The Last European Landscape to be Colonised: A Case Study of Land-Use Change in the Far North of Sweden 1850–1930

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ABSTRACT

The agricultural colonisation of the interior of northern Sweden in the eighteenth and nineteenth centuries can be regarded as Europe's last colonising venture supported by an economy based on self-sufficiency. Nevertheless, nomadic Sami people have practised basic economic approaches to resources and environment in this region for thousands of years. The aim of this study was to analyse the swift land-use transition, from nomadic to agricultural, in the last colonised landscape of northern Sweden. Using historical documents and maps together with modern maps and a field survey, we wanted to link land-use patterns as strongly as possible to landscape features and ecosystems. Resource use of farmers and the native Samis showed many similarities with some important exceptions. Some obvious disparities seem to have evolved, mainly connected to the animal species that were domesticated. With the Sami people involved and interfering with the colonisation process, their use of resources contributed significantly to local economy and land use therefore became intensified. Interestingly, in the studied area the main driving force for establishment of new settlements was commercial forestry. However, in the last colonised landscape, forestry reached its physical limits, leaving mountain birch forests with evidence of traditional Sami land use and Sami historical traces.

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KEYWORDS

Northern Sweden, forest history, historical maps, land-use changes, culturally modified trees, Sami people

INTRODUCTION

The colonisation of the interior of northern Sweden in the eighteenth and nineteenth centuries was a part of a worldwide process of settlement and woodland clearance for cultivation.[1] It can be regarded as Europe's last colonising venture supported by an economy based on self-sufficiency, which changed land-use patterns in these northern forests.[2] Agriculture spread from central and southern Europe, and reached southern Sweden about 4000 years B.P. The northern coast, along the Gulf of Bothnia, was settled during the agrarian expansion of ca. 2000 years B.P., but the colonisation of the northern interior did not start until the late eighteenth century, peaking during the first half of the nineteenth century, and then ceasing in the early twentieth century.[3] It was a process strictly controlled by the state with precisely regulated privileges and obligations.[4] As in other countries within the circumpolar boreal forest – Norway, Finland, Canada and Russia/Siberia – environmental factors played key roles. [5] The boreal forest is marginal with respect to cultivation, with an extremely brief growing period, harsh winters, often a very thin soil and high altitudes. While viable colonisation during the nineteenth century mostly depended on exports of crops or a close association with the mining or timber industries, the colonisation of the interior of northern Sweden essentially occurred within the framework of a self-sufficient economy, based on cattle breeding plus fishing and hunting in the forests.[6] However, at the very end of the colonisation period, the timber industry played an increasing part of the economy; for some settlements work in the forest even became the main income. The pioneer settlers mainly came from the long-established settlements in the coastal area around the Gulf of Bothnia.

Before and during this process, and despite the difficulties associated with the agricultural colonisation of this marginal area, the native, nomadic Sami people lived in the interior of northern Sweden for thousands of years. In order to survive in this subarctic environment over millennia, an economy based on reindeer herding, fishing, hunting and trapping developed. The Sami inhabit the northern parts of Norway, Sweden, Finland and north-western Russia. Among the eighty ethnic groups that inhabit the arctic and subarctic areas of the northern hemisphere, only the Eurasian groups have a history of domesticating and herding the reindeer (*Rangifer tarandus* L.). Three main groups of the Sami can be distinguished in Sweden. The mountain Samis migrated with the reindeer from their summer grazing areas in the Scandinavian mountain range or the Atlantic coast, to their winter grazing areas in the boreal forest or in the coastal areas of

the Gulf of Bothnia. The second group, the forest Samis, had smaller herds of reindeer and had a more restricted movement pattern, staying in the boreal forest all year round. The third group of Samis lived without reindeer and relied on an economy mainly based on fishing. In contrast to the European colonisation of other parts of the world, the Sami were given an opportunity to participate in the process of colonisation.[7] This was also the case for the native population of Latin America colonised by the French Canadian 'métis', but not in Siberia, where the natives were excluded from the settlement process.[8]

The consolidation of the two reindeer-holding Sami groups has its background in the intensification of reindeer herding during the sixteenth and seventeenth centuries. This development had distinct socio-economic effects and there were several driving forces behind the trend. First, the fur and wild animal trade, important elements in the Sami economy, decreased during the sixteenth century. The reasons for this were partly increasing international competition, mainly from North America, and partly decreasing populations of wild animals in northern Sweden as a result of intensified hunting. Second, there was increasing government interest in the development of reindeer herding, because of the potential capacity, and the resultant increase in tax income and meat production. An important factor in this intensification, which accentuated the separation of the forest and mountain Samis, was that the borders of the Sami territories were adjusted to account for the long-distance movements of the mountain reindeer along the river valleys. The forest Samis, who owned fewer reindeer and depended more on hunting and fishing, found their territories restricted and reduced, so became less mobile, staying in the boreal forest all year.[9]

Although the correlation between early arrival and occupancy of the best land was not perfect, a number of site factors clearly influenced the settlement process.[10] The first settlers that arrived in the eighteenth century occupied favourable areas for ground clearance, close to bogs for haymaking, and near areas for hunting and fishing.[11] Large lakes were extremely attractive features when selecting sites to settle, due to the importance of fishing and their positive effect on the local climate.[12] The colonisation was continued by the descendents of the pioneers, who often settled close to their ancestors' homesteads. This process was slow, and up to the late nineteenth century, large areas remained un-colonised. At this time, the increasing value of timber from the vast and unexploited forest gave rise to a new driving force controlled by the state. The increased need for woodsmen strongly influenced the final colonisation enterprise of the interior of northern Sweden and state forest areas were established.[13] In the northernmost part of Sweden this last venture began in the late nineteenth century and ended fifty years later.

The state forests were located in areas with good timber resources, and thus in unfavourable areas from the perspective of cultivation. The most distant settlements in the state forests were established at altitudes only one or two hundred metres lower than the tree line. These settlements could not be described as

farms. Cultivation of grain was not possible and even growing potatoes was precarious. The modest cattle-breeding was dependent on natural meadows several kilometres from the homesteads. On the smallest settlements only one single cow and a few goats were kept. However, basic economic approaches to the resources and environment in this landscape had already been practised by the Sami for thousands of years. A study of the land use in this last area to be colonised should illustrate how different cultures use the same landscape and resources therein for livelihood.

Aim of the study

This study is a case-study of a land-use transition, from nomadic to agricultural, in a forested landscape of northern Sweden situated at latitude of 66°N and examines the resulting ecological consequences. Colonisation is traced and the natural resources used by the two different cultures are distinguished, described and compared. The subsequent introduction of forestry and its consequences are also discussed. The period under consideration is from the late 1700s to the early 1900s, with particular focus on the late 1800s. The specific questions we want to answer are: (a) How did land use by the native Samis and the settlers differ when it came to use of specific natural resources, domestic animals and overall human impact on the ecosystem? (b) How did the native Samis cope with the agricultural colonisation process? (c) Which were the driving forces behind the colonisation of this northern landscape? and (d) What were the ecological consequences of the transition of land use in the different parts of this landscape?

MATERIAL AND METHODS

Study area

The study area lies between latitudes 66°05' and 66°95', close to the Caledonian mountain range in north-western Sweden (Figure 1). It is included in a transition zone of ecosystem properties known, globally, as the tundra-taiga interface.[14] The area covers 1,590 square kilometres and is delimited by two extensive water systems: the river *Skellefte älv* in the southwest and the river *Pite älv* in the northeast. The demarcations coincide with the boundaries of the Sami village *Ståkke*. The water level of the rivers rise from 400m above sea level in the east and 500m above sea level in the west. Lakes are common in the area and their outflow is connected by streams to either of the large rivers. The topography, in general, shows a northwest-southeast orientation. The interior comprises hilly areas with extended ridges as well as solitary mountains with elevations up to 800m above sea level. The overall appearance of the land surface is irregular and ribbed with fairly large scale transverse ridges (Rogen morain). The moraine is

FIGURE 1. Location of the study area.

composed of coarse stony till, often with a surface cap of large boulders. There are also areas of boulder fields. The dominant land cover is coniferous forest. Forests dominated by Scots pine (*Pinus sylvestris* L.) are common at lower altitudes, near the large rivers. On the mountain slopes, pine is replaced by Norway spruce (*Picea abies* (L.) Karst.) and mountain-birch (*Betula pubescens* ssp. *czerepanovii* (N. I. Orlova) Hämet-Ahti). The entire interior of the west part of the study area is covered with birch-dominated forest, with some high mountain peaks above the tree line. Mountain-birch forest is also found in the north. Wetlands are common and often have a ridged structure because of the

underlying Rogen morain. The eastern part contains the most wetlands and includes the largest coherent wetland habitats.

The study area lies in the centre of the Scandinavian peninsula and, therefore, the Atlantic Ocean in the west and the Gulf of Bothnia in the east have only a limited effect on climate. The temperature range over the year is large, with a mean of -13ºC in January and +14ºC degrees in July.[15] Precipitation amounts to about 700mm, distributed evenly throughout the year. The local climatic variations within the study area are mainly due to differences in altitude and proximity to the two river systems. The growing season is about 120 days long and begins at a time when daylight lasts almost 24 hours. Frost during the early period of growth is unusual, but temperatures below zero degrees are common towards the end of the growth period, and commence in late July or August. Snow covers the ground from October or November until late April or May and the maximum depth, of 70 to 80 cm, is reached in March. In the autumn or early winter and in periods of melting during the winter, some layers in the snow cover become hard or coarse-grained.

Sources for the study and analyses

The study is based on an interdisciplinary approach in which primary historical sources (maps, delineation documents, forest management plans and parish registrations) are combined with modern vegetation and topographical maps and a field study to express historical land-use patterns in ecological terms, and to link them as strongly as possible to landscape features.

Primary sources are the archives at the Swedish Forest Service (currently Sw. Sveaskog, previously Sw. Domänverket) and the regional office of the

TABLE 1. Unpublished surveys and maps used in this study.

The Land Survey Office, Luleå, Sweden (Lantmäteriet LM)
Delineation maps and documents for Arjeplog Parish 1891- (Avvittringshandlingar, Arjeplogs socken); Eggeltj, Ståkke, Strand and Holm (aktnr APJ 44:55, APJ 44:39, APJ 44:40, APJ 47, 52, APJ 106:236)
The provincial archives, Härnösand, Sweden (Landsarkivet LA)
Forest service (Domänverket)
Forest management plans with maps
Malmesjaurs revir
State forest area Eggelats block II 1924
State forest area Granliden 1925

Swedish National Land Survey (Sw. Lantmäteriet). The specific sources used are delineation documents and maps, the earliest forest surveys, and foresters' reports, from 1891–1925 (Table 1). Written sources include both quantitative data on forest structure, arable land and haymaking areas plus some qualitative data on aspects such as grazing practices. The maps could easily be combined with modern maps in order to characterise important landscape features connected with historical land use.[16] Maps illustrate the coverage of arable land as well as the scattered haymaking areas (Figure 2). A field study was furthermore conducted in order to validate information on the historical maps and survey for traces of past land use in the forest, especially culturally modified trees. Fortunately, some old-growth forest had been preserved surrounding three different Sami huts and was carefully surveyed for culturally modified trees.[17] The area closest to the Sami huts, within a radius of 100 metres, was surveyed completely. A wider area, with a radius of 500 metres was surveyed using transects 20 metres wide and 180 metres apart. Any live, culturally modified trees were photographed, measured and cored, in order to date the modification dendrochronologically.[18]

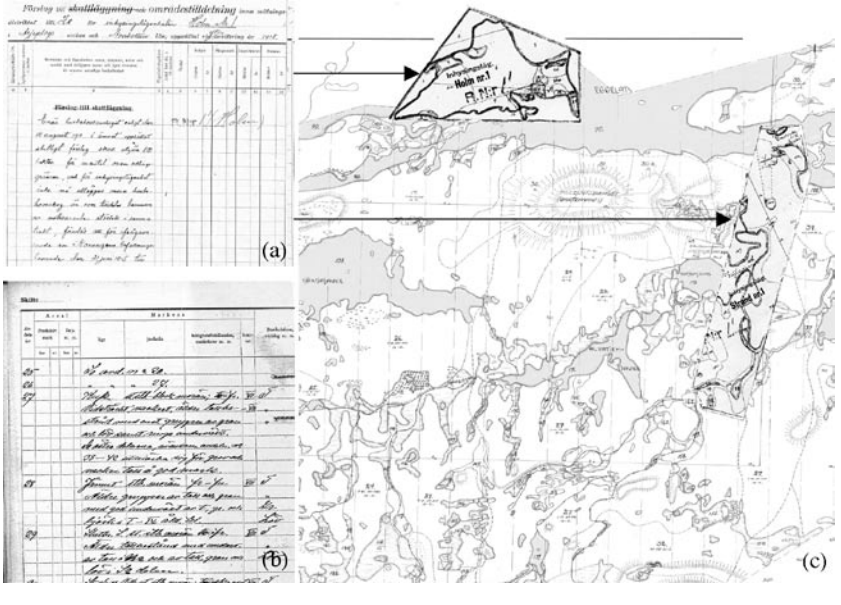

FIGURE 2. Primary sources. Delineation documents (a) and forest management plans (b) were linked to maps (c) and the information concerning land use were combined.

RESULTS

Sami land use

The Sami have adapted to the environment and climate of the northern interior of Sweden over a long time, and have developed methods to utilise the natural resources, including the reindeer, in this region. Northern Scandinavia is characterised by a sharply seasonal climate, with long winters and a short growing season. One obvious adaptation has, therefore, been seasonal movements due to shifting resource availability over large landscapes. The intensive nature of reindeer herding and the importance of other resources, such as fishing and hunting, determined movement patterns. Forest reindeer husbandry in the study area included milking the cows and was very intensive, with a break of only a few weeks in late spring and early autumn. Several forest Sami families herded reindeer in one large herd (about 200 reindeer) during the winter and in two separate herds during the summer.[19] The wintering area was mainly in the south-eastern, low-altitude part of the study area and extended down between the two rivers Skellefte älv and Pite älv. The summer sites were in the west and north high-altitude areas, with an elevation over 500 m above sea-level. The size and extent of the summer grazing areas has changed over time and the Sami territory extended further west up into the mountainous region prior to the nineteenth century.[20] The many settlements established by the forest Samis were, as a rule, located close to a fishing lake and were separated by only a few kilometres, making the seasonal movements relatively short.[21]

Summer areas were located in the high-altitude mountain birch forests (Figure 3a). After the period of calving, from the middle of May to the middle of June, the intensive summer milking period began. From late June to the middle of August the reindeer were gathered together all day on specific milking grounds, consisting of moist moor, where they could graze on the vegetation of brushwood, dwarf birch (*Betula nana* L.), grasses and herbs.[22] The leaves of deciduous trees and shrubs were important reindeer-food. Birch-bark was harvested and contributed to the human diet.[23] The reindeer entered the milking-grounds voluntarily. These often consisted of timber enclosures, in which smoking fires had been started, providing an environment free of biting insects.[24] During the evening, the herd was moved away from the milking grounds onto night-time pasture. This pastureland was an open, water-rich mire or swamp and foraging was directed towards the herb- and graminoid-rich plant communities.[25] The most nutrient-rich mires, habitats for waterclover (*Menyanthes trifoliata* L.) and horsetail (*Equisetum* sp.), were thought to be the most attractive for reindeer. The choice of mire for the night changed over time due to the risk of destruction by trampling, especially on small mires. Nevertheless, moderate grazing promoted the growth of grasses.[26] The enclosures were built out of timber,

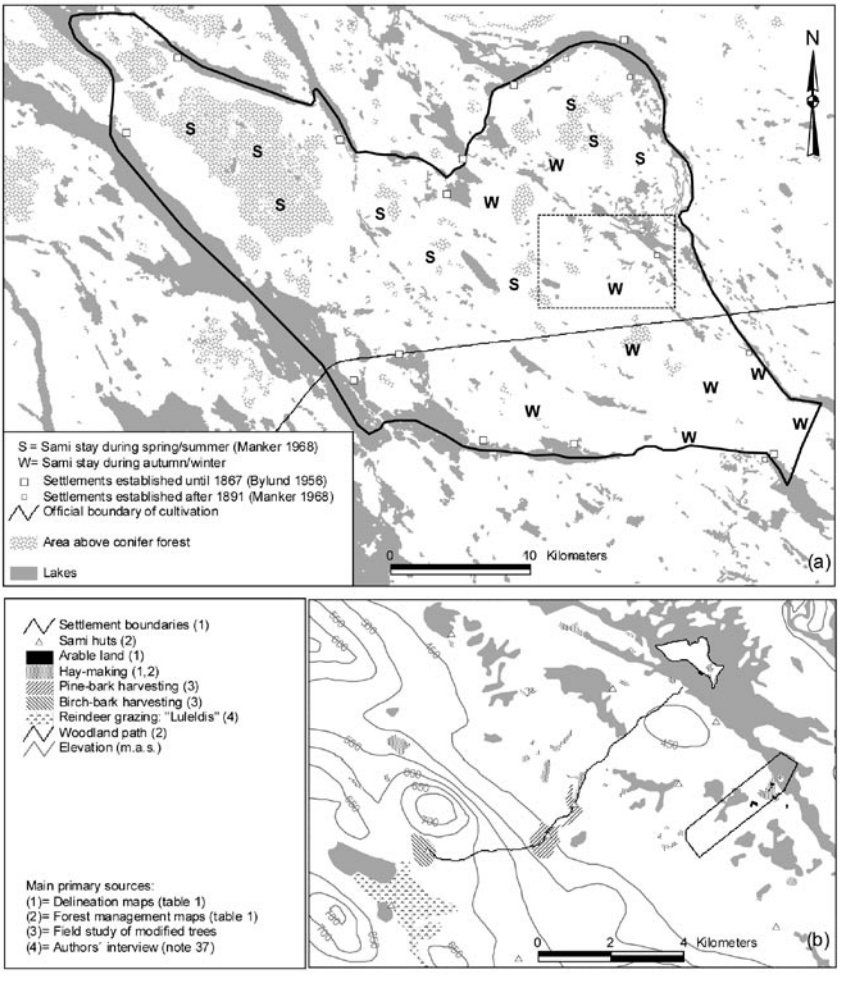

FIGURE 3. Historical land use patterns. Overview of the studied area (a) and a magnified section (b) showing landscape features derived from both nomadic and farming cultures and illustrative for the land use transition 1850-1930.

about four or five logs in height, and simply dovetailed at the corners.[27] The enclosure diameter was usually about 30 metres.[28] The fireplaces, constructed to deter biting insects, were usually made of three logs from dead standing trees, placed on the ground edge-to-edge. Spruce-twigs and moss were then added to generate the required smoke.[29]

When the temperature fell at the end of August, there was a shift in reindeer food preference. The major new component in the reindeer diet became mushrooms.[30] Large numbers of these were found in moist conifer forests with mosses and brushwood. Because of the scattered nature of this resource, and the reduction in the number of insects, herding was difficult at this time. The mating season lasted for approximately two weeks at the end of September. Before the mating some of the males were usually slaughtered. When the first snow arrived, tracking became possible and herding was easier again. The reindeer continued to graze as long as the grass (*Deschampsia flexuosa* L.) was visible through the snow. Hunting and gathering were important activities during the autumn and spring when reindeer herding did not require so much attention. Forest birds, such as Western Capercaillie (*Tetrao urogallus*), and small mammals were trapped using a variety of springs and traps. Berries, plants and plant parts were collected.

The inner bark of pine and birch were used as a standard plant food resource as well as for many other purposes.[31] Traces of such use (Figure 4a) were found on many living and dead standing trees in clusters within the areas investigated.[32] Of the 51 scars found, 20 were found on dead trees and 15 could be dated. Most of the scars were found around the 'Etkes' settlement located in the pine forest. Here, the mean density was 1.8 bark-peeled trees per hectare. Dating the scars indicates harvest events mainly in the 1830s to 1860s (Figure 4c). The oldest scar was dated to 1779 and the youngest to 1899. The scars were mostly about 50 cm long, but their length ranged from 12 to 130 cm. The majority of affected trees were pines, but four of them were birches, and were found around the 'Pejveltis' settlement located in the mountain birch forest (Figure 3b).[33]

When the snow covered the ground in late October, the diet of the reindeer changed. Lichens became the preferred component of the reindeer diet during the winter, but other constituents, such as mosses and vascular plants, were also important to balance the diet with respect to nitrogen and minerals.[34] The most nutrient-rich grazing areas were found during winter in the pine-dominated lichen- and moss- moorland with brushwood (*Calluna vulgaris* L., *Empetrum nigrum* L. and *Vaccinium vitis-idaea* L.). The reindeer did not move around, but were active throughout the winter, digging out lichens from under the snow. Large areas of this habitat were used close to the large river systems in the eastern, low-altitude part of Ståkke (Figure 3a). In late winter, when the snow crust made it too difficult to reach the lichens, the localised warmer climate close to the heat-storing waters offered relatively loose snow to dig in. The main slaughter was concentrated in midwinter (new year), due to the easy handling and storage

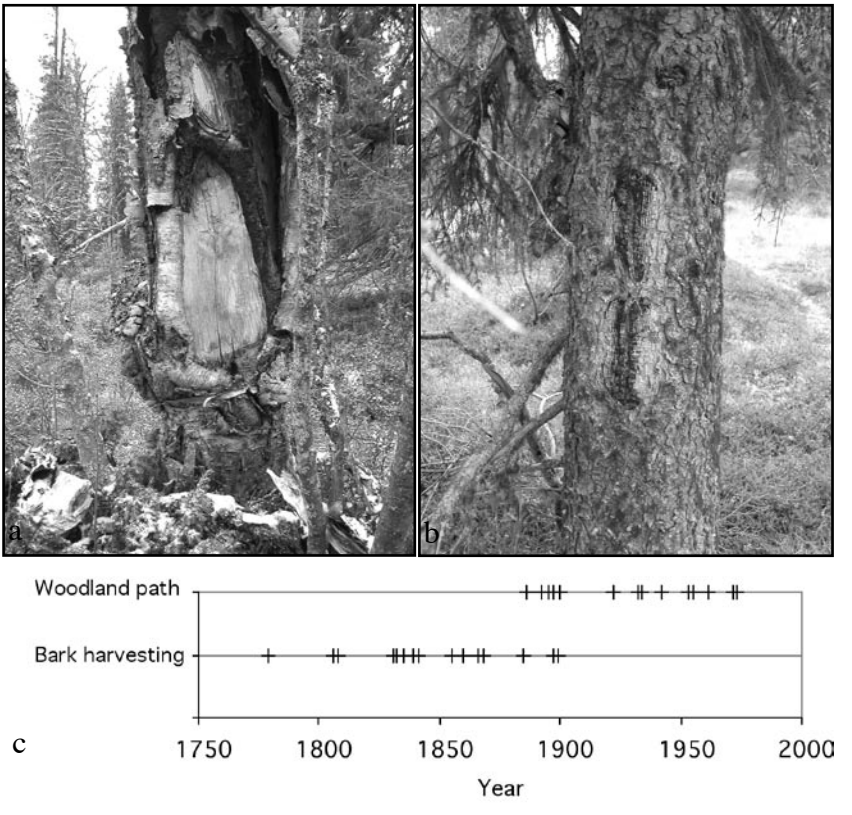

Figure 4. Traces (scars) from bark harvesting practices on birch *Betula pubescens* Ehrh. (a) and markings of woodland paths on Norway spruce *Picea abies* (L.) Karst. (b) with scar dating diagram (c).

of the meat in the low temperatures.[35] Fresh-water fish have always been a very important part of the Sami diet. The key species caught during the winter were probably rapacious carp (*Aspius aspius* L.) and whitefish (*Coregonus lavaretus* L.). Each family had its own fishing water and winter settlements were, as a rule, located close to a stream or lake.[36] Most were close to the river Pite älv. The pine-dominated forests close to the winter settlement offered enough firewood for the long, cold winter. In order to increase the availability of dead wood suitable for firewood, trees were ring-barked, a practice that later became controversial.[37] During harsh winters, when a hard snow crust prevented the reindeer from reaching lichens on the ground, an emergency supply of lichens growing in the branches of pine was made available by cutting down whole stands of the trees.[38]

Agrarian colonisation

As outlined in the state regulations during the seventeenth and eighteens centuries, the state's vision was to cultivate the 'wilderness' in the interior of northern Sweden in the same way as in the south of Sweden, with an agricultural economy based on the cultivation of cereals. However, settlers of the northern interior had to adapt to the harsh environment with its short growing seasons and extensive wetlands. This resulted in a subarctic farming economy based on several diverse resources in which natural pasturelands; hay-producing sedge bogs came to be key elements. The fishing-waters were also critical for subsistence, and were essential for new settlers to survive the first few years. Because of these special requirements, colonisation patterns resembled wedges along the river valleys, with outlying points on the shores of large lakes.[39]

During the nineteenth century, when the population and the number of new settlements increased for the first time after pioneer colonisation, the study area began to be colonised (Figure 3a). The settlers were mostly descendents of pioneer settlers coming from the south. The rivers flowed through many lakes, around islands and via shallow, slow-moving streams, thus offering suitable habitats for many fish species to spawn and resulting in plentiful fishing-waters. The first settlements in the study area were located on the banks of the southern river system (Skellefte älv). The north river system (Pite älv) was not colonised until the mid-nineteenth century. At this time, the state began to exert more control over the colonisation process, in order to protect timber, which was increasing in value.

However, there was also an increasing need for local forestry labour, and in the early 1890s the colonisation process accelerated again. In 1892, the study area was divided into private land and state-owned land and an official boundary of cultivation was established by the government beyond which no new settlements would be allowed. This was to protect the Sami territories. Despite this, several spontaneous settlements were legalised within the state-owned forests and beyond the boundary of cultivation. These were the most remote outposts of settlement and represent the last phase in the colonisation of the interior of northern Sweden.

The main goal when the state initiated a new settlement was that it had to be self-sufficient.[40] It had to be possible to cultivate the soil and the scattered resources needed to be sufficient to feed the livestock and settlers. The size of the allotted areas varied, but they had to be relatively extensive in marginal positions close to the mountains or in areas with poor soils, in order to be able to support the settlers. The government calculated tax based on the yield of the different meadows and fields and the resulting figure reflected the productivity or size of the settlement. Two of the last settlements to be established in the study area were *Strand* and *Holm* (Figure 3b). These settlements were established in 1892, then in 1918 additional areas with timber-resources were allotted to them. The buildings of the Strand settlement were located only about 100 metres from

the shore of Eggelats, a lake in the Pite älv drainage basin. The arable land of Strand consisted of several plots on sandy humus. Most of the plots were located within 100 metres of the buildings on the open, hard ground, but the largest plots were surrounded by pine forest, located a few hundred metres away. The area of arable land was 0.6 hectares and, in addition, there were 1.7 hectares of potential arable land that was not in use in 1918. The only arable plot on Holm (an island in lake Eggelats) was located close to the buildings and had a total area of only 0.13 hectares with 1.6 hectares of potential arable land. Because of the harsh climate, it was not possible to grow grain at these settlements. The fields were suitable for potatoes, a more frost-resistant crop. It was advantageous to live close to the arable plots, as they required much care.[41]

However, resources within the settlement were insufficient to feed the livestock, so there was a need for complementary grazing and fodder collection. The birch forests on the mountain slopes at higher elevations offered suitable grazing areas during the summer and the riverbanks and wetlands produced hay for the long winter. The main 'catching area' for hay for the settlements of Strand and Holm lay within approximately five kilometres of them, although scattered meadows over 10 kilometres away were also used (Figure 3b). The moisture conditions within the landscape of Rogen morain were diverse, and flooded communities of different sedge-, rush- and horsetail-species were carefully chosen for the hay-harvest.[42] The hay was placed on hay-fences where it was stored until early winter. Areas close to small streams or the shoreline of Eggelats were used most commonly. In 1918, an area of 70 hectares of fens and mesic grasslands was mown by scythe at the two settlements Strand and Holm (Table 2). Of the 53 hectares of grasslands mown by the inhabitants of Strand, 43 were located close to a stream or lake. Most of the hay-harvest for Holm was gathered from distant, scattered meadows in the state forest (73 per cent). Each summer, 378 kilograms and 115 kilograms of hay, dry weight, were collected at

TABLE 2. Hay-making areas for the settlements of *Strand* and *Holm* (hectares). Based on delineation documents (Table 1).

	Hay quality	**Strand**	**Holm**
Hard, dry ground	High	2.34	2.5
Close to river or lake	Medium	43.325	1.65
Mire	Low	7.75	11.1
Close		20.195	4.15
Distant		32.5	11.1
Total		53.145	15.25

Strand and Holm, respectively. The best quality hay came from hard, dry sites. This hay was worth twice as much as that from the mires (Table 2). Grasslands close to streams and lakes produced hay of intermediate quality.[43]

Forests were also allocated to the settlements in 1918 for domestic use, consisting of 75 and 25 hectares for Strand and Holm, respectively. In these stands, timber for buildings could be logged. The forest in the settlements, as well that of the surroundings, was pine-dominated, comprising 90 per cent pine and 10 per cent spruce.[44] Fuel wood, for heat and cooking, was also important for the settlers in this area. Dead wood was used for this purpose.

When a wetland suitable for haymaking was found outside the infields, the settlers quickly marked it to declare their right to cut the hay on it.[45] Marking consisted of setting up a hay-barn or a hay-fence, 'blazing' the trees close to the mire, or erecting a barked pole.[46] Blazing trees was a common practice, which was also used for navigating in the forest (Figure 4 b).[47] The blazes were created by cutting away a piece of bark 91±27 cm (n=78) above the ground, so that it could be clearly identified from a distance. The size of the blaze varied from seven to 65 centimetres in height (mean 32±12 cm, n=81). When bark began to grow over the blaze, new blazes were created, either on another tree or on the same one, on top of the old blaze. In this way, different generations of blazes could be distinguished along the same path. The woodland path studied ran from the settlement of Holm and exhibited two periods of blazing activity (Figure 4c). The earlier period lasted from 1886 until 1900 (n=5) and the more recent one started in 1922 and continued until at least 1973 (n=10). The trail is still used today, but the practice of blazing trees has ceased, due to pressure from the logging companies.

DISCUSSION

Nomadism, farming and the Swedish state

The agrarian colonisation of the interior of northern Sweden was driven, above all, by population growth. An important impetus therefore came from individuals who wanted to establish new homesteads, despite the difficulties associated with this harsh environment. However, the Swedish state strictly regulated colonisation, and had an interest in using the resources as efficiently as possible, so as to maximise tax income. The traditional Sami economy was highly valued since tax had been collected on the profitable fur trade since at least the fourteenth century.[48] The state introduced laws that were actually designed to protect the Sami interests, for example defining hunting areas, restricted to within five kilometres of the homesteads.[49]

The community status of forest Samis was weakened during the nineteenth century. The 'reindeer grazing laws' passed from 1886 and 1898 did not in

principle distinguish between mountain herding Samis and forest Samis, but at this time (in the national debate and when it came to state policies) a practical definition began to emerge which in effect only granted the grazing rights to the first group.[50] The forest Samis, with their relatively more restricted movements pattern and smaller reindeer herds, in reality landed outside this definition. This situation gave the forest Samis incitement to give up traditional forest Sami practices, and strengthened the ongoing colonisation process further by settling, working on small farms during the summer and in the forest during the winter.[51] The government had an interest in combining population growth with increasing agricultural production, and because fishing was of such importance for the maintenance in this region, legislation became important to ensure continued colonisation despite the climatic limitations on farming.[52] The Swedish state also promoted colonisation by granting tax exemptions to farmers.

Conflicts between Sami people and settlers often concerned fishing waters. The most suitable areas for colonisation were those close to large water bodies, moreover fishing waters, with a favourable local climate, river sediment to cultivate and extended wetland areas for haymaking. For the forest Samis, losing their fishing-rights to immigrants would have ruined the family economy. Samis who wanted to strengthen their right to the hereditary land, plus those who wanted to avoid a nomadic life because of poor health or old age, and those who had lost their reindeer, were motivated to settle.

The Sami economy was a very important factor in the settlement process. In fact, a third of the settlers had Sami origins.[53] The lifestyle of the Sami people shifted gradually and some developed a unique semi-nomadism that combined reindeer herding and farming even within the same family.[54] The settlement of Holm in the study area was established in 1892 and was occupied by a mountain Sami family in the first two decades of the twentieth century. This family used at least four additional Sami settlements (huts) scattered in the study area, and owned a herd of reindeer as well as a cow and a few goats. [55]A woodland path connecting these settlements had been marked out from 1886 onwards (Figure 3b). Widespread traces of the traditional practice of bark harvesting were also found around some of these Sami settlements. The practice of bark harvesting ended abruptly in 1899, due to the increased supply of alternative carbohydrate food items and also because of the logging. The state foresters wanted this practice to stop since the resulting bark-peeling scars lowered the value of the timber trees. All these events illustrate the swiftness of the changes in local land use that occurred during colonisation. In only 23 years the intensive reindeer herding, milking and bark harvesting practices ended when farming was introduced together with its new products and related life-style adaptations. From that point onwards, parallel approaches to the resources and environment appeared within the same landscape (Figure 3b).

Domestic animals

The change of land use and ecological consequences in the study area up to 1930 was associated with the transition from an intensive reindeer economy, which included milking the cows, into a combined reindeer-herding/cattle-breeding economy (Figure 5). The more energy that was put into cattle-breeding the less the need for reindeer milk and other products, resulting in a complete cessation of the practice of reindeer milking around 1915.[56] The number of reindeer, however, increased from a few hundred to a maximum of 2716 individuals in this area in 1931.[57] In addition, the total number of cattle increased from a few individuals to approximately a hundred, and there was a three- or four-fold increase in the number of goats during the nineteenth century. These were completely new species within the economy, and their fodder needs differed from those of the reindeer. Cattle needed to be tended in a cowshed for the whole winter, and to be fed with hay harvested from natural meadows. This created a new, inviolable framework into which the settlers' life-style had to fit.

Nomadic people	**Farmers (a)**
Reindeer-herding (increasing reindeer-herds up to 1930). Milking of reindeer (cessation in 1915) and meat production.	Cattle breeding with forest grazing and the introduction of hay-making practices. Milking of cattle (successively becoming a substitute for reindeer milking) and meat production.
Nomadic lifestyle (attending to the reindeer herds all year). With the increased size of reindeer herds and the cessation of milking, the intensive herding practices as well as the mobility decreases)	Sedentary lifestyle (staying at the settlement most of the year)

Change of land use/ecological impact in the study area 1850–1930 (b)
Increased grazing in the forests
Increased pressure on fish and wildlife
Decreased secondary deforestation (e.g. firewood) in high-altitude forests
Increased secondary deforestation in low-altitude forests
Abandonment of milking grounds
Cultivation of abandoned reindeer grounds
Introduced hay-harvesting on riverbanks and wetlands

FIGURE 5. Summary of land use and ecological impact in the study area: land use of nomadic people and farmers respectively (a), and related resource use and ecological impact (b).

Mobility

The seasonal movements associated with reindeer herding were from the low-altitude pine-dominated forests close to the large river systems during the winter to the high-altitude mountainous birch forests in the core area during the summer. The whole study area was visited during at least part of the year to utilise seasonal resources: grazing areas, food and firewood. Although forest clearance was never part of the forest reindeer-herding regime, forest stands were affected by secondary deforestation due to firewood collection and timber felling for construction. Thus, the seasonal movements of the Samis resulted in 'islands' of sparsely wooded areas around their settlements.[58] In contrast, settlers lived in the same place all year round, so the use of resources was much more concentrated within the settlement and its surroundings. The exceptions were grazing and haymaking areas, which could lie tens of kilometres away. The settlers also had reasons to clear forests intentionally, in order to increase pasture and fodder areas.[59] This requirement, together with their sedentary lifestyle, resulted in the settlers having a stronger local impact than the nomadic Samis.

The low-altitude pine-dominated forests

All twelve early settlements established before 1867, as well as the later, spontaneous settlements, were established in the only suitable environment for settlement: the areas close to one of the two river systems. These lowest altitude areas became more intensively used. New ecological systems were created within the landscape when the riverbanks and many of the low-lying wetlands were used for haymaking. The reindeer, which visited this area during winter, did not graze on these wetlands but searched for lichens in the dry, pine-dominated forest stands. The intensified exploitation of these low-altitude areas was significant, even when there was no additional modification, such as irrigation, to increase hay production.[60] A very effective way to 're-use' ecosystems were to cultivate the abandoned reindeer grounds. The arable land of Holm and Strand; sandy, hard ground with a higher growth capacity than the surroundings, was old reindeer-enclosures in which the ground had been tramped by hooves and fertilised with manure over a long period. This was the most suitable soil to cultivate before manure from the cattle was available to spread on the fields.

The high-altitude birch-dominated forests

It was in the state forests that the agrarian colonisation reached the limits imposed by the physical conditions. Colonisation never reached the birch-dominated mountain forests above the conifer forest, although these high-altitude areas were used by the settlers for summer farming. Livestock numbers (cows and goats) were, however, always low and summer farm settlements never developed as they had in central Sweden and Norway.[61] The most obvious intensification

of land use in these high-altitude areas was the tenfold increase in reindeer in the first decades of the twentieth century. Suitable grazing areas were visited and grazed more intensively during the summer. These high-altitude mountain birch forests were marginal for tree growth and only weak stresses, causing an increase in tree death and/or inhibiting regeneration, would have been sufficient to 'push' the forest limits downhill.[62] Large reindeer herds probably deforested the area named Luleldis, which was well known by the inhabitants as a grazing area and is still treeless today, although it seems to have all the prerequisites for forest growth. Ironically, when the previous intensive herding and milking practices diminished, the need to live for the whole summer in the mountains became less important, and the consumption of firewood declined. The change from intensive to extensive reindeer-herding also involved the abandonment of milking grounds: the fertilised plots of semi-natural grassland. These were then available for reforestation.

Forestry

During the second half of the nineteenth century, the northern parts of Sweden were successively drawn into participating in the international economy. New market players were the expanding mining, hydroelectric power and sawmill industries. The initial forest exploitation driven by the sawmill industries was directed towards one specific resource, large diameter pines, and was part of the moving European timber 'frontier' and the worldwide process of forest clearance.[63] To exploit the boreal forests, there was a need for local manpower, and the sawmill companies therefore had an interest in establishing new settlements. The government decision to establish the settlements of Strand and Holm, despite their lack of agricultural viability, was a result of the potential for earning a living from work in the forest. Large volumes of timber were extracted within the study area after a storm-felling in 1899, but commercial logging did not start until 1923, when the first management plan was implemented. The two extensive water systems offered suitable watercourses for floating timber, a prerequisite for exploiting the forests at this time.[64]

Until the 1930s, logging was only undertaken during the winter, and it was possible to combine work in the forest with farming.[65] To combine logging in the forest with reindeer herding was not as simple, at least for the mountain Samis, who had to follow the movements of the reindeer herds during the winter grazing, at exactly the same time as the logging activity. In contrast, the forest Samis were more sedentary, and found it easier to undertake forest work during the winter. The local people became increasingly involved in the market economy.

Suddenly, from the 1950s, state forestry began to employ woodsmen working all year round. It was no longer possible to combine forestry with farming. Without this key subsidiary income the small peasants could not attain a socially

acceptable living standard. The small farms now became a burden to the settlers and were abandoned. The local economy based on self-sufficiency (as practised by both nomadic Samis and, later, settlers) that had lasted for thousands of years came to an end. Even the extensive reindeer herding was now incorporated in the market economy. Timber and pulp-wood was transported to the industrial sites along the coast of the Gulf of Bothnia. The new land use was directed towards a few products, it was landscape-encompassing, and driven by the needs of the industrial complexes, far from the exploited forests. The conifer forests were clear-cut and transformed into high-yielding forests with even-aged stands.[66] This dramatic transformation had severe consequences for reindeer herding. Snow compression and the presence of waste products complicated grazing and the reindeer instincts that had prompted seasonal movements were weakened. Hence, much more effort was required for the Samis to follow traditional practices.[67] Also many traces of the earlier land use, such as patterns in forest structure and culturally modified trees were erased by the logging of the old Scots pines.[68]

CONCLUSIONS

As the final wave in the last colonising venture in Europe based on self-sufficiency, the settlement of the state forests in the interior of northern Sweden lacked many characteristics of an agricultural 'frontier'. Deforestation of large areas was not common, neither was grain cultivation. As in many other marginal areas, the settlers had to adapt to the harsh environment, realising that cattle breeding was more successful than cultivation of land and that subsidiary occupations were necessary for survival. Five main issues have been raised in this case study concerning the outcome of land use and basic approaches to resources and environment during the settlement of a harsh environment.

First, there were many similarities between the Samis and the settlers when it came to resource use. The clearest illustration of this tendency here can be obtained by comparing the Samis who did not herd reindeers with the settlers during the first few years of colonisation. For both of these groups fishing was essential for survival. In addition, the forests offered dead trees for firewood as well as prey, plants and plant parts for food.

Second, disparities in land use between the natives and the settlers may evolve for many reasons (Figure 5). The Swedish state treated the two cultures differently in different periods, so as to maximise tax income. The two cultures originated from different environments and parts of the world, bringing different knowledge, perceptions and practices to the same landscape. The most obvious differences were in the animal species that were domesticated. Cows, goats and horses have completely different requirements from reindeer in terms of nursing and fodder needs.

Third, unlike many European colonisations in different parts of the world, the agricultural colonisation of the northern interior of Sweden involved the native people. The Samis actively participated in the colonisation process. When this happens, land use becomes intensified, due to the simultaneous effects of native and farmer practices on the same landscape. In the state forests above the cultivation boundary, the contribution of the Sami resource use to the local economy was most significant. However, this study cannot discern whether or not the increased diversity of resource use during colonisation would have increased resilience, or the capacity to adapt to changing conditions, because of the extremely short period of farming.[69]

Fourth, external driving forces can extend agricultural 'frontiers' spatially and temporally, for instance onto areas where the soils are uncultivable or the growing seasons too short. In most of northern Sweden, the agricultural frontier (settlement frontier) preceded the timber frontier by several decades (or more, in some case). However, in this case, when the settlement frontier reached the least productive land in the most northerly locations and at the highest altitudes these two 'frontiers' were almost simultaneous. This resulted in settlements in very unfavourable places because the settlers could rely on getting work in logging even if the growing of crops had little success. Without the growing Swedish sawmill industry and the increasing need for timber on the European market, the colonisation process would have ceased in the nineteenth century and never reached the last outposts within the state forests. From a settlers perspective the agricultural frontier and the timber frontier in this area merged into one.

Finally, the mountain birch ecosystems, found along the whole Caledonian mountain range, stand out as having a unique land-use history. Neither agriculture nor forestry ever reached these forests. While forestry has overwhelmed nearly all traces of previous human impact in the low-altitude pine-dominated forests, the high-altitude birch-dominated forests still show evidence of the nomadic Sami land use and the change in organisation of this land use during the twentieth century.[70] Similarly, the historical traces found in these forests today mainly have Sami origins.

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NOTES

[1] The history of the worldwide woodland clearance is discussed in Williams 2000.

[2] For the history of pioneering settlers, see Campbell 1982.

[3] For the colonisation until 1867 see Bylund 1956, inserted map 1; Arell 1979, 27–9, 31.

[4] For colonisation mainly controlled by the state cf. Wood 1997.

[5] Mörner 1982, 320.

[6] Mörner 1982, 320–3.

[7] Mörner 1982, 325; for opposite conditions see e.g. Castro 2002; Brunger 2003.

[8] Mörner 1982, 325; for the situation in Canada, cf. Jarvenpa and Brumbach 1985.

[9] Lundmark 1982, 75–7; Lundgren 1987, 53–5.

[10] Cf. Roy et al. 2002, 154.

[11] The distribution of settlements is discussed in Bylund 1960.

[12] E.g., Arell 1979, 49–52.

[13] For the colonisation on state forest areas see Bergström 1979, 22–23.

[14] This is also a unique fringe zone with socio-economic peculiarities: Payette et al. 2002, 15.

[15] Hultblad 1968, 23–4.

[16] The recent maps used in this study were Vegetationskarta 25 H Arjeplog, 25 I Stensund, 26 H Jäkkvik, 26 I Luvos (Lantmäteriet 1985–1992); Blå kartan 25 I Stensund, 26 I Luvos (Lantmäteriet 1996–1997).

[17] For different applications concerning studies of culturally modified trees see e.g. Kaye and Swetnam 1999; Prince 2001.

[18] For a description of the concept of culturally modified trees (CMTs) see for example Mobley and Eldridge 1992; Östlund et al. 2002. For coring and dating of scars in living trees see for example Sheppard et al. 1988; Ericsson et al. 2003.

[19] Manker 1968, 85.

[20] Djupedal 1987.

[21] Sami settlements (huts) are included in modern (Sw. Blå kartan) as well as forest management maps (table 1).

[22] This intensive period of herding is described in detail in Ruong 1943/44, 129–32.

[23] Drake 1918, 154.

[24] Ruong 1943/44, 132–4.

[25] Mårell et al. 2002, 860.

[26] Modern vegetations maps (Sw. Vegetationskarta) with multiple wetland and birch forest classes offered the possibility to control that the needs for pasture close to the Sami settlements within the study area were satisfied, which strengthened reliability of secondary sources.

[27] Manker 1968, 200–5.

[28] Östlund et al. 2003, 79.

[29] Ruong 1943/44, 132–4.

[30] Hultblad 1968, 137; Gaare and Skogland 1975.

[31] Drake 1918, 154. The primary purpose for the Samis to take inner bark from pines and birches was to use it as food. The largest bark-peelings (> c. 80 cm in length) were done for this reason. Smaller inner bark sheets were used for wrapping of sinews, see Zackrisson et al. 2000. A comparative practice of taking bark for food can be found in Canada, see for example Gottesfeld 1992.

[32] Aggregation of bark-peeled trees is discussed in Marshall 2002; Östlund et al. 2003.

[33] However, the authors have observed that Sami historical traces such as wooden foundations of abandoned Sami huts as well as pine trees with scars from bark harvesting were not only connected to the registered Sami settlements (included in maps) but also have a more scattered distribution in the landscape. This indicates an ancient presence of Samis and a change in the distribution of Sami settlements and the coherent use of natural resources in the past centuries.

[34] Storeheier et al. 2002, 156.

[35] Hultblad 1968, 136.

[36] Manker 1968, 87.

[37] Cf. Stubbs 1998. Traces from this practice are included in the concept of culturally modified trees, see Östlund et al. 2002, Figure 2b.

[38] Authors' interview: Valter Nilsson Stokki, Oct. 2002, Snierra (Strand), Arjeplog.

[39] Enequist 1960, 213.

[40] Arell 1979, 32–4.

[41] Arable land was carefully described in the delineation documents and maps and also mentioned in the forest management plans. The viability of the farms was measured in terms of census (Sw. mantal) where a farm with 1/1 census could support one family. The studied 'farms' *Strand* and *Holm* only had a census of 3/32 and 1/32 respectively.

[42] Bylund 1956, 292–3.

[43] The hay-making areas and their productivity were carefully measured and described in delineation documents and maps. This indicates their high importance in family economy, equivalent to arable land.

[44] Not showed in this study, the first forest management plans include a complete mapping of the forest and details of stand characteristics, e.g. age distribution.

[45] Campbell 1982, 172.

[46] Campbell 1982, 172; Östlund et al. 2002, 54–5.

[47] Ågren 1984, 269; Ericsson et al. 2003, 284–5.

[48] The role of merchants responsible for this tax collection is described in Lundmark 1998, 18–24.

[49] Moritz 1986, 58.

[50] Lundmark 1998, 108–9; The practical definition was connected to the preferences for large reindeer herds, see Lundgren 1987, 64; Also, cf. Lundmark 1982, 75–7.

[51] Thus, participating in the colonisation process, see Lundgren 1987, 65.

[52] Lundgren 1987, 77–8.

[53] Mörner 1982, 325–6.

[54] Hultblad 1968, 146–7.

[55] Authors' interview *op. cit.*

[56] Ruong 1943/44, 128.

[57] Manker 1968, 85.

[58] Östlund et al. 2003, 83–5.

[59] Eriksson 1997, 63–5.

[60] For examples of irrigation systems see Campbell 1982.

[61] Cf. Ericsson et al. 2000; Olsson et al. 2000.

[62] E.g. Payette et al. 2002, 16–8.

[63] Björklund 2000, 174–5.

[64] For the importance of watercourses for the timber industry see Törnlund and Östlund 2002, 86.

[65] Bäcklund 1988, 121–123.

[66] Östlund et al. 1997, 1203; Linder and Östlund 1998, 15–7.

[67] Lundgren 1987, 93.

[68] Östlund et al 2003, 85–7

[69] For a discussion of cultural transitional areas – zones where two or more cultures converge and interact – and of social-ecological resilience see Turner et al. 2003.

[70] For a discussion of human impact of the tundra-taiga interface see Vlassova 2002 and Callaghan et al. 2002.

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