

Transitions in herd management of semi-domesticated reindeer in northern Finland

Timo P. Helle¹ & Lotta M. Jaakkola²

¹ Finnish Forest Research Institute, Rovaniemi Research Unit, P.O. Box 16, FI-96301 Rovaniemi, Finland (e-mail: timo.helle@metla.fi)

² Environmental sciences, P.O. Box 35, FI-40014 University of Jyväskylä, Finland

Received 9 Jan. 2007, revised version received 5 Nov. 2007, accepted 2 Mar 2007

Helle, T. P. & Jaakkola, L. M. 2008: Transitions in herd management of semi-domesticated reindeer in northern Finland. — *Ann. Zool. Fennici* 45: 81–101.

In northern Finland, reindeer-herd management has experienced two major transitions: extensification of intensive herding, and development of supplementary/corral feeding in winter. The transitions were studied in six herding associations in different parts of the Finnish reindeer management area. It was suggested that intensive herding turns into more extensive forms as the reasons for intensive herding (predation, reindeer disappearing to foreign areas, protection of agricultural fields) gradually ceased to exist. The results of the study, based on interviews of elderly reindeer herders, were variable. In the three southern areas intensive herding changed to the free ranging system at the latest during WWII, whilst in the northern areas intensive herding was replaced by extensive herding with the aid of snowmobiles in the 1960s. In the southern herding associations, especially, supplementary/corral feeding in winter was considered necessary, from the 1970s onwards, to compensate for the loss of arboreal lichens associated with forest regeneration.

Introduction

The theory of hierarchical habitat selection describes the habitat selection of animals at the scale of patch, landscape and region (Senft *et al.* 1987, Peterson & Parker 1998). In the case of reindeer (including caribou) (*Rangifer tarandus*), the patches used by reindeer in winter are the feeding craters made by the animals in the snow, or other objects such as a tree bearing arboreal lichens (*Alectoria* sp. and *Bryoria* sp.) (Rettie & Messier 2000, Johnsson *et al.* 2002). The main factors affecting habitat selection at the patch level are dietary preferences, food biomass and food availability, the last of which is determined by the characteristics of the snow cover (Pruitt

1979, Johnsson *et al.* 2002). The landscape consists of a collection of such patches, and the factors guiding decision-making are therefore mainly the same as those at the patch level. For reindeer, the regional level often corresponds to the area of the seasonal home ranges, and the main factors affecting the decision making of the animals are site fidelity, primarily expressed with respect to calving grounds and summer pastures (Helle 1980a, Schaefer *et al.* 2000).

Although semi-domesticated reindeer mainly use the same habitats as their wild ancestors, reindeer herders have had a considerable influence on reindeer habitat selection. This presupposes that the reindeer are herded, *viz.* kept under control. In full nomadism, herding was

self-evident throughout the year, but herding in winter continued when associated with permanent settlement. Herding has been necessary to protect reindeer against large predators, and to prevent the reindeer from moving into the area of neighbouring herding associations (Itkonen 1948, Kortessalmi 1996), as well as causing damage to agricultural fields or stored hay (Reindeer Management Act 1932). In addition, herders were ready with their herds for the seasonal migrations and to respond, within the winter pastures, to changes in local food availability by moving to more suitable areas (Itkonen 1948, Beach 1981: 92–93).

The herders, as well as anthropologists, have traditionally divided herding into two forms, intensive and extensive (Tomasson 1918, Ruong 1964, Hultblad 1968, Beach 1981: 34–36, 499–500). Furthermore, in northern Finland herding has to a great extent been replaced by a free-ranging system (Kortessalmi 1996) or ranching (Ingold 1980), in which reindeer was gathered only twice a year. Supplementary feeding started in the southern half of the Finnish reindeer management area in the late 1960s, spread rapidly towards the north, and has had a drastic impact on management routines (Helle & Saastamoinen 1979, Nieminen & Autto 1989, Kumpula *et al.* 1998).

According to Ruong's (1964) basic definition, the form of herding is the product of inter-relationships between land, reindeer and man. Thus the transition in herd management might be linked to the changes in these inter-relationships. Ruong's (1964) "land" comprises various aspects of grazing conditions, including the impacts of reindeer grazing and other forms of land use. First of all, the herding form has to be adapted to the fragmented grazing lands associated with modern forestry (Beach 1981: 267). In northern Finland, the diverse conflict between reindeer management and forestry goes far back in history. Up until the beginning of the 20th century, reindeer herders felled trees rich in arboreal lichens for reindeer ("reindeer cuttings") in mid and late winter in the southern part of the reindeer management area (Kortessalmi 1996), which is a practice that the forest authorities and foresters considered to be a waste of wood (Metsähaltilus 1907, Heikinheimo 1920). From the early

1960s onwards, reindeer herders have blamed that cuttings cause damage to the most important winter pastures (Aikio 1975, Sipilä *et al.* 2000, and Annual reports of the herding associations of Ivalo and Hammastunturi). That is in agreement with the findings that semi-domesticated reindeer and wild ruminants dwelling in forest areas prefer in winter mature or old-growth forests, irrespective whether the animals are feeding upon reindeer lichens (*Cladina* ssp.) or arboreal lichens (Chichowsky 1989, Helle *et al.* 1990, Goward 2000, Kumpula *et al.* 2007).

The purpose of this study was to describe the forms of herding in use at different times and in different areas, to identify relevant factors and changes in such factors using Ruong's (1964) "herding triangle" as a frame, and to evaluate their relative importance for the intensity of herding and development of supplementary/corral feeding in northern Finland. In order to avoid the confusion caused by the historically and geographically variable use of the terms "intensive" and "extensive" herding (Ruong 1964, Beach 1981: 509–510), we applied the theory of hierarchical habitat selection (Apps *et al.* 2001, Rettie & Messier 2000, Johnson *et al.* 2002) in describing the herding form. The study covers the period from the 1930s to the 1980s, and is based on interviews with elderly reindeer herders. In economic terms, the form of herding is primarily determined by the size of the investment *versus* the return (Beach 1981: 333, 474–476). As result, we suggested that intensive herding changes to more extensive herding in conditions where occurrence of large predators, straying of reindeer into foreign areas, and damage to stored hay, no longer cause any considerable costs to reindeer management, or side-jobs provided higher incomes than intensive herding. In addition, we examined the effect of the condition of winter pastures and forestry-mediated changes in forest structure on the transition process and on the development of supplemental/corral feeding.

Background of the study

Herd-management practices

In Finland, reindeer husbandry reached approxi-

mately its present distribution — the northernmost third of the country — during the 18th century (Kortessalmi 1996). In 1898, the Senate of Finland decreed that the reindeer husbandry area must be divided into herding associations, each responsible for the proper management of reindeer in its own area. A total of 65 herding associations were established, each having precisely defined borders (at present the number is 56) (Fig. 1). Every reindeer owner is a member of the local association, although the reindeer are owned individually. As regards pasture use and institutional systems, the organisation is based on the Finnish model, while some of the herding associations in the Saami area in northernmost Lapland (communities of Utsjoki, Inari and Enontekiö) have followed their own old system, in which the reindeer are managed by smaller collective units, *siidas*.

The greatest threats in traditional reindeer management were large predators, reindeer straying into foreign areas, and damage caused by reindeer to agricultural fields and stored hay. All these threats required the herd to be kept under control or the problems to be solved by other means (Itkonen 1948, Kortessalmi 1996). R. Helle (1966) described in detail the annual rhythm of reindeer management, with its range of different activities. The most drastic change since Helle's publication is, in addition to the introduction of snowmobiles, that hay making in mid-summer has been a normal summer activity of reindeer herders, especially in the southern half of the area ever since the early 1970s.

Data on the numbers of large predators are based, especially in earlier days, on bounty statistics (Pulliainen 1965, 1974, Siivonen 1972, E. Nyholm unpubl. data). The state started to pay bounties for killed large predators in the middle of the 19th century, first in southern and central Finland but, by the end of the 19th century, also in northern Finland. This continued up until 1975, when the bounties were replaced by compensation paid by the state for domestic animals killed by large predators.

In the beginning of the 20th century the number of wolves (*Canis lupus*) in the whole of Finland amounted to a few dozen individuals (Pulliainen 1965) and, according to the bounty statistics, wolves were almost totally absent in

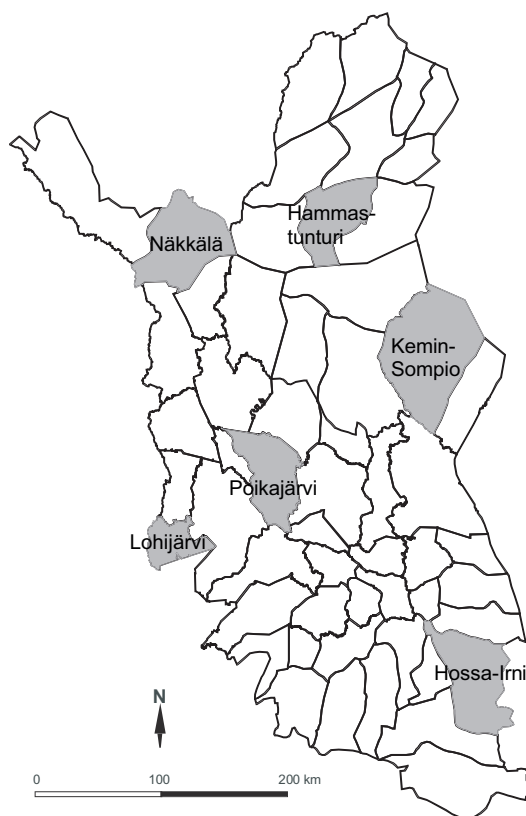


Fig. 1. The Finnish reindeer management area and the study herding associations.

northern Finland up until the end of the 1930s. Reindeer kills by wolves were reported at the end of the 1930s and early 1940s, followed by clear peaks in the late 1940s and early 1950s, the beginning of the 1960s and the middle of the 1970s. In 1975, the state paid compensation for a total of 557 reindeer killed by wolves, most of them in herding associations located close to the Finnish–Soviet Union border.

In the beginning of the 20th century, wolverines (*Gulo gulo*) occurred regularly only in the eastern and northern parts of Lapland. Annually bounties were paid for about 20 wolverines up until the 1940s. In 1951 and 1952 the number of bounties amounted to between 40 and 80, after which they stabilized to about 40 around the middle of the 1970s. In 1975, the number of reindeer killed by wolverines totalled 204, most of them in northern or northeastern Lapland (E. Nyholm unpubl. data).

The Reindeer Management Act (1932) stipulated that reindeer had to be managed in the area of their own association. The primary aim of the law was to prevent the intentional use of the pastures of a neighbouring herding association but, due to widely roaming stray animals, the law also stipulated how the reindeer found in round-ups of neighbouring herding associations were to be managed. These orders included, for instance, so called “redemption payment”, which the herding association was charged for the extra work done with their reindeer. The aim of this practice was to ensure that reindeer that had strayed into foreign areas were reported to the reindeer owner or herding association in question. Very little is known about the occurrence of reindeer thefts, although it is commonly mentioned as one reason for herding (Paulaharju 1922, Kännö 1992, Kortessalmi 1996, Alapuranen 2003).

In addition to herding, the fences built along the state borders and between herding associations served to keep the reindeer in their own area. The fence along the Finnish–Soviet Union border was built already in the beginning of the 20th century, and along the Norwegian and Swedish borders in the middle of the 1950s. In northernmost Lapland most of the herding associations were fenced during the 1960s, whilst in the southern half of the reindeer management area fencing has been uncommon.

It is a common assumption that one of the limiting factors in the old management systems based on intensive herding was labourious. The history of reindeer husbandry is full of anecdotes about how a relatively rich herder became poor when he got older, because he could no longer keep the herd under control (Paulaharju 1922, Kännö 1992). In open or semi-open terrain, the optimal herd size in relation to food availability and labour requirement ranged between 1500–3000 reindeer, although herds of up to 7000 were reported (Itkonen 1948). In normal snow conditions an average-sized herd required two men, possibly with dogs, for the daily herding activity. In difficult snow conditions, or if there was a threat from wolves and wolverines, more herders were needed and herding was necessary also during the night. More labour was needed when the reindeer were fed on the arboreal lichens of felled trees. Trees were felled for reindeer in mid

and late winter especially in the southern and southeastern parts of the reindeer management area during the late 19th and early 20th century (Heikinheimo 1920, Kortessalmi 1996).

In Finnish Lapland, intensive winter herding was commonly associated with leach-calving. The female reindeer were tethered to trees or small logs, and each day were moved 2–4 times to an area with fresh, lichen-dominated vegetation. The newborn calf was earmarked just after the birth and the female with her calf was released. Leach-calving started in April and ended in mid-June (Hannula 2000). One man could manage about 100–150 reindeer, or possibly less (Hannula 2000). Leach-calving was a widespread practice in the middle and northern parts of the reindeer management area until the beginning of the 20th century, and continued in northeastern Lapland up until the 1960s (Hannula 2000). In the 1970s a system was developed for use together with supplementary/corral feeding, in which calving took place in yard corrals (southern area) or large calving corrals (northern area) in natural pastures, where the reindeer received some supplementary food, usually dry hay. The latter system was characteristic especially in Inari.

The “snowmobile revolution”, which took place in the northern part of the reindeer management area in the early–mid-1960s, reduced the amount of manpower needed in herd management and altered the reindeer–man relationships (Pelto *et al.* 1968, Pelto 1973). Tight, continuous control over the herd became unnecessary because the animals could be gathered together, when necessary, by snowmobiles with less manpower than earlier. Another novel feature has been supplementary feeding with dry hay in winter, starting in the southern part of the reindeer management area around 1970 and spreading rapidly towards the north (Helle & Saastamoinen 1979, Nieminen & Autto 1989).

Forestry

The commercial use of forests in northern Finland started in the latter part of the 19th century (Pohtila 1979). The saw, pulp and paper mills were located on the coast. The main pres-

sure in commercial cuttings was initially on the easily accessible, dry upland forest sites along the rivers running into the Gulf of Bothnia. The low average growth and yield of these “natural” forests, reported by the 1st and 2nd National Forest Inventory (in the years 1921–1924 and 1936–1938, respectively), was a consequence of the high proportion of over-aged forests from the viewpoint of forestry. At that time, only 14% of the forests in northern Finland were less than 80 years old and the forests, over-aged from the viewpoint of wood production (Mattila 1979), covered more than 50% of the forested land area.

Forest use intensified after WWII due to the ceding of Finnish territory and the payment of war indemnities to the Soviet Union, and the need to rebuild the country’s infrastructure. As compared with the pre-war period, the amount of cuttings doubled. From the late 1940s onwards, the seed tree and shelter wood cutting methods replaced selective cuttings based on minimum diameter, and clear-cuttings requiring seeding or planting also became more and more important (Pohtila 1984). The main cutting pressure was still on the forests located along rivers and brooks that made floating possible (Pohtila 1979). In the 1950s and 1960s chain saws, tractors, lorries and mechanized road construction techniques removed the “zero limits”, and transportation of the timber became economically profitable even from the most remote areas.

In the 1960s, the main goals of the forestry programs in northern Finland were to regenerate, at a relatively fast rate, the old forests into young Scots pine (*Pinus sylvestris*) stands. The establishment of new processing plants by the timber industries, or enlargement of the old ones, set new goals on wood production. As a consequence, large clear-cutting areas appeared in northern Finland accompanied, except on the driest sites, by soil scarification (Pohtila 1979). The changes in the age structure of the forests in northern Finland are given in Fig. 2.

Material and methods

Study herding associations

This study describes the management prac-

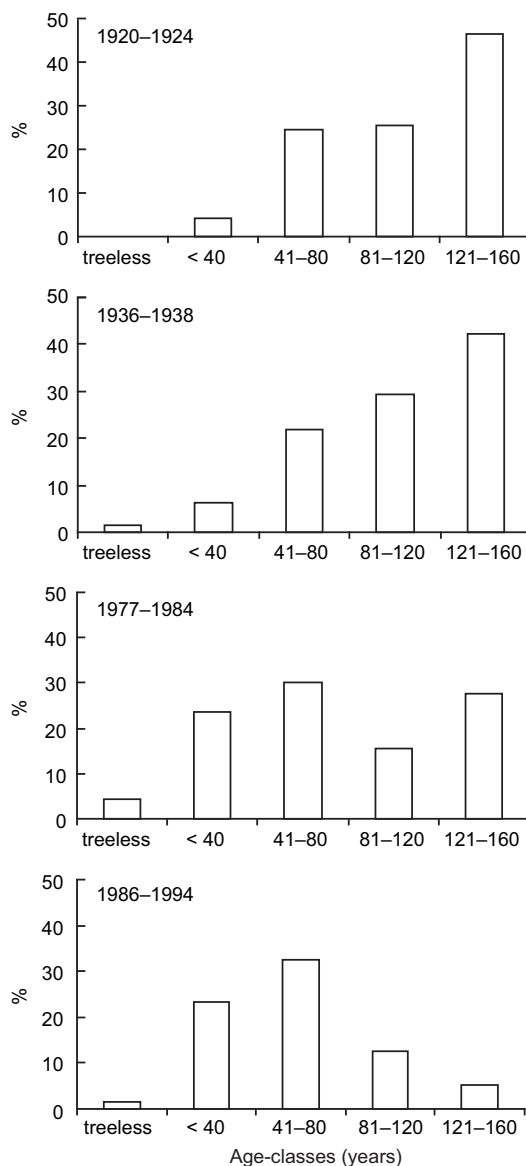


Fig. 2. The age structure of forests in northern Finland according to four national forest inventories between 1920–1924 and 1986–1994. Data covers the counties of Lapland and Oulu, from which 44% belong to the reindeer management area. Sources: Ilvessalo (1927, 1948), Kuusela *et al.* (1986) and Tomppo *et al.* (2001).

tices and transitions in six herding associations in northern Finland (Fig. 1). The associations were not randomly selected, but the aim was to find herding associations that represented the “typical” herding association in each region. In these herding associations, especially Hossa-Irni

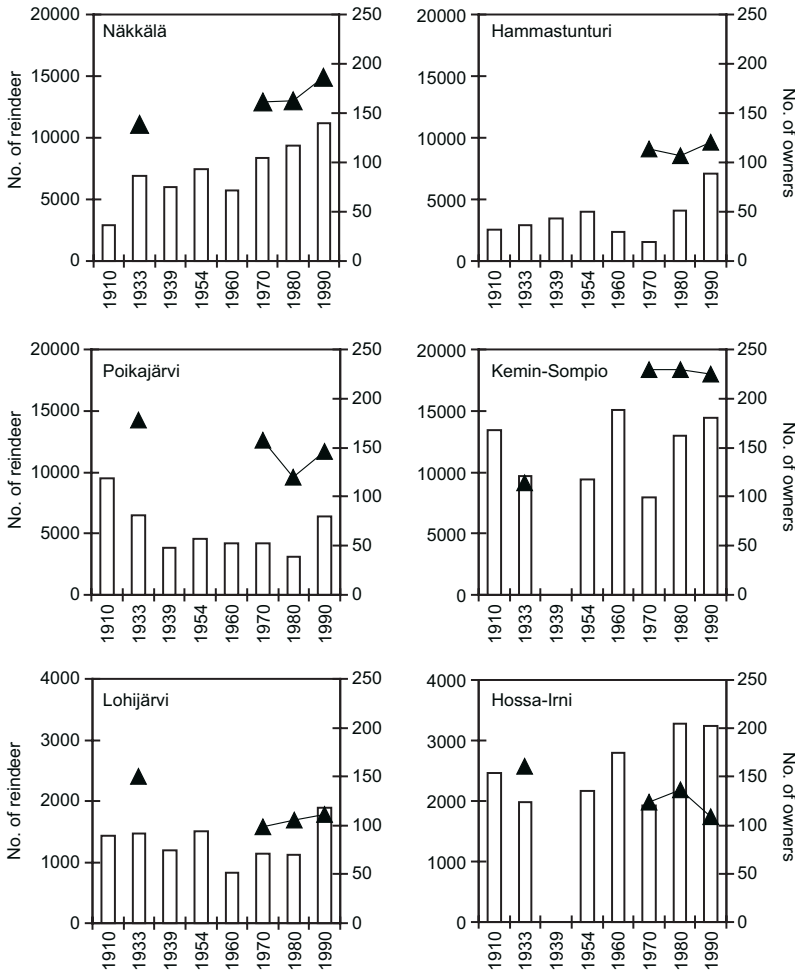


Fig. 3. The number of reindeer (columns) between 1910 and 1990 and the number of reindeer owners (triangles) at four points of time in the study herding associations in northern Finland. Source: Reindeer Herders' Association (Paliskuntain Yhdistys) and Anon. (1934).

(Kortesalmi 1996) and Lohijärvi (Holster 1948), there is more old literary information available than for most of the other herding associations. The neighbouring herding associations are, in general, very similar to each other as regards the natural conditions, reindeer density, reindeer per owner, as well as herding practices (Keisarilinen porolaidunkomissio 1914, Helle *et al.* 1980, Nieminen & Autto 1989), and therefore the results can be generalized over larger areas.

Two of the study herding associations, Näkkälä and Hammastunturi, are located on and around the coniferous forest line, which comprises both Scots pine forests and fell tops. Most of the herders are Saami. In the other herding associations the reindeer are owned and managed by Finnish people with the exception of the reindeer owners in Lohijärvi, who still in the beginning of the 20th

century considered themselves to be forest Saami, who moved from Sweden to Lohijärvi in the 1830s (Holster 1948). Data on the number of reindeer owners are available from 1933 (Anon. 1934) and 1967 onwards (Reindeer Herders' Association) (Fig. 3). The number of owners reached a maximum in the three southern herding associations (Hossa-Irni, Lohijärvi and Poikajärvi) in 1933, whereas in Kemin-Sompio and Näkkälä (data for Hammastunturi lacking) the number were higher in recent decades (Fig. 3). The average herd size for the whole period was lowest in Lohijärvi (11) and Hossa-Irni (15), and ranged in the four northernmost associations between 29 and 41. One should note, however, that the number of reindeer per household has been considerably higher, because often all the family members, including children, had their own earmark and are therefore

treated in the statistics as reindeer owners. With few exceptions, there were full-time herders only in Kemin-Sompio, Hammastunturi and Näkkälä; elsewhere reindeer husbandry has been a subsidiary livelihood combined with small-scale agriculture, dairy farming, fishing and forest work, and most of the herders also had their own forests.

The reindeer numbers in Lohijärvi, Hammastunturi and Näkkälä peaked around 1990, in Poikajärvi already in 1908, and in Kemin-Sompio in 1960 (Fig. 3). When the reindeer numbers are compared over the decades one should note that, still in the 1960s, the numbers were obvious underestimates (Alaruikka 1964). All the reindeer, spread out in the remote wilderness, were simply not found, or else confused animals could not be driven over long distances to round-up corrals; the latter case was characteristic in the 1960s during the “snowmobile revolution” (Pelto 1973, Lenstra 1975).

The reindeer numbers in relation to the total land area and area with lichen-rich land (Kumpula *et al.* 1997) are presented in Table 1. In two herding association the borders changed during the study period. Hossa and Irni, which had originally been separated, were joined in the

1950s. In order to make the reindeer numbers comparable, the reindeer numbers for Hossa and Irni were summed. Hammastunturi, in contrast, was separated from Inarin Kyrö in the 1950s, and attained its present borders in the 1960s. The reindeer numbers for earlier times are based on the assumption that the number of animals in the present Hammastunturi herding association has been proportional, with respect to the area, to the number in earlier larger units.

The gross reindeer density increases, but the density per lichen pasture decreases, on moving from the south to the north due to fact that the proportion of lichen-rich land increases along the same gradient (Mattila 1981) (Table 1).

The cuttings peaked in Turtola-Ylitornio (Lohijärvi) and Raudanjoki (Poikajärvi) already during the 1950s, and in Ylikemi (Kemin-Sompio) and Inari (Hammastunturi) 10–20 years later (Fig. 4). In Näkkälä, coniferous forests occur only on the southern edge of the area, and therefore the volume of cuttings was relatively low. Kuusamo differs from the other southern areas, since most of the forests were located, up until the 1950s, beyond the “zero limit”; the cuttings peaked there in the middle of the 1960s.

Table 1. Reindeer density (summer herd) calculated for land area (Density 1) and area of lichen pasture (Density 2) (Kumpula *et al.* 1997) in the study herding associations in northern Finland in 1910–1990. Pasture quality (condition of lichen vegetation): + = poor; ++ = moderate; +++ = good; – = lacking data (Keisarillinen porolaidunkomissio 1914, Paliskuntain yhdistys 1935, 1962, Kärenlampi 1972, Helle 1980b, Mattila 1981, 1998).

Herding association		1910	1933	1939	1954	1960	1970	1980	1990
Hossa-Irni	Density 1	0.7	0.6		0.6	1.0	0.7	1.2	1.2
	Density 2	5.4	4.4		4.7	7.7	5.3	9.0	8.9
	Pasture	++	++			+		+	+
Lohijärvi	Density 1	1.0	1.0	0.8	1.1	0.7	1.0	1.0	1.6
	Density 2	12.7	13.1	10.6	13.4	9.1	12.6	12.4	20.9
	Pasture	+	+			+		+	+
Poikajärvi	Density 1	3.1	2.1	1.3	1.5	1.7	1.7	1.3	2.7
	Density 2	19.2	13.1	7.9	9.3	10.6	10.6	7.9	16.2
	Pasture	++	–			+		+	+
Kemin-Sompio	Density 1	1.9	1.4		1.3	2.6	1.4	2.3	2.5
	Density 2	11.8	8.6		8.3	16.6	8.8	14.3	16.0
	Pasture	+++	+++			++		+	+
Hammastunturi	Density 1	1.0	1.1	1.3	1.5	1.1	0.7	1.9	3.3
	Density 2	3.3	3.7	4.4	5.2	3.8	2.5	6.5	11.4
	Pasture	++	++			++		++	–
Näkkälä	Density 1	0.7	1.7	1.4	1.8	1.7	2.5	2.8	3.4
	Density 2	2.2	5.3	4.5	5.7	5.4	8.0	8.9	10.6
	Pasture	++	–			++		++	–

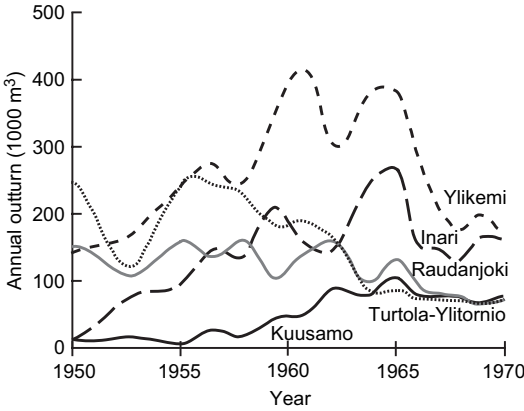


Fig. 4. The annual outturns in 1949–1970 in the forest districts of Forestry Board (Metsähallitus) covered by the study herding associations. Inari (Hammastunturi), Ylikemi (Kemin-Sompio), Raudanjoki (Poikajärvi), Turtola-Ylitornio (Lohijärvi) and Kuusamo (Hossa-Irni). Source: Metsähallitus 1948–1970, no. of register 510: 2.

Interviews with reindeer herders

We interviewed a total of 12 reindeer herders. Most of them had been involved in the management of reindeer for more than 50 years, and they all held important positions (foreman or a member, vice chairman or chairman on the board of the herding association) in the organization of the herding association, reserved for the most active professional herders (Table 2). Some of them also belonged to the board of the Reindeer Herders’ Association, the highest decision-making body in reindeer management. If more than one person was interviewed in the same herding association, then the interviewees represented different *siidas* i.e. teams.

Our approach was based on qualitative content analysis (Slater 1999). The questions posed to the interviewees (Table 3) were aimed to describe the herding methods and other management practices, and to identify the environmental, socio-economic and technological factors influencing these practices. The interviewees were encouraged to tell about things related to the actual question in order to ensure that all essential aspects were included. The interviews, which were recorded and transcribed, were carried out at interviewees’ homes. An interview lasted about 5 hours.

Table 2. Information on the reindeer herders interviewed in sex herding associations in northern Finland. Abbreviations: HA = herding association, RHA = Reindeer Herders’ Association.

No.	Name	Herding association	Year of birth	Herder since	Occupations	Duties in reindeer management
1	Veikko Väisänen	Hossa-Irni	1925	1941	Reindeer husbandry, farming	Head of HA in the 1970s, on the board of RHA in the 1970s and 1980s
2	Mikko Holster	Lohijärvi	1916	1932	Reindeer husbandry, farming	Head of HA > 25 yrs in the 1950s-1970s
3	Martti Mustonen	Poikajärvi	1926	1941	Reindeer husbandry, farming	On the board of HA 1968-85, before that foreman
4	Jouko Mustonen	Poikajärvi	1938	1956	Reindeer husbandry	Head of HA 1975–1981, vice head 1981–1987
5	Kauko Hannula	Kemin-Sompio	1931	1947	Reindeer husbandry	Foreman in the 1950s and 1960s, > 20 yrs on the board of HA since 1968
6	Voitto Leskisenoja	Kemin-Sompio	1932	1945	Reindeer husbandry	Foreman in the 1950s–1960s, on the board of HA in 1960s and 1970s
7	Matti Merivirta	Kemin-Sompio	1937	1951	Reindeer husbandry	Foreman 14 yrs in the 1960s and 1970s
8	Yrjö Mattus	Hammastunturi	1930	1945	Reindeer husbandry	On the board of HA several 3 yrs periods since 1968
9	Olavi Magga	Hammastunturi	1931	1945	Reindeer husbandry	On the board of HA in the 1960’ and 1970s
10	Juhani Magga	Hammastunturi	1939	1955	Reindeer husbandry	Head of HA 1983–1990, on the board of RHA 16 yrs., of which 13 yrs as a vice chairman
11	Juhan-Taneli Magga	Näkkälä	1931	1946	Reindeer husbandry	Head of HA in the 1970s, on the board of RHA in the 1980s
12	Esa Kumpulainen	Näkkälä	1943	1956	Reindeer husbandry	On the board of HA since 1968, vice head from the 1990s

In qualitative content analysis it is known that the concepts and terms used by the interviewer influence the answers of the interviewees (Slater 1999). Therefore in the interviews we did not use the terms for various herding forms (intensive, *tiukka* in Finnish; extensive, *löyhä*; free-ranging, *vapaa laidunnus*), because their meaning has varied with time and geographic area (Ruong 1964, Beach 1981: 509–510). The form of herding was determined afterwards based on the descriptions of the interviewees by applying the theory on hierarchical habitat selection (Apps *et al.* 2001, Rettie & Messier 2000, Johnson *et al.* 2002).

In the most intensive herd-management practices the herder regulated the foraging decisions of the reindeer at the patch scale. At the herd level, herding was considered intensive if the reindeer were not allowed to disperse over an area wider than that which two men could ski around daily and turn back reindeer trying to leave the herd. The radius of such an area was maximally a few kilometers (Itkonen 1948) and corresponded to the landscape level, or part of it, in hierarchical habitat selection.

In extensive herding the herd is dispersed over a wider area and is no longer under the constant control of the herders (Beach 1981: 499–508). The aim is to keep the reindeer within

a given part of the area of the herding association, and this corresponds to intervention by the herder at the level of several landscapes or of the region. In a free-ranging system (Ingold 1980, Kortessalmi 1996), the reindeer roam freely in small herds, except during short periods of calf marking in mid-summer and round-ups in autumn–winter. In Finland, the area of a single herding association varies between 470 and 5690 km² (Reindeer Herders' Association), but each individual reindeer does not necessarily use the whole area.

In herding by snowmobiles, the herd is commonly allowed to spread out over an area comprising several landscapes, but it can be gathered together in one or some few days, as was the case in intensive herding on skies. In this study we classify such a herding as extensive, i.e. corresponding to habitat selection at the level of several landscapes. When reindeer were given supplementary fodder on natural pastures in mid and late winter, the reindeer gathered voluntarily at the feeding places. As the hay was normally spread along the snowmobile trails crossing several landscapes, we also call such a herding practice extensive herding.

The distribution of the reindeer is not the only difference between intensive and extensive herding. The time devoted to managing the rein-

Table 3. Questions presented for the reindeer herders at the interviews in six herding associations in northern Finland.

Herding	Pastures	Change	Adaptation
Herding before WWII	Condition of the pastures reindeer lichens and arboreal lichens	At what time intensive herding ceased?	How has reindeer husbandry adapted to various changes?
Herding after WWII	When were reindeer lichens used?	What was the role of large predators?	
When and how were the reindeer herded?	When were arboreal lichens used?	When were the fences between the herding associations built?	
Why were the reindeer herded?	Were trees cut down for reindeer?	What was the role of man-power and snowmobiles?	
How many men were needed?	Did reindeer graze on cutting areas?	When did supplementary/corral feeding start and which were the reasons?	
Were the reindeer fed? How?	Were the reindeer assembled in the forest felling areas?	How were the reindeer fed?	

deer increases the tameness grade of the reindeer (Beach 1981: 430). In extensive herding using supplementary feeding, the reindeer are as tame or even tamer as in old kind of intensive herding, although contacts between the herders and animals might be less frequent. Supplementary feeding is used also in the free-ranging system. Reindeer can still select their pastures freely, and hay is transported to areas selected by the reindeer.

The analysis was continued by connecting the form of herding to various environmental, economic and technological factors, such as those described by the interviewees. In the interpretation of the results, we attempted to evaluate the relative importance of the various factors and the variation in them.

Results

Old intensive herding

The interviewees had personal experience of intensive herding, except in Hossa-Irni. Otherwise the management practices were rather similar despite the considerable differences in environmental conditions. Gathering the reindeer for round-ups normally started in November, and the largest round-ups were arranged in January–March. The reindeer were kept in separate herds in order to prevent the counted and uncounted animals from becoming mixed. After the round-ups, each *siida* i.e. herding team moved with their reindeer to their own winter grounds with lichen pastures, keeping the herd together until calving was over or the females were taken for leach-calving.

Dogs were used regularly in the three northernmost areas and, to a lesser extent, also in Lohijärvi and Poikajärvi. In Näkkälä, Hammastunturi and Kemin-Sompio, the herd was moved once a week to a new area with an undisturbed snow cover. Thus the reindeer were kept in better condition and the movement also served, as mentioned by the interviewees, pasture rotation, *viz.* an area grazed by reindeer during the winter was left outside the grazing range for a number of consecutive years in order to give the lichen vegetation time to recover.

In Näkkälä, both interviewees told that, during difficult snow conditions, the herders assisted the reindeer to crater down to the ground vegetation, even for as long as one month: the herders started the feeding craters with a shovel, allowing the reindeer to widen the feeding holes by themselves (int. 11, 12). The same was done, if needed, in leach-calving in Kemin-Sompio (int. 5, 6, 7). There, the females were taken into leach on the average on 8 April, when the ice-crust period was still to come. Arboreal lichens were also used to keep the reindeer in the herd by felling single, less valuable trees or, more commonly, by cutting off dead branches rich in arboreal lichens from the trees onto the snow. This was practiced in every herding association involved in this study, in the southern areas more commonly than in the northern ones.

Depending on the snow conditions, intensive herding could be changed into extensive herding or the free-ranging system. The best-known case is Lohijärvi (int. 2, Holster 1948), where “bad winters” occurred in 1893–1968. Icing in early winter or deep and hard snow in mid-winter caused problems for the reindeer in 15 winters, six of which (1911/1912, 1935/1936, 1939/1940, 1948/1949, 1954/1955 and 1968/1969) were considered “famine years” due to the high winter mortality and a low calf crop. In “bad winters” the reindeer were allowed to disperse and feed on arboreal lichens, although they were intensively herded in “normal winters” before WWII. However, in April–May the reindeer gathered in their normal calving ground, where they were taken under control and managed as one herd until August. In summer female reindeer were milked up until the late 1930s (int. 2), which was at that time completely exceptional outside the Saami area in northernmost Lapland.

In Kemin-Sompio the reindeer were released from intensive herding in February–March in four winters during 1942–1964 due to the excessive snow conditions, which prevented access to reindeer lichens and caused failure in leach-calving (int. 5, 6, 7). Even in “normal” winters reindeer attempted to disperse to seek arboreal lichens (mainly in old Scots pine forests) that dropped onto the snow after winter storms (int. 7). In Näkkälä and Hammastunturi, an occasional thick and hard snow cover in the forest

pastures was avoided by taking the reindeer to the adjacent fells, where food availability was better on the wind-swept slopes (int. 8, 9, 10, 11, 12). The herd was allowed to disperse over a wider area than in intensive herding. However, if an ice layer covered the fell pastures, reindeer were allowed to disperse for feeding on arboreal lichens; in the northern *siida* of Näkkälä even mountain birch forests were considered important (int. 12).

Extensification of herding

The transition from intensive herding to more extensive practices took place during a time span of about 40 years, starting in the late 1910s in the Hossa-Irni herding association, and in the northern herding associations in the 1960s (Fig. 5). In the three southern herding associations intensive herding changed abruptly to the free-ranging method, whilst in the north intensive herding was replaced by extensive herding based on the use of snowmobiles. In Lohijärvi and Poikajärvi the transition from intensive herding to the free-ranging system took place during wartime (1939–1945). In Kemin-Sompio intensive herding ceased during wartime, because it was located in the frontline area occupied by Finnish, German and Soviet troops.

As regards the protection of reindeer against large predators, it was a common experience among the interviewees that the “worst killer” was the wolf, followed by wolverine. Losses caused by wolverines to herded reindeer were generally rather small, whilst dispersed reindeer were easy prey for wolverines (int. 1, 7). Nevertheless, the transition was not directly related to the decline in the numbers of wolves and wolverines. In the beginning of the 20th century, wolves were absent but wolverines rather common in Hossa-Irni. Lohijärvi and Poikajärvi were the only areas that were practically predator-free prior the transition, and the occurrence of wolves and wolverines was occasional already in the 1920s and 1930s. In Kemin-Sompio, Hammastunturi and Näkkälä, wolverines were a constant threat to the reindeer in the beginning of the 1960s during the time of extensification of intensive herding. Predator peaks, such as that

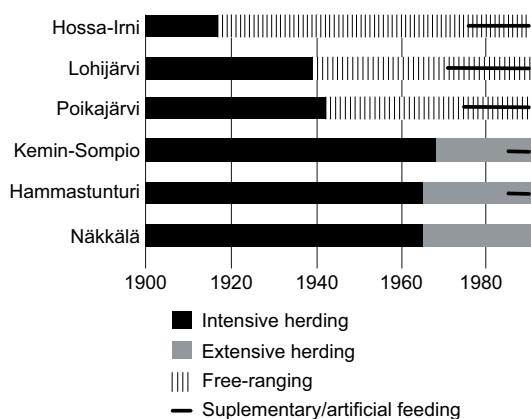


Fig. 5. Transitions in the herd-management of semi-domesticated reindeer in the study herding associations in northern Finland in 1900–1990.

in Hossa-Irni in the mid-1960s (11 wolves killed in one winter) or in Kemin-Sompio in the late 1960s and early 1970s (a lot of wolverines), did not result in return to intensive herding. In Hossa-Irni, the development of corral feeding in the 1980s was, at least partly, associated with the high predator risk in areas close to the Soviet border (int. 1).

In those herding associations where transition took place despite a prevalence of wolves and especially wolverines, many herders used the time released from herding for predator control, which was encouraged by “killing payments” paid by both the state and the herding association (int. 7). Therefore, professional hunters also participated in predator control, before the state began to compensate in 1975 for the losses caused by large predators. The wolverine has been protected since 1979, but there is still a hunting season for wolves.

The importance of fencing as a necessity in transition was variable. Hossa-Irni and Kemin-Sompio had fences along their borders already in the beginning of the 20th century, or at least in the most critical directions (the eastern national border), and they were considered to be an important factor making the transition possible (int. 1, 5, 6, 7). During the time of transition during WWII, Lohijärvi and Poikajärvi had no fences on the borders of the herding association (int. 2, 3). In Näkkälä and Hammastunturi fences were built in the beginning of the 1960s, which

the interviewees considered to be an important factor that made intensive herding unnecessary.

As regards runaway reindeer, the interviewees in the three southern reindeer associations told that it was an old rule that foreign reindeer must be handled as one's own animals (int. 1, 2, 3, 4). It was a common practice, also elsewhere, that the herding associations sent their representatives to the round-ups of neighbouring associations, where they decided what to do with their reindeer. In Näkkälä, both interviewees (int. 11, 12), representing different *siidas*, admitted that the disappearance of reindeer was a constant problem requiring intensive herding in old times. Later on, extensive herding and edge guarding (see Beach 1981: 500) with aid of snowmobiles at border areas was needed in order to keep the reindeer within the area of the *siida*; fences did not separate these from each other. Both indicated that reindeer which were not looked after could disappear. This was the main reason why the herders did their utmost still in the 1970s to prevent the dispersal of reindeer to look for arboreal lichens (int. 11). However, if intensification of herding was necessary in order to prevent starvation of the reindeer, edge guarding by skiing or later by driving snowmobiles was used to prevent movement into foreign areas (int. 11, 12).

None of our interviewees considered that the protection of hay piled in open fields required intensive herding since WWII. Agricultural fields were fenced, if needed.

The work involved in herding has played an important role in transition. The lack of manpower during the war (1939–1945) left the reindeer practically unmanaged for years. In Lohijärvi and Poikajärvi the herders did not return to pre-war intensive herding. Interviewees in both herding associations told that rebuilding the devastated county and forest work offered a better income than the strongly reduced reindeer herds (int. 2, 3). In Kemin-Sompio, in contrast, most of the herders returned to pre-war routines, including leach-calving, despite the drastic reduction in the number of reindeer. One interviewee (int. 7) told that his father-in-law had 890 reindeer before the war, but only 90 were left after the war. Similarly, in Näkkälä and Hammastunturi herding was intensified after the war.

Transitions in relation to pasture conditions and forestry

In Hossa-Irni, the early and abrupt transition from intensive herding to the free-ranging system was caused by the loss of extensive, good lichen pastures on the Russian side of the border when Finland became independent in 1918. That was told to our int. 1 by older reindeer herders who had been involved in the management of reindeer during that time (see also Kortessalmi 1996). The accepted free ranging system did not mean that the reindeer were totally left on their own: their food availability, as well as the movements of wolves and wolverines, was followed.

In other study herding associations our interviewees had their own experiences of the transition from intensive herding to more extensive herding forms, but the comments on the importance of the condition of lichen pastures were rather few. However, it was a common observation that lichen vegetation recovered due to the decline in the reindeer population during WWII. Despite this, the herders in Lohijärvi and Poikajärvi did not return to intensive herding after the war (int. 2, 3, 4).

In Kemin-Sompio, the three interviewees considered forestry as the main reason for the cessation of intensive herding and associated leach-calving, which took place within a few years in the beginning of the 1960s (int. 5, 6, 7). The best lichen pastures were located along the largest rivers (Pihtijoki, Kairijoki, Kemijoki, Värriöjoki), where there was a relatively thin snow cover as compared with that on the surrounding hills. Forestry with large clear-cuttings started in the beginning of the 1950s, and cutting advanced rapidly through the riverside forests where there were good opportunities for floating. According to the interviewees, reindeer did not stay in clear-cutting areas because of compaction of the snow.

Despite strong herding efforts (still without snowmobiles), reindeer escaped to neighbouring extensive felling areas to feed on arboreal lichens or dispersed into the surrounding upland areas with deeper snow, but lesser lichens, making intensive herding impossible. In addition, the most traditional leach-calving sites located along the riversides could not be used because of cutting residues (int. 7).

The later years were described as “chaotic” due to the loss of the best lichen pastures in combination with high reindeer numbers (Fig. 3), “bad winters”, and difficulties in using snowmobiles to gather the reindeer. In addition to which, calf-marking had to be organized in a new way, viz. by calf-marking round-ups in mid-summer (int. 5). These problems were partly solved in the late 1960 by the construction of a new fence along the northeastern edge of the area of the herding association. The old fence to prevent reindeer straying into the Soviet Union, located about 10 km from the border, was replaced by a new one built close to the border. The new pasture area had been ungrazed since the late 1930s and only extensive herding was needed to keep the reindeer within the area. During the 1980s a new winter pasture area, about 630 km² in size, was fenced in the northern edge of the herding association in the Urho Kekkonen National Park (int. 7). Outside these actual winter pastures the reindeer lived in small herds looking for uncut patches in the fragmented forest landscape (int. 5, 6, 7).

All the interviewees unanimously stressed the negative impacts of forestry. Heavy criticism was levelled especially against the large clear-cuttings from the late 1940s onwards, and soil scarification, which was introduced during the 1960s. In Hossa-Irni, Lohijärvi and Poikajärvi the interviewees drew attention to the loss of old forests rich in arboreal lichens. The interviewee from Hossa-Irni (int. 1) told that reindeer never faced a food shortage as long as there were uncut forests rich in arboreal lichens, even in conditions where access to ground lichens was occasionally prevented by icing already in early winter. This reduction of arboreal lichens was also mentioned in the northern herding associations studied, but there the negative impacts of cuttings on the abundance of reindeer lichens were considered to be even more important.

Until the 1970s, most of the commercial cuttings were carried out in wintertime and this provided arboreal lichens for reindeer. In Kemin-Sompio cuttings were considered negative even from this point of view, because they attracted reindeer and thus made herding difficult, resulting in failure in leach-calving. In contrast, in the more southern study areas “the noise of the

chainsaw was the dinner bell for reindeer”, and the reindeer were also gathered intentionally into cutting areas (int. 1, 3, 4). On cutting areas, however, falling trees frequently killed reindeer. Therefore interviewees from the three southernmost herding associations pointed out that reindeer herders also worked as forest workers, being able to advise the less experienced workers about how to avoid such situations.

Supplementary/corral feeding

Supplementary feeding with dry hay was carried out in Lohijärvi and Poikajärvi for the first time in winter 1968–1969 (int. 2, 3, 4), which was characterized by exceptionally difficult snow conditions. Even so, the winter mortality was high. In winter 1972–1973, the snow conditions were even worse in the northern half of the reindeer management area. Dry hay was also used in Kemin-Sompio and Hammastunturi to prevent starvation. As mentioned by the interviewees, these were the first occasions when dry hay could be used for reindeer. Earlier all the hay was needed for cattle. As int. 1 expressed it: “The wife would have gone on strike if the hay had been given to the reindeer”. The acute need for supplementary feeding was triggered by the difficult snow conditions, but it was underlined, especially in the three southernmost herding associations, by the loss of arboreal lichens due to cuttings.

Winter-feeding rapidly developed into a normal practice. In order to be prepared for bad conditions in the coming winter, hay had to be harvested every summer and hay was used even though supplementary feeding would have not been necessary; hay could not be stored until the following winter. In Lohijärvi, most of the reindeer were gathered into feeding corrals for 2–4 winter months since the late 1970s (int. 2), whilst Hossa-Irni and Poikajärvi invested more in supplementary feeding on natural pastures up until the 1980s. In corral feeding, the reindeer received, in addition to hay, dried birch (*Betula pubescens*) leaves, reindeer lichens (purchased from the area south of the reindeer management area) and commercial reindeer feed. During the 1980s, some teams or *siidas* in Kemin-Sompio

and Hammastunturi started to use supplemental feeding as a mixture of corral feeding and feeding on natural pastures (int. 8, 9, 10). The three interviewees in Hammastunturi pointed out that hay supplement was used in order to keep the reindeer within the traditional area of the *siida* and also to reduce herding efforts. Feeding tamed the reindeer, which helped the gathering of reindeer by walking which, still in the 1980s, was a normal practice in southern areas in summer and autumn.

Discussion

This paper describes, based on interviews with elderly reindeer herders, the transitions in the herd-management of semi-domesticated reindeer in six herding associations in northern Finland. The transition from intensive winter herding to more extensive forms of herding took place between the late 1910s and the 1960s. In the three southern study areas (Hossa-Irni, Lohijärvi and Poikajärvi) intensive herding changed directly to the free-ranging system, whilst in the three northern ones (Kemin-Sompio, Hammastunturi and Näkkälä) intensive herding was replaced by extensive herding with the assistance of snowmobiles.

Factors affecting the transition process

We suggested that intensive herding changes to more extensive herding routines in conditions where the occurrence of large predators, the straying of reindeer into foreign areas and the damage to stored hay no longer cause any considerable losses costs to reindeer management, or side-jobs provide higher incomes than intensive herding. Data received from the interviewees supported, to a large extent, these suggestions, but there were considerable differences between the study herding association in how the interviewees evaluated the relative importance of the factors influencing the intensity of herding.

As regards the predator threat, Lohijärvi and Poikajärvi were practically predator-free prior the transition, whilst in Hossa-Irni and the three northernmost areas, intensive herding ceased despite the occasional prevalence of wolves and

the constant threat of wolverines. Reindeer could not be defended against predatory attack, if they were not under continuous supervision by the herders (Ingold 1980). In order to prevent losses among dispersed reindeer, gathering of reindeer for round-ups often changed to wolf hunting (Hossa-Irni), and many herders especially in Kemin-Sompio directed their attention to hunting predators, which also provided income in terms of bounties, fur and meat (bear). One should note that the snowmobile could be legally used in predator hunting up until 1968, i.e. during several winters. The increasing efforts in predator control reduced the abundance of large predators everywhere in northern Finland (Siivonen 1972, Pulliainen 1974). In 1975, the state changed its predator policy and replaced kill payments with indemnifications covering the value of the reindeer killed by predators, and by protecting the wolverine, according to Bern's treaty in 1979. The role of the herders subsequently became to search for and report killed animals.

In the southern part of the reindeer management area, especially in Lohijärvi and Poikajärvi, fencing was considered of minor importance for transition by preventing the dispersal of reindeer into foreign areas. The regulations dealing with foreign reindeer were written in the Reindeer Management Act (1932), and they followed the old institutional systems developed by the reindeer herders themselves (Kortesalmi 1998). The basic message of the regulations was that one's own reindeer and reindeer from foreign herding associations had to be handled in the same way, and money from the slaughtered foreign reindeer must be sent to the owner of the animal; this was obtained, if otherwise not known, from the "reindeer earmark booklet" maintained by the Reindeer Herders Association. The regulations strengthened the reciprocal trust that "runaway reindeer" did not disappear.

In contrast, in Näkkälä and Hammastunturi fences around the herding associations were considered to be an important factor in the transition. "The fence makes good neighbours" was told to Lenstra (1975) by reindeer herders in northern Lapland. This ensured that reindeer did not disappear into foreign areas, and it also reduced pasture competition along the border edges. In Näkkälä, however, the reindeer *siidas* have their

own areas, which are not separated from each other by fences. Both interviewees considered open borders to be an important factor requiring at least extensive herding in terms of “edge guarding” (see Beach 1981: 500).

In Lohijärvi and Poikajärvi the ultimate factor for the cessation of intensive herding was the post-war period, which can be generalized to concern the whole southern part of the reindeer management area (Alaruikka 1964). The whole of society experienced radical changes. Before WWII people in the countryside mainly followed a subsistence way of life (Massa 1994). In order to get the devastated country back onto its feet after the war, the state made large investments in reconstruction, field clearance and forestry (Ursin 1980, Pohtila 1984). A monetary economy rapidly replaced the pre-war subsistence way of life characteristic of large parts of the countryside.

This change was also reflected in reindeer management, which had earlier been practiced as a subsidy livelihood by backwoods farmers. Now they used opportunity to choose between reindeer management and wage work provided by forest cuttings in winter. Many herders choose forest work, because the number of reindeer had declined during wartime by 53% (204 600 vs. 96 800) on the average (Alaruikka 1947). This fits in with Beach’s (1981: 333) conclusion that intensive herding changes to less intensive forms, when side-jobs provided a better income than investment in intensive herding. Differences in the timing of herding and forest work helped the transition: the largest round-ups were commonly over in December–January, making it possible to be engaged in forest work in the later part of the winter and in spring and early summer (floating) without the threat of the reindeer not being properly managed.

Despite the fact that the herds declined even more in the three northernmost areas, the herders returned to pre-war intensive herding. Large predators, wolverines especially, were still abundant and this required intensive herding. Moreover, people continued their earlier subsistence way of life because the general socio-economic development, with its new working opportunities, did not reach these remote areas until the 1960s. Cultural reasons were also important.

The Saami did not rate forest workers very high and this distinction still existed after the war (Saami herders interviewed in this study). Even in Kemin-Sompio, although the herders were Finnish speaking, young men from herder families were more likely choose reindeer herding than forestry.

In our three northernmost herding associations, the transition to extensive herding was associated with the “snowmobile revolution”, which is a commonly used example of how a single technological innovation had profound influences on herding practices, as well as on the economics and social relations in the herders’ society (Pelto *et al.* 1968, Pelto 1973). The emergent ranching-like management system was characterized by completely wild reindeer, which were distributed over extensive areas according to the food availability, and collected only twice a year using snowmobiles in winter (Ingold 1980). The reduced tameness was considered a serious problem in our northern herding associations during the “snowmobile revolution”, although the transition did not lead to a ranching-like system, in contrast to many other northern herding associations at that time (Pelto *et al.* 1968, Lenstra 1975, Ingold 1978, 1980). The great variation in the number of reindeer between successive years without a high mortality indicated failure in gathering the reindeer for the round-ups, and resulted in reduced harvesting and marketing opportunities, corresponding to what Beach (1981: 476) called “over-extensification”, which was characteristic especially in Kemin-Sompio in the mid-1960s.

Relationships to pasture conditions and forestry

The reason for the transition has been explained by the deterioration of lichen pastures due to over-grazing (Tomasson 1918, Ingold 1976, 1980). This is in agreement with knowledge of the social organization of wild rangifers: a concentrated, rich food supply (usually good lichen pasture) enables a gregarious herd structure, whilst a scant or scattered food supply (poor lichen pasture or forest with arboreal lichens) results in dispersal of the animals (Bergerud

1974, Helle 1980a). This is consistent with the experience of our many interviewees that reindeer lived in larger herds and stayed in the same area longer if the lichen vegetation was in good condition.

In this study, the association between the condition of lichen pastures and the herding form appeared to be highly variable (Table 1 and Fig. 5). In Lohijärvi, reindeer were herded intensively until WWII, although the condition of lichen pastures was graded as “poor” (lichen height about 1 cm) already in the 1910s (Keisarillinen porolaidunkomisiooni 1914; Table 1). The reduction in availability of reindeer lichens was considered to be the primary factor resulting in extensification of intensive herding in two of our study herding associations. In Hossa-Irni that was associated with the loss of good lichen pastures on the Russian side 1918, whilst in Kemin-Sompio the three interviewees related the transition to the pasture loss caused by forestry in combination with the high reindeer numbers (Table 1 and Fig. 3) and difficult snow conditions in winter. Clear-cuttings advanced along the riversides, which were the forests most valuable for herding because of their rich lichen vegetation and easy snow conditions, and which were used also for leach-calving. The influence of snow on access to forage is commonly acknowledged (Pruitt 1979, Helle 1984), and it strongly influences the habitat selection of reindeer in open fell habitats which offer almost snow-free wind-swept ridges in mid and late winter (Skogland 1978, Helle & Särkelä 1993). In forest habitats, snow-mediated spatial heterogeneity of food availability has received less attention. However, Kumpula *et al.* (2007) found that the snow depth and the snow hardness increased with the altitude influencing the pasture use of semi-domesticated reindeer.

In addition, our interviewees in Kemin-Sompio especially pointed out the avoidance of large clear-cut areas due to wind-hardened snow, as reported e.g. by Alaruikka (1964), Eriksson (1976) and Beach (1981: 266), which is in agreement with the general relationship between wind speed and the snow hardness (Pomeroy & Brun 2001). Therefore one would expect that lichen vegetation would recover on clear-cuts and seedling stands due to the low grazing pressure.

However, extensive inventory data from the late 1970s showed a completely opposite trend especially in northern Lapland (Mattila 1981). The mean lichen biomass in Kemin-Sompio (and adjacent Pohjois-Salla) on dry sites (mainly *Empetrum-Myrtillus-Cladina* type) was about 44% lower in young forests (< 70 yrs) than in mature ones (> 70 yrs), the corresponding figure in sub-dry sites (mainly *Empetrum-Myrtillus* type) being 29%. Also in Inari, including Hammastunturi, the mean lichen biomass in young forests on dry sites was 20% and on sub-dry sites 27% lower than in mature forests.

In general, the percent cover and biomass of reindeer lichens are related to reindeer density calculated on the basis of the area of lichen pastures (Helle 1982, Kumpula *et al.* 2000, *see also* Mattila 2004), therefore the condition of lichen pastures was poor in the southern part of the reindeer management area already before the time of intensive forestry (Keisarillinen porolaidunkomisiooni 1914; Table 1). However, there might also be negative impacts of other factors, as evidenced by a strong decrease in the percent cover of reindeer lichen outside the reindeer management area between 1951–1953 and 1995 (Nousiainen 2000). In northern Finland, forestry practices affecting abundance of reindeer lichens include prescribed burning and soil scarification (on fresh and sub-dry sites) (Ferm & Pohtila 1977, Eriksson & Raunistola 1990, Webb 1998, Roturier & Bergsten 2006), cutting residues covering lichen vegetation (Kauppi 1990, Kumpula 2003), in addition to which clear-cutting changes the habitat selection of reindeer during the summer. Before the practice of clear-cutting started, reindeer concentrated in the summer on open mires and fells that provided both food and, due to the wind, relief from blood-sucking insects (Ahti 1973, Haukioja & Heino 1974). Later on, clear-cut areas were commonly mentioned as the sites of summer pastures (Ferm & Pohtila 1977, Helle 1980a, Mäkitalo *et al.* 1998, Kumpula *et al.* 2007). In the summer, the diet of the reindeer contains only very small amounts of reindeer lichens (Helle 1982), whilst trampling by reindeer destroys the fragile lichen vegetation on the driest sites especially (Pegau 1970, Oksanen 1978, Boudreau & Payette 2001).

Development of supplementary/corral feeding

According to our interviewees, the second sharp transition in herd-management was associated with the rapid extension of supplementary/corral feeding from the late 1960s onwards, described in details by Helle and Saastamoinen (1979) and Nieminen and Autto (1989). In comparison with Sweden for instance, it is an exceptional feature in the management of reindeer (Moen & Danell 2003). The Field Reservation Scheme, enacted in 1969, made possible the use of hay. Farmers were paid for leaving their fields uncultivated, but haymaking for reindeer was allowed in these fields. An increasing number of farmer-reindeer herders took advantage of this opportunity, which explains the rapid extension of supplementary feeding. This was costly, but meat production also increased due to the decreased mortality and increased reproduction and carcass weights (Kojola & Helle 1991, Helle & Kojola 1993, 1994).

Our interviewees pointed out that the ultimate reason for the use of hay was the reduction in arboreal lichens, occurring most abundantly in old forests ((Mattila 1979, Esseen *et al.* 1996, Jaakkola *et al.* 2006). Pasture inventories covering the whole reindeer management area indicated that about 60% of the forests were totally lacking in arboreal lichens in the 1970s because of the young stand age (Mattila 1979), while in northern national parks without forestry the proportion is only 2%–5% (Jaakkola *et al.* 2006). In the mid-1970s, 51% of the herding associations, most of them located in the southern half of the reindeer management area, considered the scarcity of old forests rich in arboreal lichens as the minimum factor determining the carrying capacity of winter pastures; an additional 22% suggested that they lacked both arboreal lichens and reindeer lichens (Helle & Saastamoinen 1979).

Arboreal lichens were used in several and variable kinds of occasion. Among our study areas, Hossa-Irni was the only one where “reindeer cuttings” were a normal practice until the beginning of the 20th century (Heikinheimo 1920, Kortosalmi 1996). “Reindeer cuttings” were the only way to keep the reindeer in the

herd in areas with restricted lichen pastures and deep snow (Inha 1909); intensive herding with the aid of felled trees was, however, necessary due to predators and the otherwise disappearance of reindeer. Since WWII, arboreal lichens on fallen trees in commercial cuttings were an important food source for reindeer for decades. In 1975 30%, and in 1977 15% of the total reindeer population lived on cutting areas in mid-winter, most commonly in the southern part of the reindeer management area (Saastamoinen 1978, Helle & Saastamoinen 1979). According to our interviewees, reindeer herders themselves cut single trees or knocked down the lower branches of trees still in the 1960s and 1970s in order to keep the reindeer in a given area (extensive herding) or to ensure food availability of freely roaming reindeer (free-ranging system).

Our interviewees also emphasized the importance of arboreal lichens, which reindeer obtained in standing forests or those fallen on the snow in winter storms. In the southern part of the area arboreal lichens were a part of the “normal” winter diet of reindeer, whilst in the northern part they are used in conditions where access to ground forage is limited in early spring or occasionally already earlier by hard or deep snow. Helle and Saastamoinen (1979) found during two winters in the 1970s that during January–March 21%–30% of the reindeer lived mainly on arboreal lichens, the percentage being the highest in the southern half of the reindeer management area.

“The intensification spiral” (Beach 1981: 476), i.e. the development in an opposite direction to “over-extensification”, was clearly observable in our study areas. It was associated with the population decline caused by high winter mortality, which took place in our southern study areas in the late 1960s and in the northern ones in 1972–1974. In the southern half, intensification was due to the rapid extension of supplementary/corral feeding (Helle & Saastamoinen 1979). In the north, the role of feeding was less still in the 1970s, but a combination of extensive herding and supplementary feeding developed in many herding associations, including Hammastunturi, in our study during the following decade (Nieminen & Autto 1989).

The tameness degree of reindeer increased and they were as tame as before the “wild years” of the “snowmobile revolution”. Supplementary feeding, an emergent phenomenon, revitalized the old herding methods, including individual recognition of reindeer and pasture rotation. The same happened to a lesser extent in Näkkälä and Kemin-Sompio, without supplementary feeding, due to frequent and peaceful contacts with snowmobile-driving herders. In general, “The intensification spiral” increased the accuracy by which the reindeer could be gathered for round-ups. Alaruikka (1964) estimated that, before the “snowmobile revolution”, about 15% of the reindeer avoided the annual round-ups and were thus missing from the official reindeer statistics. Estimates from the early phases of “the snowmobile revolution” have not been presented, but by the late 1970s and early 1980s the proportion of uncounted reindeer was only 1%–2% (Helle & Kojola 1993).

The “intensification spiral” apparently led to “feeding competition” in conditions where the highest permitted number of reindeer was reached (Helle *et al.* 1985), which was a common feature throughout the whole reindeer management area from the late 1970s onwards until the end of the 1980s (Helle & Kojola 2006). At that time every owner had to reduce his herd by an overall fixed percentage (Reindeer Management Act 1932). The calculations are based on statistics from the previous winter’s round-ups. Thus they do not take into account the fact that, on natural pastures, winter mortality may be higher and reproduction lower than in herds fed supplementary or artificially in corrals. Subsequently, maintaining the herd requires the intensification of feeding if the other owners are already doing so, otherwise, the herd starts to decline.

Acknowledgements

Financial support for this study was generously provided by the Ministry of Agriculture and Forestry. We are grateful to the interviewees who kindly offered us their time and knowledge: Hossa-Irni: Veikko Väisänen; Lohijärvi: Mikko Holster; Poikajärvi: Martti Mustonen and Jouko Mustonen; Kemin-Sompio: Kauko Hannula, Voitto Leskisenoja and Matti Merivirta; Hammastunturi: Juhani Magga, Olavi Magga and Yrjö Mattus; Näkkälä: Esa Kumpulainen and

Juhan-Taneli Magga. We thank Hugh Beach and an anonymous referee for their valuable comments to the manuscript. We are indebted to Aarno Niva, Raimo Pikkupeura and Jouni Puoskari for their assistance in preparing the manuscript, and to John Derome who corrected the language of the manuscript.

References

- Ahti, T. 1973: Suot porolaitumina. — *Poromies* 1973(3): 12–14.
- Aikio, O. 1975: Ei turhia kokeiluja Pohjois-Lapissa. — *Poromies* 1975(6): 11–12.
- Alapuranen, O. 2003: *Tuiskun peittäjä jälki. Muistoja poropoliisin taipaleelta.* — Yliopistopaino, Helsinki.
- Alaruikka, Y. 1947: Porotalouden sodanjälkeinen kehitys. — *Poromies* 1947(4): 39–40.
- Alaruikka, Y. 1964: *Suomen porotalous.* — Paliskuntain yhdistys, Rovaniemi.
- Anon. 1934: Paliskuntain osakkaiden ja porojen lukumäärät sekä porotuotteitten hinnat. — *Poromies* 1934(1): 14–15.
- Apps, C., McLellan, B., Kinley, T. & Flaa, J. 2001: Scale-dependent habitat selection by mountain caribou, Columbia Mountains, British Columbia. — *J. Wildl. Manage.* 65: 65–77.
- Beach, H. 1981: *Reindeer-herd management in transition. The case of Tuorpon saameby in northern Sweden.* — Acta Universitatis Upsalensis, Uppsala Studies in Cultural Anthropology 3, Uppsala.
- Bergerud 1974: The role of the environment in the aggregation, movement and disturbance behaviour of caribou. — In: Geist, V. & Walther, F. (eds.), *The behaviour of ungulates and its relation to management:* 552–584. IUCN Publications, New Series, Morges, Switzerland.
- Boudreau, S. & Payette, S. 2001: Growth performance of *Cladina stellaris* following caribou disturbance in subarctic Quebec. — *Ecoscience* 11: 347–355.
- Cichowski, D. 1989: *Seasonal movements, habitat use and winter feeding ecology of woodland caribou in west-central British Columbia.* — M.Sc. thesis, Univ. of British Columbia, Vancouver, BC.
- Eriksson, O. 1976: Snöförhållandenas inverkan på renbetning. — *Meddel. Växtbiol. Inst. Uppsala* 1976(2): 1–19.
- Eriksson, O. & Raunistola, T. 1990: Impact of soil scarification on reindeer pastures. — *Rangifer*, Special Issue 3: 99–106.
- Esseen, P.-A., Renhorn, K.-E. & Pettersson, R. B. 1996: Epiphytic lichen biomass in managed and old-growth boreal forests: effect of branch quality. — *Ecological Applications* 6: 228–238.
- Ferm, A. & Pohtila, E. 1977: Succession of ground vegetation and levelling of ploughed tracks on reforestation areas in Finnish Lapland. — *Folia Forestalia* 319: 1–34. [In Finnish with English summary].
- Goward, T. 2000: Fire, terrestrial lichens, and the Itcha-Olgachuz caribou. — In: Darling, M. (ed.), *Proceedings of a Conference on the Biology and Management of Species and Habitats at Risk, Kamloops, B.C., Feb. 1999*, vol.

- 2: 665–669. University College of the Cariboo, Kamloops, B.C. Ministry of Environment Lands and Parks, Victoria, B.C.
- Hannula, M. 2000: *Porojen hihnavaotusperinne*. — Maa- ja metsätalousministeriö. Lapin painotuote, Kemijärvi.
- Haukioja, E. & Heino, J. 1974: Birch consumption by reindeer (*Rangifer tarandus*) in Finnish Lapland. — *Rep. Kevo Sub-arctic Res. Stat.* 11: 22–25.
- Heikinheimo, O. 1920: Vorkommen, Umfang und Holzvorräte der Fichtenwälder in Nord-Finnland. — *Communicationes ex Inst. Quaest. For. Finl.* 3: 1–170. [In Finnish with German summary].
- Helle, R. 1966: An investigation of reindeer husbandry in Finland. — *Acta Lapponica Fenniae* 5: 1–65.
- Helle, T. 1980a: Observations on home ranges and grouping patterns of free-ranging semi-domestic reindeer (*Rangifer tarandus tarandus* L.) in Kuusamo, northeastern Finland. — *Research Institute of Northern Finland A* 2: 29–48.
- Helle, T. 1980b: Laiduntilanteen muutokset ja riskinotto Suomen poronhoidossa. — *Lapin tutkimusseuran vuosikirja XXI*: 13–22.
- Helle, T. 1982: *Poron ja peuran jäljillä*. — Kirjayhtymä, Vaasa.
- Helle, T. 1984: Foraging behaviour of the semi-domesticated reindeer (*Rangifer tarandus* L.) in relation to snow in Finnish Lapland. — *Rep. Kevo Sub-arctic Res. Stat.* 19: 49–56.
- Helle, T. & Kojola, I. 1993: Reproduction and mortality of Finnish semi-domesticated reindeer in relation to density and management strategies. — *Arctic* 46: 72–77.
- Helle, T. & Kojola, I. 1994: Body mass variation in semidomesticated reindeer. — *Can. J. Zool.* 72: 681–688.
- Helle, T. & Kojola, I. 2006: Population trends of semi-domesticated reindeer in Fennoscandia — evaluation of explanations. — In: Forbes, B., Böler, M., Muller-Wille, L., Hukkinen, J., Muller, F., Gunz, N. & Konstantinov, Y. (eds.), *Reindeer management in northernmost Europe. Ecological Studies*, vol. 184: 319–339. Springer-Verlag, Berlin–Heidelberg.
- Helle, T. & Saastamoinen, O. 1979: The winter use of food resources of semi-domestic reindeer in northern Finland. — *Comm. Inst. Forest. Fenn.* 95: 1–26.
- Helle, T. & Särkelä, M. 1993: The effects of outdoor recreation on range use by semi-domesticated reindeer. — *Scand. J. For. Res.* 8: 123–133.
- Helle, T., Aspi, J. & Kilpelä, S.-S. 1990: The effects of stand characteristics on reindeer lichens and range used by semidomesticated reindeer. — *Rangifer*, Special Issue 3: 107–114.
- Helle, T., Huttu-Hiltunen, V. & Rajala, P. 1980: *Porotalous. Renskötsel. Reindeer husbandry*. — Suomen kartasto, WSOY.
- Helle, T., Pöyhönen, I. & Lotvonen, E. 1985: Economic evaluation of current trends in Finnish reindeer management. — *Research Institute of Northern Finland A* 3: 50–61.
- Holster, K. 1948: Suopungin heittoja. — *Poromies* 1948(2): 21–23.
- Hultblad, F. 1968: *Övergång från nomadism till agrar bosättning i Jokkmokks socken*. — Acta Lapponica XIV, Nordiska Museet, Lund.
- Ingold T. 1976: *The Skolt Lapps today*. — Cambridge University Press, Cambridge.
- Ingold, T. 1978: The rationalization of reindeer management. — *Development and Change* 9: 103–132.
- Ingold, T. 1980: *Hunters, pastoralists and ranchers: reindeer economies and transformations*. — Cambridge University Press, Cambridge.
- Iivessalo, Y. 1927: Tulokset 1921–24 suoritetusta valtakunnan metsien arvioinnista. — *Communicationes ex Inst. Quaest. For. Finl.* 11.1: 1–613.
- Iivessalo, Y. 1948: Nyky-Suomen metsävarat. — *Communicationes ex Inst. Quaest. For. Finl.* 35.5: 1–52.
- Inha, I. K. 1909: *Suomen maisemia*. — WSOY, Porvoo.
- Itkonen, T. 1948: *Suomen lappalaiset vuoteen 1945*, osa II. — WSOY, Porvoo–Helsinki.
- Jaakkola, L., Helle, T., Soppela, J., Kuitunen, M. & Yrjönen, M. 2006: Effects of forest characters on the abundance of alectoroid lichens in northern Finland. — *Can. J. For. Res.* 36: 2955–2965.
- Johnson, C., Parker, K., Heard, D. & Gillingham, M. 2002: Foraging across a variable landscape: behavioral decisions made by woodland caribou at multiple spatial scales. — *Oecologia* (Berlin) 127: 590–602.
- Kauppi, M. 1990: The effects of litter and waste wood on a *Cladina stellaris* carpet. — *Aquilo, Serie Botanica* 29: 33–38.
- Keisarillinen porolaidunkomisio 1914. — Komiteanmietintö, Rovaniemi.
- Kojola, I. & Helle, T. 1991: Productivity of semi-domesticated reindeer in Finland. — *Rangifer* 11: 53–63.
- Kortesalmi, J. 1996: *Peasant reindeer breeding in Northwest Russian Carelia: its origins and development up to 1922*. — Suomen muinaismuistoyhdistys, Vammalan Kirjapaino Oy, Vammala. [In Finnish with English summary].
- Kortesalmi, J. 1998: Economics and ecology in peasant reindeer husbandry. — *Studia historica septentrionalia* 34: 191–200.
- Kumpula, J. 2003: *Metsänkäsittelyn vaikutukset porolaitumiin*. — Kala- ja riistaraportteja 286, Riistan ja kalantutkimus, Helsinki.
- Kumpula, J. & Colpaert, A. 2007: Snow conditions and usability value of pastureland for semi-domesticated reindeer (*Rangifer tarandus tarandus*) in northern boreal forest area. — *Rangifer* 27: 25–39.
- Kumpula, J., Colpaert, A. & Anttonen, M. 2007: Does forest harvesting and linear infrastructure change the usability value of pastureland for semi-domesticated reindeer (*Rangifer tarandus*)? — *Ann. Zool. Fennici* 44: 161–178.
- Kumpula, J., Colpaert, A. & Nieminen, M. 1998: Reproduction and productivity of semi-domesticated reindeer in northern Finland. — *Can. J. Zool.* 76: 269–277.
- Kumpula, J., Colpaert, A. & Nieminen, M. 2000: Condition, potential recovery, and productivity of lichen (*Cladonia* spp.) ranges in the Finnish reindeer management area. — *Arctic* 53: 152–160.
- Kumpula, J., Colpaert, A., Kumpula, T. & Nieminen, M. 1997: *Suomen poronhoitoalueen talvilaidunvarat*. —

- Kala- ja riistaraportteja 93. Riistan- ja kalantutkimus, Helsinki.
- Kuusela, K., Mattila, E. & Salminen, S. 1986: Metsävarat piirimetsälautakunnittain Pohjois-Suomessa 1982–1984. — *Folia Forestalia* 655: 1–86.
- Kännö, S. 1992: *Mosku*. — WSOY, Porvoo–Helsinki–Juva.
- Kärenlampi, L. 1972: Suomen poronhoitoalueen jäkälämaiden kunto, jäkälämäärät ja tuottoarvot. — *Poromies* 39: 17–19.
- Lenstra, M. 1975: *Changes in the Lappish herding system in the reindeer herding district Sodankylän Lapin paliskunta*. — M.Sc. thesis, Oulu University.
- Massa, I. 1994: *Pohjoinen luonnonvalloitus*. — Gaudeamus, Helsinki.
- Mattila, E. 1979: Kangasmaiden luppometsien ominaisuuksia Suomen poronhoitoalueella 1976–1978 [Characteristics of the mineral soil forests with arboreal lichens (*Alectoria*, *Bryoria* and *Usnea* spp.) in the Finnish reindeer management area] — *Folia Forestalia* 417: 1–39. [In Finnish with English summary].
- Mattila, E. 1981: Survey of reindeer winter ranges as a part of the Finnish National Forest Inventory in 1976–1978. — *Comm. Inst. For. Fenn.* 99: 1–74.
- Mattila, E. 1998: Porojen lautumia mitattu Suomessa pian puoli vuosisataa. — *Metsätutkimuslaitoksen tiedonantoja* 678: 67–83.
- Mattila, E. 2004: *Porojen eräiden ravintokasvien esiintyminen poronhoitoalueella Kainuun merkkipiirissä ja poronhoitoalueen ulkopuolisella alueella Kainuussa 2002–2003 – vertaileva tutkimus aluetasolla*. — Metsätutkimuslaitoksen tiedonantoja 930.
- Metsähallitus 1907: *Kirje Keisarilliselle Senaatille. Metsähallituksen kertomus vuodelta 1907. Suomenmaan virallinen tilasto 1909–1911*. — Metsänhoitolaitos. Metsähallituksen kertomus vuosilta 1907, 1908 ja 1909. Keisarillinen Kirjapaino, Helsinki.
- Metsähallitus 1948–1970: *Metsähallituksen III arkisto 1948–1970*, luettelon nro 510:2. — Metsähallitus, Helsinki.
- Moen, J. & Danell, Ö. 2003: Reindeer in the Swedish mountains: An assessment of grazing impacts. — *Ambio* 32: 397–402.
- Mäkitalo, K., Penttilä, T. & Räsänen, P. 1998: Porojen ja jäniksen vaikutus hieskoivun luontaiseen uudistumiseen tuoreilla kankailla Etelä- ja Keski-Lapissa. — *Metsätutkimuslaitoksen tiedonantoja* 678: 109–121.
- Nieminen, M. & Autto, P. 1989: Porojen laitumet ja ruokinta poronhoitovuonna 1986–87. — *Poromies* 56: 38–43.
- Nousiainen, H. 2000: Cladina, poronjäkälet. — In: Reinikainen, A., Mäkipää, R., Vanha-Majamaa, I. & Hotanen, J.-P. (eds.), *Kasvit muuttuvassa metsäluonnossa*: 288–294. Tammi, Helsinki.
- Oksanen, L. 1978: Lichen grounds of Finnmarksvidda northern Norway in relation to summer and winter grazing by reindeer. — *Rep. Kevo Sub-arctic Res. Stat.* 14: 64–71.
- Paliskuntain Yhdistys 1935: *Porolaiduntutkimus*. — Paliskuntain Yhdistys, Rovaniemi.
- Paliskuntain Yhdistys 1962: *Porolaiduntutkimus*. — Paliskuntain Yhdistys, Rovaniemi.
- Paulaharju, S. 1922: *Lapin muisteluksia*. — WSOY, Porvoo.
- Pegau, E. 1970: Effect of reindeer trampling and grazing on lichens. — *J. Range Manage.* 23: 95–97.
- Pelto, P. J. 1973: *The snowmobile revolution: technology and social change in the arctic*. — Benjamin and Cummings, Melo Park California.
- Pelto, P. J., Linkola, M. & Samallahti, P. 1968: The snowmobile revolution in Lapland. — *Suomalais-Ugrilaisen Seuran Aikakauskirja* 69: 1–42.
- Peterson, D. & Parker, T. (eds.) 1998: *Ecological scale: theory and applications*, vol. 5. — Columbia University Press, New York.
- Pohtila, E. 1979: “Metsänviljelytalouden” läpimurto. — *Silva Fennica* 13: 18–19.
- Pohtila, E. 1984: Lapin metsätalous. — In: Linkola, M. (ed.), *Lappi*, osa 3: 283–303. Karisto, Hämeenlinna.
- Pomeroy, J. & Brun, E. 2001: Physical properties of snow. — In: Jones, H., Pomeroy, J., Walker, D. & Hoham, R. (eds.), *Snow ecology*: 45–118. Cambridge University Press.
- Pruitt, W. 1979: A numerical “Snow Index” for reindeer (*Rangifer tarandus*) winter ecology (Mammalia, Cervidae). — *Ann. Zool. Fennici* 16: 271–280.
- Pulliaainen, E. 1965: Studies on the wolf (*Canis lupus* L.) in Finland. — *Ann. Zool. Fennici* 2: 215–259.
- Pulliaainen, E. 1974: *Suomen suurpedot*. — Tammi Helsinki.
- Reindeer Management Act [Poronhoitolaki] 1932: *Suomen laki* 239/1932.
- Rettie, W. & Messier, F. 2000: Hierarchical habitat selection by woodland caribou: its relationship to limiting factors. — *Ecography* 23: 466–478.
- Roturier, S. & Bergsten, U. 2006. Influence of soil scarification on reindeer foraging and damage to planted *Pinus sylvestris* seedlings. — *Scan. J. For. Res.* 21: 209–220.
- Ruong, I. 1964: Jähkäkaska sameby. Särtryck ur Svenska Landsmål och svenskt folkliv. — *Tidskrift utgiven av Landsmåls- och folkminnes arkiv I Uppsala*.
- Saastamoinen, O. 1978: Cutting areas as reindeer pasturage. — *Comm. Inst. For. Fenn.* 95: 1–28.
- Schaefer, J., Bergman, C. & Lutich, S. 2000: Site fidelity of female caribou at multiple spatial scales. — *Landscape Ecology* 15: 731–739.
- Senft, R., Coughenour, M., Bailey, D., Rittenhouse, L., Sala, O. & Swift, D. 1987: Large herbivore foraging and ecological hierarchies. — *BioScience* 37: 789–799.
- Siivonen, L. 1972: *Suomen nisäkkäät*. — Tammi, Helsinki-Keuruu.
- Sipilä, P., Magga, H. & Aikio, P. 2000: *Luppoa etsimässä. Lapin paliskunnan alueen luppolaidunten inventointi 1999–2000*. — Oulun painotuote Oy, Oulu.
- Skogland, T. 1978: Characteristics of the snow cover and its relationship to wild mountain reindeer (*Rangifer tarandus tarandus* L.) feeding strategies. — *Arc. Alp. Res.* 10: 569–580.
- Slater, D. 1999: Analysis cultural objects: content analysis and semiotics. — In: Seale, C. (ed.), *Researching society and culture*: 233–244. Sage Publications, London.
- Tomasson, T. 1918: *Renskötsel, dess utveckling och betingelser*. — Samernas Vita Bok VII: 2, Stockholm.
- Tomppo, E., Henttonen, H. & Tuomainen, T. 2001: Valtakunnan metsien 8. inventoinnin menetelmä ja tulokset metsäkeskuksittain Pohjois-Suomessa 1992–94 sekä tulok-

- set Etelä-Suomessa 1986–92 ja koko maassa 1986–92.
— *Metsätieteen aikakauskirja* 1 B/2001: 99–248.
- Ursin, M. 1980: *Pohjois-Suomen tuhot ja jälleenrakennus saksalaissodan 1944–1945 jälkeen*. — *Studia Historica Septentrionalia* 2, Pohjois-Suomen Historiallinen Yhdistys, Rovaniemi.
- Webb, E. 1998: Survival, persistence, and regeneration of the reindeer lichen, *Cladina stellaris*, *C. rangiferina* and *C. mitis* following clearcut logging and forest fire in north-western Ontario. — *Rangifer*, Special Issue 10: 41–47.