products when possible; including direct storage of subsistence and exchange products and indirect storage via social relationships and keeping domestic animals. Mobility is more difficult to ascertain, whilst it is possible that some Sami may have relocated in times of local resource variability, there may have been numerous internal and external limitations on the extent of relocations.

The most powerful buffering mechanisms tend to be those which exist to cope with infrequent and extreme variability. Halstead and O'Shea (1989: 5) argue that, whilst these mechanisms may be used infrequently they are immensely important for cultural survival, and in many cases become culturally embedded in order that they are maintained for times of need. These mechanisms may be costly to maintain, and if only used rarely, a balance will need to be struck between having effective buffers whilst not reducing the efficiency of the normal subsistence strategy. Therefore, these embedded mechanisms may provide other cultural functions and may not be immediately obvious as a buffering mechanism (*ibid.*: 3). The maintenance, use and embedding of these mechanisms creates new situations which may have their own sets of risks, and in this way have the potential to lead to 'radical transformation of society', as other mechanisms are abandoned or broader cultural change occurs.

'Either way, high-level coping mechanisms are an unstable element at the core of human culture, which can trigger a chain reaction of changes throughout society' (Halstead and O'Shea, 1989: 6).

Keeping small numbers of tame reindeer may have been one such high-level coping mechanism. It provided an emergency source of food which was probably only drawn upon infrequently, but was embedded in the culture by the other functions it performed: providing secondary subsistence products and labour. The symbolic importance placed on reindeer, and the importance of reindeer products for subsistence and exchange may have facilitated this cultural embedding. However, the increased climatic variability of the LIA triggered this high-level mechanism to be used more frequently, which created new sets of risks to be buffered. If climatic variability became perceived to be the norm (or at least more frequent environmental conditions), then keeping increased numbers of domestic animals may have been encouraged to buffer this variability. There would have also been risks associated with the impact of climatic variability on domestic reindeer which would have to be managed (explored in chapter 7).

If this high-level coping mechanism was used more frequently, more investment would be required to maintain it, and, in this way, it may have been an important lever in the cultural change that took place in this period for some Sami. There still remains, however, the question as to why this cultural change was so sustained. The assembled evidence appears to suggest that this buffering mechanism had been in use for a long period of time as part of a mixed economy, and it is likely that it may have been drawn upon in preceding periods of variability, with herd sizes increasing and decreasing slightly according to the decisions made. Some authors (Ingold, 1988) have suggested that the social relations of production of hunting and herding are different enough to preclude a return to an economy based predominantly on hunting, which may explain the sustained change. However, this is not supported by the evidence assembled in this thesis. The archaeological, historical and anthropological research does not indicate that there was a substantial change in ideology or values associated with the intensification of herding (although it is questionable whether this would be obviously manifest within the archaeological record). Furthermore, there are examples from other parts of the world (Krupnik, 1993) that indicate which societies have alternated between strategies of predominantly hunting and herding. The answer to this question may lie in a more detailed exploration of the range of subsistence choices made by Sami at this time. The focus of this thesis is those Sami who chose to intensify their reliance on domestic reindeer, but many more subsistence paths were open, including: intensification of hunting; fishing; animal husbandry; and employment by the state (herding state owned reindeer and providing labour for early northern industries, for example ore extraction). The choice to pursue a strategy focussed on reindeer may have, in part, been driven by a desire to balance subsistence and cultural needs with demands from the Swedish state, within the context of an increasingly variable and unpredictable climate. It may, in fact, be the continuity in values (around the importance of reindeer products), rather than a change in values, that characterised those Sami that chose to pursue reindeer herding. This choice was also made within a context of declining wild reindeer numbers; meaning that a return to reindeer hunting may not have been possible.

Conclusions

The aim of this thesis was to take a bottom-up approach to explore whether environmental change associated with the Little Ice Age played a role in cultural change amongst sections of northern Swedish Sami communities. A multi-disciplinary approach was taken, drawing on published research from anthropology, history, environmental sciences and with a particular focus on archaeology. The findings indicate that, despite being an extremely well researched topic, this is still a much contested period of cultural change in Sami history with multiple perspectives from a wide range of disciplines. In attempting to draw some of these perspectives together a number of conclusions can be drawn.

The nature of this transition is not as complete as presented in some previous research. Prior to this period the Sami had employed a mixed subsistence strategy, hunting reindeer and small mammals and birds, gathering plants, fishing in lakes and rivers, trading with other Sami and non-Sami groups, and keeping small numbers of domestic reindeer (principally for milk, labour and as hunting decoys). What is apparent over this period is a shift in emphasis with some Sami *intensifying* the exploitation of the products of domestic reindeer and accumulating larger reindeer herds, at the expense of other subsistence activities. In contrast to some characterisations of pastoral societies, there is considerable continuity in terms of resource utilisation techniques, settlement patterns and potentially ideology, religious practices, societal organisation and values amongst the Sami during this period. This indicates that definitions of hunting and pastoralism do not sit easily with Sami subsistence strategies, and that these terms are inadequate in representing the range of subsistence patterns that may have existed in the past. This may have contributed to the lack of consensus in the literature regarding the nature and timing of the emergence of reindeer herding. Within this thesis an attempt has been made to see this transition as more fluid, a shift in emphasis as opposed to a radical cultural transformation. Within this continuum of subsistence practices, there is an identifiable shift in emphasis within the mixed economy, in the mid-seventeenth century, where herd sizes reached levels at which they could potentially provide over 40% of the caloric requirements of a Sami family from the products of carnivorous pastoralism alone.

The reasons behind this shift are complex and highly contextual, and those put forward in previous research only provide part of the picture. In particular, the role of environmental change within this context has not been adequately explored. This thesis has assembled a clear line of evidence from the nature of the environmental change, to the potential impacts this had on reindeer physiology and behaviour, and how this would then impact on the Sami communities exploiting reindeer and how they may have made subsistence choices. This evidence has been used to suggest that the extremely variable climate during the LIA would have had a profound effect on Sami communities exploiting domestic and wild reindeer.

Reindeer herding (at a small scale) had been employed by Sami as a high-level buffering mechanism to provide a reliable source of food and essential cultural resources during the regular pattern of environmental variability that exists within Arctic ecosystems. However, during the sixteenth and seventeenth centuries this environmental variability increased, in both frequency and severity, and moved outside of the scope of regular and predictable variability. This extreme variability had a number of consequences for subsistence patterns: wild reindeer became a less predictable and less numerous resource making hunting a less reliable subsistence activity; and, many herding activities were made more labour intensive. This led to some Sami focussing their attention on the products of domestic herds as a more reliable resource, which reduced the time available to pursue other subsistence activities and narrowed the nature of the subsistence pattern. Within the earlier mixed economy, the caloric contribution made by domestic reindeer would have mainly come from milk and cheese and occasional emergency slaughter. As herd sizes grew, the implication is that domestic reindeer began to be more regularly utilised as a source of meat.

The environmental variability associated with the LIA is not the only factor involved. Complex cultural change is rarely the product of a single trigger. It is likely that all of the factors put forward by previous researchers played a role in the intensification of reindeer herding during this period. The fact that this shift is variable both geographically and temporally lends weight to arguments for taking a situated approach to studying cultural change: looking holistically at the specific circumstances of communities and individuals. In the case of the Sami, decisions to focus on reindeer herding were likely to have been influenced by the wider socio-political and economic context of the nation states in which they lived; the specific geographic and environmental context (including what resources were available); internal social factors within Sami societies (including the symbolic importance of reindeer culturally); and, the knowledge, opinions and experiences of the individuals making subsistence choices. The intensification of reindeer herding provides fertile ground for exploring this notion of multiple causes. Socio-cultural and environmental stimuli, in particular, can be tentatively linked to provide a better understanding of how both of these may have encouraged concentration on domestic reindeer. Reindeer hunting was destabilised by the variable conditions of the LIA and, although the concentration on domestic animals may have been a more reliable subsistence base (and may have been favoured by internal cultural values), the calculations earlier in this chapter indicate it only provided part of the subsistence requirements of households. Historical sources indicate that the Sami were involved in trade and taxation relationships with the Swedish state, which encouraged intensification of reindeer exploitation to provide surplus for trade and tax payments. It can be tentatively suggested that, the ability to trade surplus reindeer meat and skins for flour, small domestic stock, *etc.,* facilitated the establishment of reindeer herding as a viable subsistence strategy. This also goes someway to explaining the patchy nature of this cultural change and why some Sami chose other subsistence patterns, as both the environmental conditions and opportunities to engage in trade may have varied geographically and temporally.

These findings indicate that there may not be a 'model' or 'theory' of the emergence of large-scale pastoralism in northern Sweden and that generalising from local-focussed studies to regional, or even global, models is dangerous: practices developed locally in context and are closely linked to the nature of that context. This may be frustrating, as it does not provide clear-cut and neat accounts of cultural change. However, a situated and multi-disciplinary approach does provide greater understanding of the nature of that cultural change. In attempting to better understand this period of change, a particular theoretical lens (buffering mechanisms) has been used to explore the varied subsistence choices open to the Sami. The application of alternative theoretical lenses may yield additional insights. In particular, an approach that acknowledges and explores the role that individual decision making processes play in broader cultural change (through considering individual agency) may provide a fruitful framework for future study.

In assembling the building blocks for this bottom-up approach this study has drawn upon almost 500 secondary sources from a wide range of disciplines. This exploration has indicated the benefits of undertaking multi-disciplinary studies of cultural change but has not perhaps realised the full potential of this approach. Clearly, a truly collaborative multidisciplinary study of this phenomenon, involving scholars with complementary disciplinary specialisms and a re-examination of the primary source data would increase understanding, and assist in unpicking the complex and varied nature of the emergence of carnivorous pastoralism during this period.

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