LARGE SCALE GRAZING SYSTEMS IN THE NORDIC REGION: THEIR HISTORY, CHARACTERISTICS AND STABILITY

A. SYSTEMS IN THE MOUNTAIN/TUNDRA LANDSCAPE

A. 1. The historical background

Until about AD 1500, the Fennoscandian Mountains were primarily grazed by wild reindeer, which were hunted by the Sámi in northern and central parts of the mountain chain and by Norsemen in southern Scandinavia[1]. The Norsemen had all along had chalets[2], to which cattle and sheep were taken for the summer, but this land use was restricted to the vicinities of valleys. The vast highlands of southern Norway were used for hunting only. The Sámi had small herds of domesticated reindeer, which were used for pulling sledges, carrying packs, milking and as attraction animals in wild reindeer hunts. To have larger herds had been impossible, since reindeer do not recognize the difference between domesticated and wild. As long as large numbers of wild reindeer strolled around, there was always the risk that domesticated animals joined the wild herds and were lost.

The period from the 16th to the 18th century was characterized by enormous expansion of the chalet-based use of southern mountains and shift from wild reindeer hunting to reindeer nomadism in the north. In many cases the chalets were established on former reindeer corral sites, which the reindeer had fertilized and thus provided good grass growth conditions. Both processes derived from the same fact: increase in the numbers of Swedes and Norsemen, which created pressure on the land and market for meat and furs. The chalets spread further and further from the major valleys, as even smaller and more elevated valleys became settled and the peasants were ready to drive their animals deeper and deeper in the highlands. In the south, wild reindeer became restricted to the hearts of the widest and/or least accessible highlands[3]. In the north, the increased meat price and demand for furs lead to overhunting of wild reindeer, which in turn allowed the most affluent Sámi to start to expand their herds of domesticated reindeer. The wild reindeer disappeared as the remnant populations joined the domesticated herds and got earmarks[4].

In the 18th century, almost the entire mountain chain and the northern tundra were intensively used by either chalet-based sheep and cattle husbandry or large-scale reindeer nomadism, which now extended even to the marine islands[5] of Northern Norway, to which reindeer were taken in summer. As a consequence of the expanding populations of reindeer, sheep and cattle, and the use of wood as fuel by herdsmen, vast expanses of mountain birch forest changed to savanna-like complexes, where open land prevailed, but scattered birches and woodland patches occurred in least accessible sites (Emanuelsson 1987, Oksanen et al. 1995; see also Fig. 1). Due to the farmers' expansion, the realm of Sámi reindeer husbandry decreased, particularly in southern parts as the Røros area in Norway and Härjedalen in Sweden. Several incidents of farmers chasing Sámi from their home are known, destroying their belongings and killings of reindeer (Fjellheim 1999, Thomasson 2002). Due to the new-won hegemony of the ideology of Social Darwinism, seeing nomadism as a dying life-mode, new legislation implemented in both countries in the late 1800s promoted the rights of the

[1] The Swedes then had no access to mountains, as Jämtland, Härjedalen and the western part of Dalarna belonged to Norway; and in the north, Swedish settlements occurred only along the coast.
[2] Summer diaries (sæters)
[3] Dovre, Jotunheimen, Hardangervidda
[4] Still today, the same Sámi word – goddi – stands for wild reindeer and for unmarked domesticated reindeer
[5] The islands had never had wild reindeer.

farmers and restricted the rights of the Sámi. E.g. the Sámi became obliged to pay compensation for, often alleged, damage on crops and haystacks of farmers, and very strict

Fig. 1. Open meadows and scattered woodlands on the island of Sievju (Seiland), Finnmark, Norway. The picture on the right hand panel, with scattered tall birches, is taken on the top of the hill on the left edge of the left side panel, documenting that the whole area could be forest without grazing.

restrictions concerning the timing and areas of reindeer grazing were imposed (Severinsen, 1979). Special policemen enforced the restrictions[6]. Accordingly, the relationships between the two peoples were often bad, to put it mildly, and were made worse by the government. However, even in areas of conflict between the two peoples, good reciprocal relations could develop on a personal and local level, through trade, lodging and mutual services[7], including tendance reindeer (Fjellheim 1995, Nordin, 2002). The situation remained basically unchanged until 1950, except that the conducts became more civilized. Pasture conventions[8] between Norway and Sweden limited the extension of border crossing reindeer management and in the 1950's the Swedish Sámi lost their traditional summer pastures on coast and the islands of Troms County.

The history outlined above is crucial for understanding the developments during the latest five decades. Both for Norsemen[9] and for the Sámi, the mountains were vitally important resources and their use had a major role in the cultural identity of both peoples. But the Norsemen and the Sámi spending much time above the timberline were of very different kinds. While the Norwegian cultural elite revered their 'Peer's and 'Solveig's, the folks driving their cattle and sheep furthest into the highlands actually tended to be poor people that had not obtained summer pastures in more convenient locations. The beautiful traditional Norwegian herding songs generally deal with the loneliness and boredom of having to spend the summers far from the villages and totally outside the social contexts, and the true life out there[10] was anything but romantic.

Conversely, the 'Piera's and 'Kátja's driving their reindeer across the highlands were the indisputable elite of the Sámi people. A 'badjeolmuš' (reindeer herdsman)[11] always looked down on the 'boanda' (farmer) and 'guolasdeaddji' (fisherman), and the reasons were understandable. The very beginning of the reindeer husbandry was an initiative of the more affluent sector of the Sámi population. The poor ones had to slaughter for their immediate

[6] called Sámi Sheriffs (lappefogd)
[7] Verdde- a guest-friendship relation .It could also include non-Sámi families. In returns for their assistance verdde could receive meat directly or even have reindeer in the herds of the herders (*tendance reindeer*).
[8] 1919, 1949 and 1972 (Reinbeitekommisjon, 2001)
[9] including the now formally Swedish inhabitants of Jämtland, Härjedalen and western Dalarna
[10] fragmentarily but quite realistically described in the Noble Prize Laureate Henrik Ibsens "Peer Gynth"
[11] exact translation = higher human being

needs and thus could not expand their reindeer herds. Moreover, the worth of a normal reindeer herd in sheer money vastly exceeded the worth of an average farm in the far north

The economies of the nomads and the stationary peoples (whether Sámi, Norse or ethnic Finns) were very different, too. A northern farmer/fisher[12] lived primarily on his own product and clothed himself/herself in hand-made, coarse wool clothes, deriving from the wool of own sheep. Only a small part of the economy was cash-based. Even a reindeer herdsman took good care of every part of a slaughtered reindeer, but meat and furs were always produced for the market and the carbohydrate part of the diet was always purchased. With the cash obtained for meat and fur, the herdsmen bought expensive Dutch broadcloth of fine wool, from which they made their showy summer clothes, plus lots of silver adornments, carried to display wealth[13]. In addition, the herdsmen had hidden treasures on the tundra. Quite early, many of them found that a bank account was a more practical way to save wealth than a hidden silver treasure. However, far from all herdsmen have been or are rich, even though that is the clearest criterion of personal success. Traditionally it was usually that a poor and a rich herder worked together trading labor force for safety (Kvist, 1990). The difference between the nomads and the stationary farmers is vividly illustrated in the traditional music. Unlike their Norse counterparts, the traditional Sámi joiks price the life on the tundra and the deer herds flooding across it.

2. The impact of the historical background on the socio-economical stability of grazing systems

The different socio-economical backgrounds have had dramatic impacts on the socio-economical stabilities of the two systems. Both developed in a time when the life of most Europeans was a continuous battle for survival and when the Nordic region was poor even when compared to the rest of the Europe. Starvation was a common cause of death[14] still in mid 1800's and expectations of the people were low[15]. However, a major change was already beginning. During the latest 150 years, the Nordic region has experienced an incredible increase in the standard of living of everyone, due to industrialization, which allowed the Nordic region to capitalize on its natural assets: raw materials and excellent work morale.

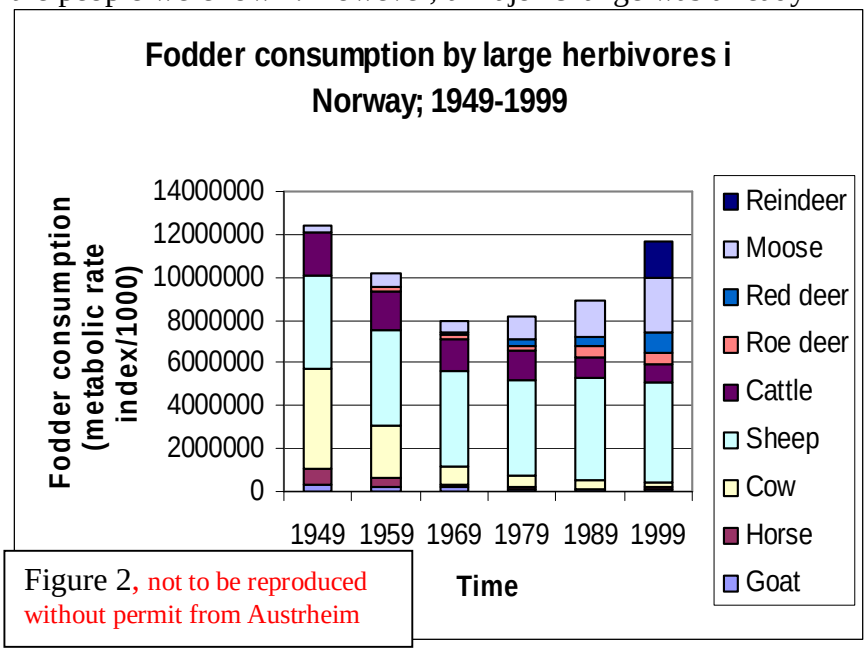


Figure 2, not to be reproduced without permit from Austrheim

Due to their different socio-economical backgrounds, two peoples traditionally using the mountains for grazing have reacted to this change in very different ways. As soon as

[12] the two livelihoods were normally combined
[13] a very essential thing in all nomad cultures
[14] the latest time of mass starvation due to crop failures was 1860's
[15] even the national and regional anthems in the Nordic region try to make the best of this situation. The official name of the anthem of NE Finland is "Nälkämaan Laulu" (The Song of the Hungerland); the second verse of the Finnish national anthem begins: "Our land is poor; will so remain, for those who search for gold..."

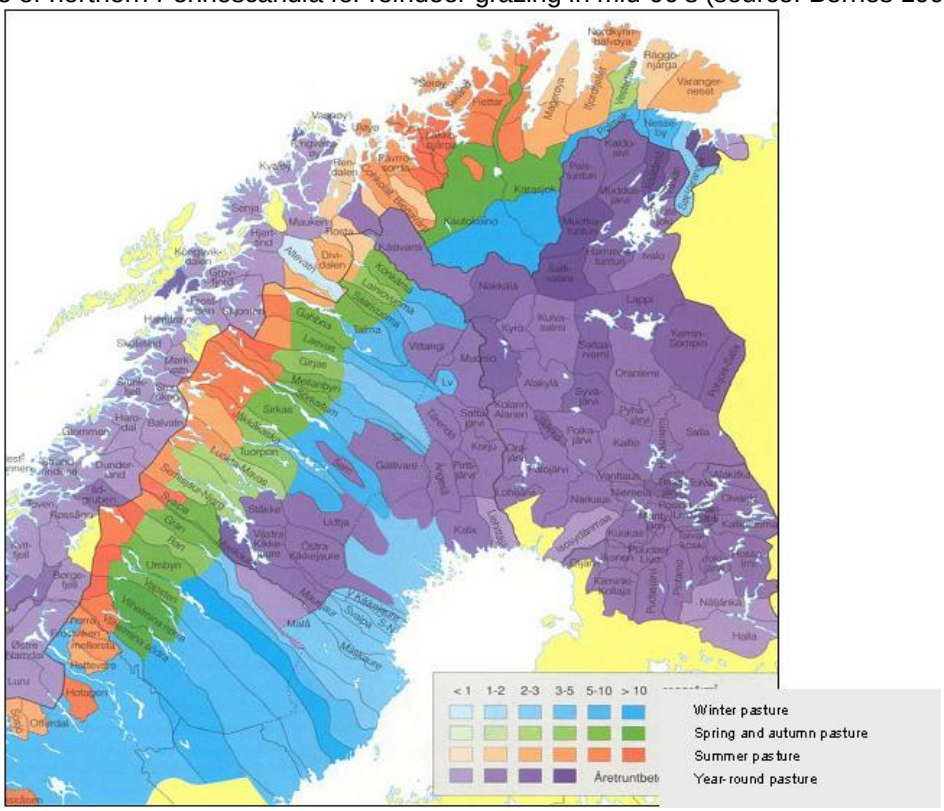
affluence started to spread in Norway, the less conveniently located chalets were abandoned. During 1950-1970, the chalet-based use of the mountains was practically abandoned. This is reflected in the dramatic reduction of milk cattle ('cows' in the chart) on outback pastures, seen in Figure 2 (Source: Austrheim, G., Solberg, E.J., Mysterud, A., unpub. data.). What were left were sheep (in practically unchanged numbers) and non-milk cattle, as these did not require daily contacts and could be taken care without moving to chalets with the family.

The deepest low in the intensity of grazing in the parts of the mountain chain traditionally used by Norsemen occurred about 1970. Thereafter, grazing intensity has increased again, but only because efficient enforcement of hunting laws has resulted to increased numbers of wild cervids. The use of mountains for grazing by sheep and non-milk cattle has remained stable in the region as a whole. Whether spatial and temporal aspects of land use have changed cannot be inferred from hard data, since agricultural authorities only record the numbers of animals on outback pastures (utmarksbeite), embracing anything outside the areas defined as intense agriculture. The fact that subsidies do not depend on the use of remote mountain areas makes it likely that the use of most remote mountains has declined and the use of near-by ones has increased. Besides landscape differences different agricultural policies explain that sheep grazing on outback pastures is common over most of Norway, but rare in Sweden.

The development of the reindeer husbandry has been totally different. The basic principle has been that every accessible square kilometer is used and every stone is turned to make more square kilometers accessible (Fig. 3). Especially the Sámi from Guovdageaidnu[16] have been busy finding gaps created by restrictions on the use of Norwegian pastures by Swedish Sámi, and expanding the area of reindeer husbandry southwards. This is just a most recent expression of an old pattern[17]. Even the southernmost and easternmost reindeer herding Sámi in Finnish and Swedish Lapland[18] originate from the Guovdageaidnu area, so do many Sámi groups living in central and southern parts of the Swedish area of reindeer husbandry, as well as some in South Sámi area of Norway . Due to the high social status of being a badjeolmmuš, re-enforced by the recent revival of the Sámi language and culture, the will for staying in the reindeer husbandry is as strong as ever, if not stronger. The government of Norway had to realize this trying to buy out Finnmark herders 55000€ of their herding concession to decrease their number. Very few families accepted this offer (St.prp. nr. 49 (1997-1998). Simultaneously, the costs of herding activities have increased tremendously by motorization, reducing the net income per reindeer, while the education level of the Sámi has dramatically increased. Consequently, many reindeer nomad families get much if not most of their net income from the salaries of Sámi women, who are involved in all kinds of modern businesses[19]. Even men often combine an income from a well-paid modern profession with reindeer husbandry.

[16] Kautokeino; literally ' the midpoint of the road'
[17] In October 2004 there is again a discussion in Nort Norwegian media of moving Guovdageaidnu herders to Troms and Nordland in order to decrease reindeer numbers in Western Finnmark
[18] e.g. Vapste and Arjepluovvi/Arjeplog southern Swedish lapland, Lišma and Vuohčču in Finnish Lapland
[19] teachers, administrators, medical doctors, high-tech specialists

Fig. 3. Use of northern Fennoscandia for reindeer grazing in mid-90's (source: Bernes 1995)



In a European perspective, the development of the Norse use of mountain pastures is thus business as usual. Nobody has to own milk cattle and move to a chalet for the summer in order to be able to feel really Norwegian, and unlike the summer camps of the Sámi, the scattered chalets did not provide social cohesion, either. Life on them was just boring and brought only meager hourly salaries. Conversely, for many Sámi, gathering to summer camps and around separation corrals are major social events and herding reindeer across the mountain and tundra landscapes is an identity-maintaining activity. Moreover, it is a fair generalization to say that an unusually large fraction of the Sámi population genuine love the mountain and tundra nature and really like to be out there in almost all seasons[20]. Being involved in reindeer husbandry thus combines the functions that working for money and hiking, hunting and fishing on mountains during the vacation has for a typical Norwegian.

In a European perspective, the Sámi reindeer husbandry thus represents an exception: a large-scale grazing system where the main problem is that there are more people willing to participate than there is place, so that there is a constant pressure to expand the physical boundaries of the grazing system. The modernization of the life has just increased the interest[21]. Many Sámi working in offices to create supplemental income are dreadfully disappointed if their work schedules imply that they miss the calf marking, slaughtering or migrations, even if these activities are often carried out in quite harsh conditions.

3. Implications of the socio-economical and ecological boundary conditions on the stability of the grazing systems

The socio-economical instability of the Norse mountain grazing system seems already to be causing vegetation changes interpreted in media as overgrazing. These discussions, deriving

[20] Late October tests the affections of even the most devoted tundra and mountain lover.
[21] plus increased both costs and possibilities to cover them

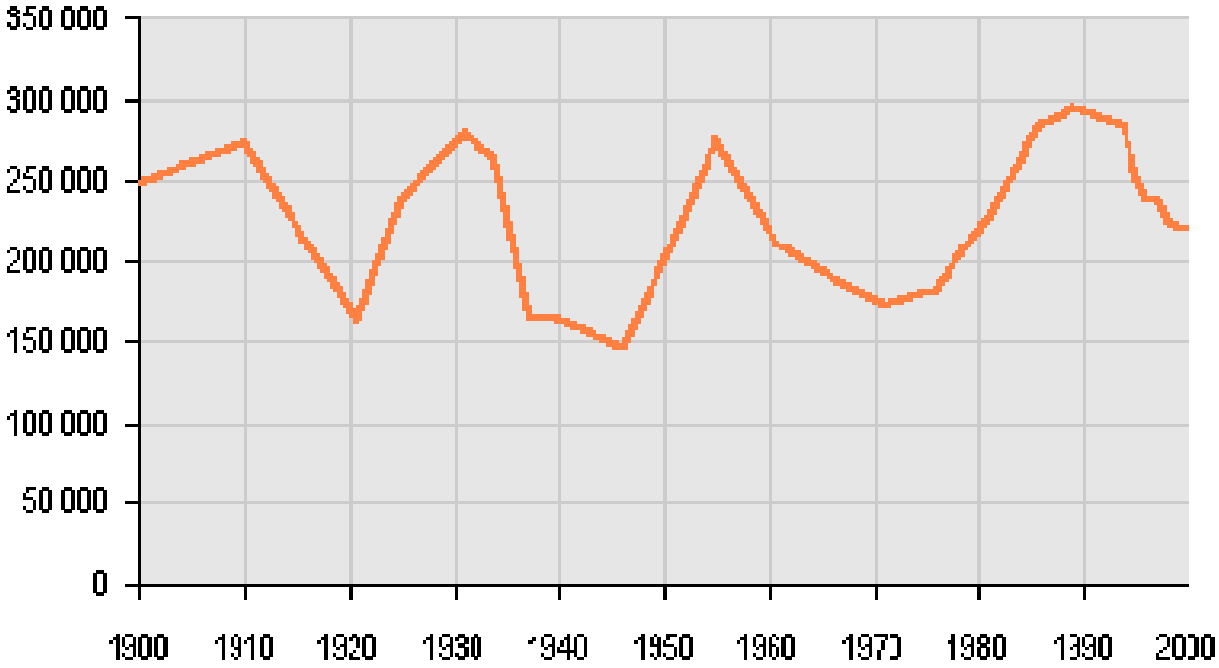
from observations of experienced lay naturalists and professional botanists are convergent, reporting increasing abundance of coarse-leaved grasses and decreasing abundances of soft-leaved forbs. While the biodiversity implications of these changes are still obscure, they probably reflect genuine decline in the value of mountain pastures of southern Norway, which may further reduce the interest of sheep owners to use mountain pastures. As the Norwegian sheep stock as a whole has remained relatively stable (Fig. 2) the alleged occurrence of large-scale overgrazing is unlikely, although local overgrazing (and undergrazing) may occur, in response to changes in spatial land use patterns (see above). A likely contributing factor for the vegetation changes is the *decrease* in the numbers of horses, cattle and goats on mountain pastures (Fig. 2). These grazers have entirely different forage preferences and grazing patterns as compared to sheep, which probably used to balance the grazing system. The increase in the numbers of cervids is not likely to re-create the lost balance, since their food preferences converge with those of the sheep. While the details are uncertain, due to the scantiness of hard data, the changes in the Norse grazing system illustrate that ecological, economical and social aspects of large scale grazing systems can contain complex feed backs, which cannot be resolved without a truly multi-disciplinary approach.

For the reindeer husbandry, the problems are of totally different nature. The motivation to stay in the reindeer husbandry is high and for many families, owning reindeer, migrating with them and taking good care of them is today as important - or even so - more important than making money on them. Although the livelihood means hard work in harsh conditions and is under heavy external interference, especially in its southern fringes, where other activities (logging, hydroelectric construction, skiing industry, hunting) and conflicts with private landowners have reduced grazing lands or made their use difficult, reindeer husbandry has so far proved to be resilient. On the other hand, the reindeer husbandry has never been characterized by stable numbers of reindeer. Instead, reindeer numbers have fluctuated violently with a period of about 30 years (Fig. 4). Traditionally, each reindeer crash has been explained by referring to some proximate factor that triggered it, but this explains only the exact timing of the crash. Ultimately, the reindeer cycle appear to be driven by a complex of ecological and socio-economical factors. Lichens are accumulating but depletable resources. Dependency on such resources tends to create cycles even in wild animals (Turchin et al. 2000). The combination of collective land use and private ownership of reindeer is an additional source of instability. If the district cannot act promptly and resolutely to a threat of overgrazing of winter ranges, we have a moment 22, where the only rational reaction of an individual herdsman is to *increase* the size of his herd in order maximize his chances to have a viable herd after the inevitable crash[22]. If money is available from other sources than reindeer meat is used for supplemental hay feeding, this will only prolong the peak, deepen the crash and prolong the time of low reindeer numbers, as it the lichen biomass will be depressed to levels from where the recovery will be slow. It seems likely that access to external money contributed to the height of the latest peak in Norway (Bernes 1995, Moen and Danell 2003) and that the technological revolution of herding techniques, particularly the extensive use of ATVs, made the peak the highest ever as they made grazing-out-of season plus trampling and down-grazing lichen pastures much more intensively than ever (Riseth & al. 2004). In Sweden, the latest peak did not differ from the previous ones (Fig. 4), which witnesses about good ability of the Sámi to counteract[23] the new sources on instability.

[22] If you have to go to 'lahtari' = must slaughter the last of your reindeer for your immediate financial support, there is no way for yourself and hardly any way for your children to return to the reindeer husbandry

[23] Beach (1981: 46-47) explains based on the herder Torkel Tomasson analysis from 1918 how depleted lichen pastures also lead to a less intensive herding and more spread of the herds preventing Malthusian catastrophes as known from e.g. St.Matthew Island (Klein, 1968)

Fig. 4. Fluctuations in reindeer numbers in the Swedish area of reindeer husbandry; the northern Sámi area accounts for > 80% of the numbers (source: Moen and Danell 2003)



Another factor aggravating the inherent ecological instability of the reindeer husbandry consists of laws and administrative borders. Reindeer lichens are very sensitive to trampling in summer (Oksanen 1978). Hence, rational use of lichen grounds requires that all reindeer are absent from them during summer and, preferentially, during the entire snow-free period. However, the northernmost herding units of the Swedish Sámi have very restricted access to their traditional summer ranges in Norway, both in terms of area and in terms of time. Finnish and Norwegian Sámi have totally lost their grazing rights in the other country, and the closure of the Finnish Norwegian border has even excluded the Norwegian Sámi from their traditional grazing grounds in northeasternmost Swedish Lapland. Moreover, schematic district borders further subdivide the Finnish part of northern Lapland, and Finnish laws entitle every reindeer owner to have his reindeer wherever within the district he finds it most convenient. When grazing is combined with unnecessary trampling, the adverse impacts of high reindeer numbers on lichens are aggravated, which inevitably leads to deeper and longer low phases or to economically unsustainable dependence on hay[24].

[24] The economic advantages of reindeer as compared to sheep depend totally on the ability of reindeer to survive on natural forage. If fed with hay, reindeer are “just oversize sheep that grow slowly and produce little wool” as a Deatno valley Sámi, owning both reindeer and sheep, put it.

Fig. 5.Summer grazing by reindeer on Jávrisduottar at the Finnish-Norwegian border. On the Norwegian side (left), where summer grazing is sporadic, the white reindeer lichens still abound. On the Finnish side (right), where summer grazing is continuously intense, lichens are largely gone.

4. Potential connections between the stability/instability of the two grazing systems and Pan-European biodiversity

In the present context, large-scale grazing systems are interesting only in the case that they have a connection to biodiversity on a European level. With respect to the arctic-alpine grazing systems, this connection is still debated. It is thus best to approach this issue by looking at the aspects of arctic-alpine biodiversity, which can be regarded as interesting in an European perspective and where connections between biodiversity and grazing seem likely. In the present context, it is natural to define Europe as the entire EU/EES area, excluding much of East Europe (e.g. Russia) but including Norway, Iceland and Fair Islands (Færøyene). Moreover, it is rational to treat the islands separately, since their ecological conditions differ radically from the conditions of the European continent, making it likely that populations on these islands differ profoundly from mainland populations with respect to their genes.

The Fennoscandian fauna contains two mammal species, whose occurrence in Europe thus defined is limited to the arctic-alpine habitats of Fennoscandia: the endemic Norwegian lemming (*Lemmus lemmus*), which has extremely violent population dynamics, with short-lived peaks and long periods of low numbers, where local extinctions are likely (Turchin et al. 2000). Little is known about the impact of reindeer on lemming dynamics, but indirect evidence suggests that the interaction between lemmings and reindeer is probably positive. Reindeer grazing favors grasses and mosses (Olofsson et al. 2001, Väre et al. 1995), which are the resources of the lemming. Lemmings, in turn are the main resource of the other strictly arctic-alpine mammal species, the acutely threatened arctic fox (*Alopex lagopus)*, (Angerbjörn et al. 1995). Any impact of reindeer on lemmings thus automatically influences the survival prospects of arctic foxes.

The botanical aspects of biodiversity in northern Europe are strongly connected to lime rich habitats, which only cover small areas but have of historical reasons much more species rich flora than the predominating lime-poor habitats (Pärtel 2002). Biodiversity of butterflies and moths follows the same pattern, since their diversity reflects the diversity of host plants. The occurrence of lime-favored arctic-alpine plants in Fennoscandia is below illustrated by the results of the ongoing European flora atlas project, now covering about 20% of the vascular plants of Europe and by the distribution maps of the most extreme rarities (Fig. 6). As we see, the bulk of the mountain chain contains few if any rare plants. Their occurrence is concentrated into two relatively small biodiversity hot spots – a southern one, located in the

central, northern and eastern parts of the South Scandinavian massif, and another, lying in the central and eastern parts of the northern massif. Out of the hot spots, the northern one is both larger and hotter than the southern one. The picture for butterflies is essentially the same. In rough terms, about 60% of the rarities occur in both areas, about 30% in the northern hot spot only, while about 10% are limited to the southern hot spot.

The northern hot spot lies entirely within the area of reindeer husbandry and since lime-rich habitats produce excellent summer forage, these habitats are and have been intensely grazed by reindeer. The same applies to the eastern fringes of the southern hot spot. Especially in the latter area, the impact of reindeer grazing has been perceived as a threat for biodiversity, though the evidence is debatable (Moen and Danell 2003). The negative views stem from observations concerning the immediate impact of grazing and trampling, which are indeed negative for practically all plants in practically all grazing systems. To judge the likely long-term effects, it is useful to compare densities of domesticated reindeer in northern Fennoscandia (Fig. 3) to the densities of wild caribou in Canada (Crête 1999). The mean densities are quite similar, suggesting that the current grazing by reindeer can be as a natural environmental factor, to which the arctic-alpine flora has been adapted. This is even seen in the characteristics of our arctic-alpine rarities, which have leaves close to ground and are dependent on sexual reproduction, i.e. require disturbed ground (see Fig. 6, right hand panel). Moreover, the abundance of rare arctic-alpine plants appears to correlate positively with the intensity of reindeer grazing (Olofsson and Oksanen 2005, see also Fig. 7). Available evidence thus suggests that reindeer grazing is favorable for the botanical aspects of arctic-alpine biodiversity; although we emphasize that these conclusions are preliminary and must be tested experimentally.

In the central parts of the southern hot spot, the impacts of the current sheep grazing are more difficult to infer, but the change of mixed livestock to sheep and wild cervids (Fig. 2) can provide problems as this change probably leads to increased grazing pressure on leaved forbs and, simultaneously, reduced grazing pressure on tall grasses and shrubs with low palatability. The nightmare scenario for the southern hot spot is thus that many arctic-alpine rarities are currently subjected to both intensified grazing damage and intensified competition. Without detailed studies it is difficult to assess the severity of this problem, but return to grazing by mixed livestock would doubtlessly be positive for most arctic-alpine rarities in the southern hot spot. To achieve this, it would be vital to find a way to make the chalet life socially and in terms of experiences as rewarding for Norse youths than the life on summer camps is for the Sámi. One strategy would be to try to get truly urban youths, with strong motivation for nature experiences, to be involved in chalet husbandry. Due to the role model status of the urban youth, this could revive the interest even on the countryside by creating the feeling that life on the mountains is ‘cool’ in the way the youth think about the concept - not just in terms of summer temperatures.

Figure 6. Occurrence arctic-alpine lime plants in the completed bands of Atlas Florae Europaea (Jalas et al. 1972-99; from Olofsson and Oksanen 2005); and the distributions of the 24 arctic-alpine plants with smallest ranges in Fennoscandia, plus pictures of them (excluding graminoids) source: Lid 1985

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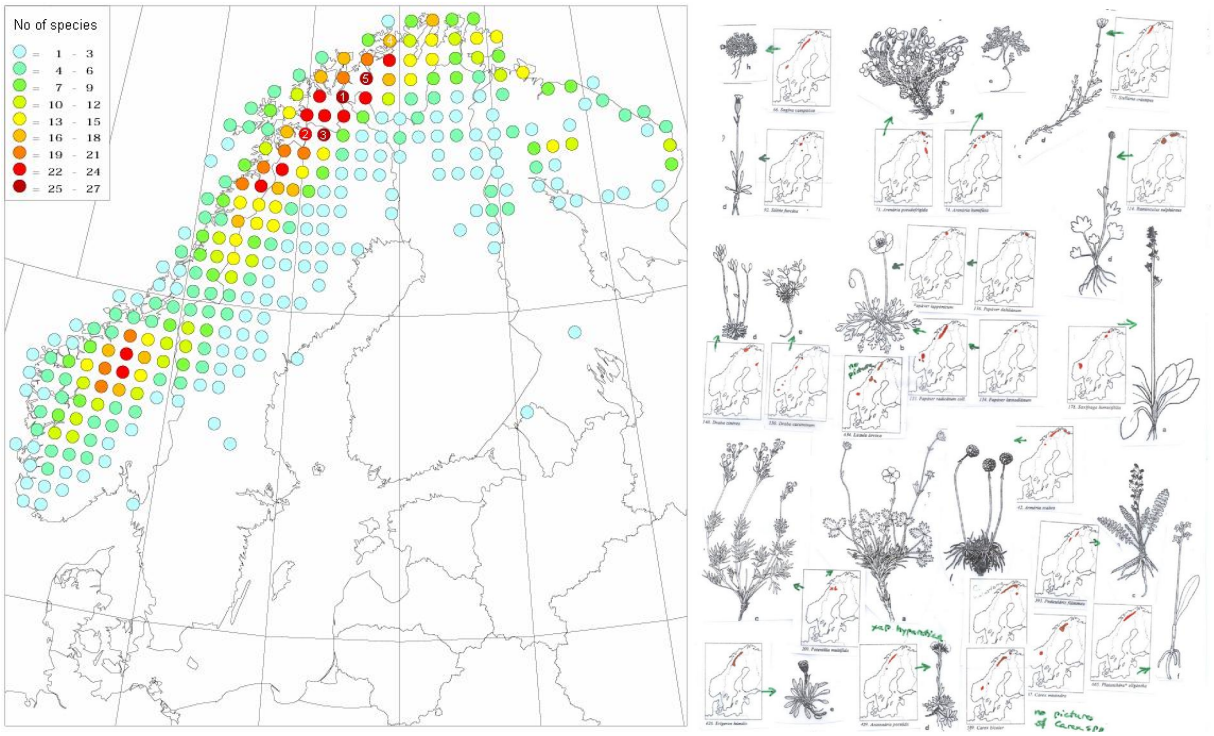
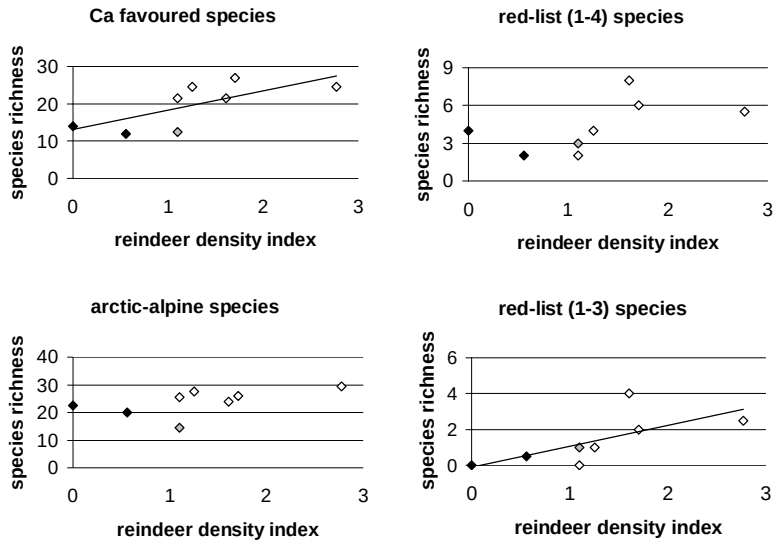
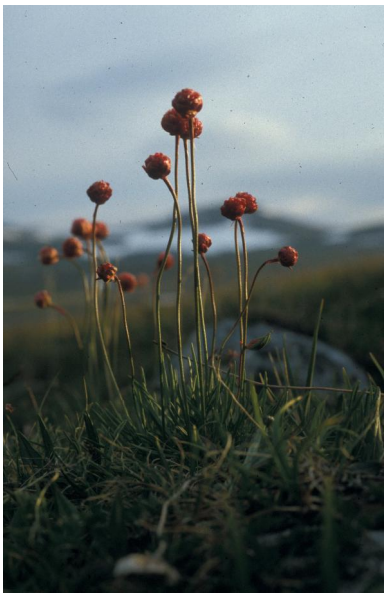


Figure 7. Relationship between reindeer grazing intensity and numbers of different categories plants on the sample plots of Olofsson and Oksanen (2005), and an example of a red-listed, Ca favored plant, *Armeria scabra*





B. SYSTEMS WITHIN THE BOREAL ZONE AND AT THE NORTHERN FRINGES OF THE TEMPERATE ZONE

1. Stationary reindeer husbandry within the Fennoscandian taiga

Large parts of the taiga are included in the area of Sámi reindeer husbandry and serve as vital production areas of winter forage – lichens (see above). Moreover, the Fennoscandian area of reindeer husbandry embraces even large forested areas, where reindeer herding is stationary and primarily carried out by people with mixed Finnish-Sámi background. Most of these herdsmen are Finnish speakers, but they still may identify themselves as 'Forest Sámi', especially so in Sweden, where such identity strengthens herding rights and other claims to natural resources. In these forest areas, reindeer husbandry did not develop spontaneously but was introduced by the initiative of the Swedish king, who wanted to broaden the resource basis of the settlers and brought in Sámi from the mountains to teach the basics of reindeer husbandry. The inhabitants of the taiga then developed own herding habits to adjust the reindeer husbandry to the constraints provided by agriculture.

Even in this stationary reindeer husbandry, the main natural winter habitats are dry, lichen rich forests. Earlier, even moist spruce taiga was an important winter habitat, since hanging lichens covered old spruces. Now such spruce forests only exist in national parks. In forestry areas, spruces just do not get old enough to carry significant amounts of hanging lichens. Even the ground lichens of dry pine forests are profoundly impacted by forestry, which has reduced the extent of natural winter habitats in the taiga. The main summer habitats of the reindeer herded within the taiga are large wetlands, which produce herbaceous forage and are windy enough to allow grazing during the mosquito plague.

The impacts of the stationary reindeer husbandry on wetland vegetation seem modest. Conversely, the impact of reindeer on the vegetation of dry forests is profound and so long lasting that the old Finnish-Russian boundary (from before 1940) is still visible in satellite images, due to major differences in abundances of mosses and lichens (Väre et al. 1995). The impact is currently much stronger than it used to be, as the stationary taiga reindeer husbandry has reacted to the reduction of natural winter resources by an increase in the use of hay. This has allowed for a radical increase in reindeer numbers after 1970 (Fig. 8), leading to profound decimation of ground lichens on pine heaths (Fig. 9).

Fig 8. Development of reindeer numbers in Finnish Lapland since 1900 (in thousands; Bernes 1995; smoothed). The vast majority of Finnish reindeer represent the stationary husbandry within the taiga.

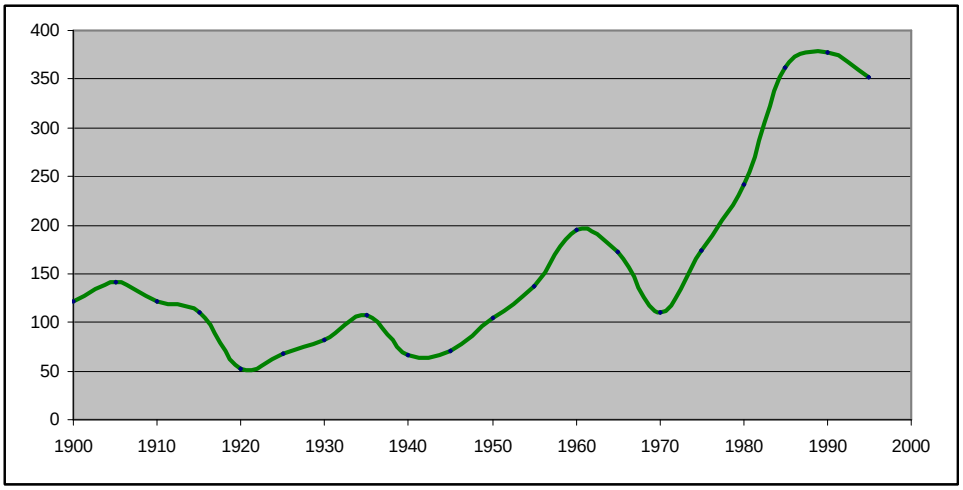


Fig. 9. Dry pine heaths at in Finnish (left) and Russian (right) Forest Lapland at the current border,. The Russian side was grazed until 1939 but has been ungrazed thereafter. Photo: Otso Suominen.

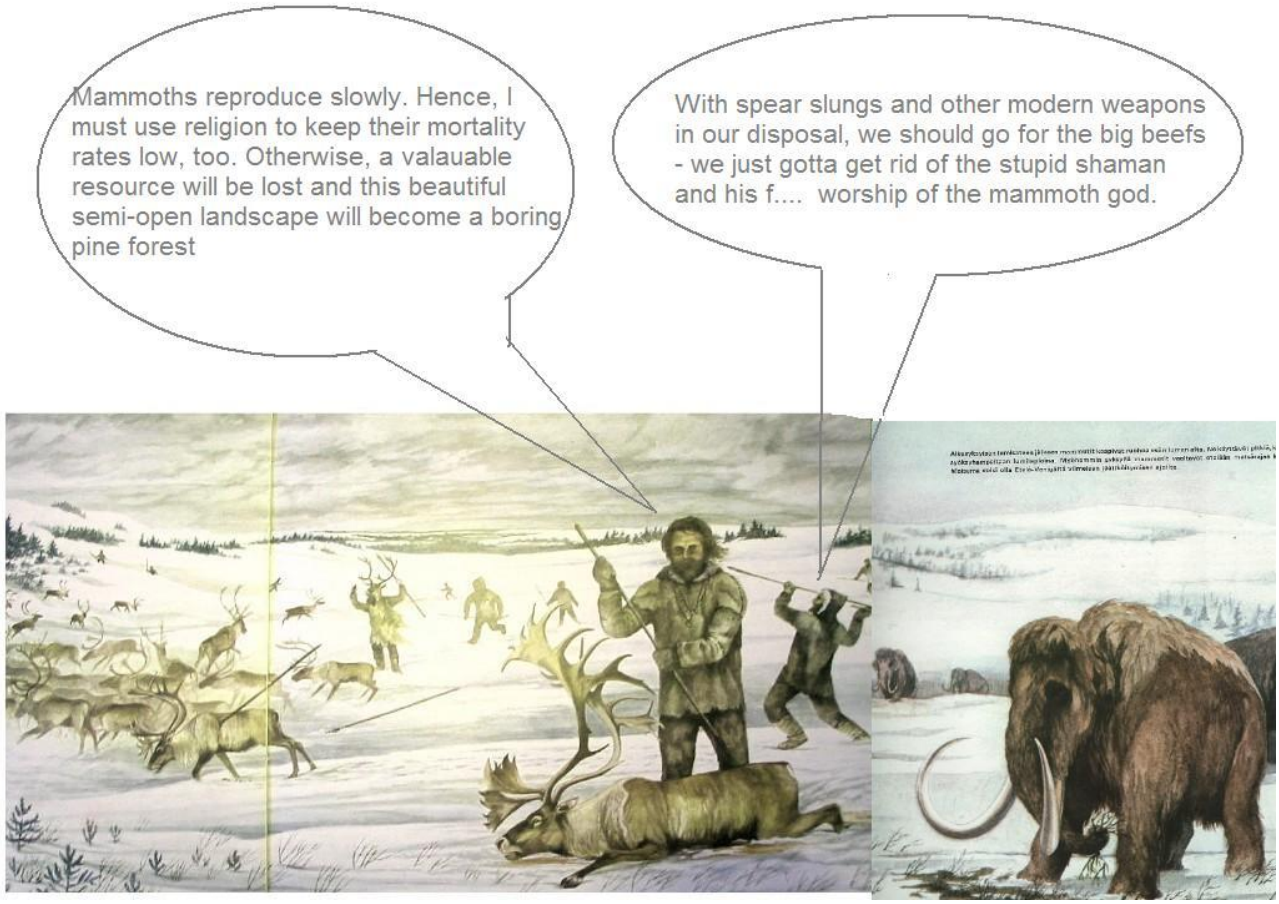
The strong impact of reindeer on dry pine heaths has been perceived as negative for aesthetic values and even for forestry, as the absence of the isolating lichen cover has resulted to changes in ground temperatures, which damage tree roots. With respect to local species richness and diversity of invertebrates, the impact of reindeer grazing in the taiga forests appears to be positive (for details and references, see Suominen and Olofsson 2000). We are unaware of any data documenting either positive or negative impacts of forest reindeer husbandry on species rare in a European perspective. Moreover, there is an essential difference in the relation between current reindeer husbandry and past impact of wild reindeer between the mountain/tundra landscape and the taiga. In the primeval taiga, the main native grazer is the moose, and predators regulate wild reindeer (caribou) numbers at a low level (Crête 1999, Crête & Manseau 1996), making it *a priori* unlikely that the taiga landscape would harbor large numbers of species dependent on reindeer grazing.

Our tentative conclusion is thus that the impacts of stationary reindeer herds within the taiga landscape are primarily local and national concerns, referring to aesthetics, forest growth and local species richness. With respect to European biodiversity, this form of reindeer grazing appears to be a neutral phenomenon. We emphasize, however, that this conclusion derives more from absence of evidence than from evidence of absence and should thus be confirmed or refuted by thorough empirical studies.

2. Sheep and cattle grazing in the taiga
including the transition between the taiga and temperate woodlands

To put the boreal cultural landscapes to proper perspective, it is useful to recall that the closed taiga is a relatively young ecosystem. In the Pleistocene – i.e. only 10 000 years ago – the boreal zone was primarily a savanna-like mosaic of woodlands and meadows (Fig. 10, Kurtén 1969). The closed taiga started to prevail first when our ancestors had extirpated northern megaherbivores. The spreading of more open boreal landscapes due to the actions of domesticated grazers was thus, to some extent, a return to the original state of this life zone. This process took different forms in different parts of the boreal zone. In western Sweden, where arable only exists in river valleys, the forested highlands between the valleys were grazed in a manner corresponding to the use of South Norwegian mountains. Animals were driven deep into highlands, where each family had a chalet (‘fäbo’) as a point of logistic support and certain amount of collaboration between families occurred. Much of the land was cleared to meadows, and grazing itself changed large areas of dense forest to semi-open woodlands and parklands, as the grazing animals reduced the survival rates of tree seedlings.

Fig. 10. An illustration of the European 'boreal savanna' in late Pleistocene; modified from Kurtén (1969), whose landscape pictures derive from careful paleo-ecological studies. The final winners – pine seedlings – are seen in the lower left corner.



Direct use of wood as construction material and fuel contributed to these changes. In less hilly areas (southern and eastern Sweden, Finland, Estonia), where soil conditions determined the distribution of cropfields, grazing lands were divided between farms, as their Swedish name[25] tells. Grazing operations occurred in small scale, but their impacts were strong, especially in areas with long outdoors grazing season (southern Sweden and the Baltic archipelagos), where this land use even created totally open heathlands (Sjörs 1960).

In interior Finland and on Highlands along the Swedish-Norwegian border, which were settled by East Finns (Savonians) to consolidate the Swedish rule, the East Finnish practice of shifting agriculture flavored the land use. Because a burned forest yielded good crops for few years only, this land use created large amounts of successional stages suitable for grazing, which delayed the succession from abandoned burn to forest. As compared to cropfield-based economy in the taiga, shifting agriculture was an enormous success. Excellent crops rewarded the hard work of felling and burning forests and harvesting the stony burns by hand with sickle. Moreover, shifting agriculture allowed for the use of higher country, where soils were rich, as the land had never been inundated by the Baltic Sea. In elevated areas, even the risk of crop failure due to frosts was smaller than in valleys, often plagued by severe thermal inversions in August nights. The consequence was rapid growth of East Finnish population. Even if this was combined with profound spatial expansion, the density of the East Finns rose locally, too, which reduced the time interval between successive

[25] utäga = outer property

burnings. As the number of animals per family remained unchanged, the abandoned burns were grazed by an increasing number of animals, slowing down their succession. The best lands on hills were cleared from stones and rendered to permanent cropfields. The consequence of all these changes was that much of the interior Finland was changed from a taiga landscape to a mosaic of small hilltop cropfields, burns ('kaski'), grazed dry ('aho') or moist ('niitty') meadows and deciduous second-growth forests, whereas coniferous forests were uncommon (Kalliola 1958). Still in late 1800's, this burned and grazed landscape was common enough to dominate in the national romantic descriptions of the Finnish countryside, and the cultural elite appreciated its aesthetic values[26].

As granites and other lime-poor rocks underlie most of the Fennoscandian taiga landscape, the meadows deriving from it are not especially rich floristically. Moreover, much of their floristic diversity derives from plants, which are uncommon in the taiga but widespread in Central Europe. However, the Fennoscandian taiga zone even includes two areas, where lime-rich habitats abound: Jämtland in western Sweden, where the lime rich edge formation of the Scandinavian mountain chain lies deep in the taiga, and a more diffuse area, embracing the archipelago of southwestern Finland and the eastern coasts of Sweden[27], where glaciers have enriched the landscape by moraines originating from the Silurian limestone beds on the bottom of the Baltic Sea. The lime-enriched meadows of these areas used to be floristically (and entomologically) rich, harboring several rare orchids and other forbs with limited distribution.

Practically all these boreal grazing systems and the landscapes created by them must today be discussed in the past tense. When timber started to have commercial value in the 1800's, shifting agriculture was restricted and later on forbidden. Laws were passed to encourage reforestation and to discourage grazing – especially so in Finland (Cajander 1914), where forestry has been the backbone of the national economy from late 1800's to the age of cell phones. As a consequence, all that remains out of the semi-natural meadows of Finland are tiny fragments (Fig. 11). Actively managed meadow preserves, roadsides and backyards of conservation-minded citizens now play the main role in the effort to preserve the boreal meadow flora (Tikka 2001). Even in Jämtland, the chalet meadows are largely gone, and their plants (including even the landscape flower of Jämtland, *Nigritella nigra*) have been decimated and restricted to naturally open habitats (fens, alpine meadows). In southeastern Norway, towards the Swedish border, livestock, mainly sheep, grazing in meadows and open boreal forest still seem to have a positive effect on biodiversity and there is a discussion whether the current active governmental promotion of wolves indirectly will reduce biodiversity. Vegetation surveys document red list species of national interest (Stabbetorp and Often, 2003).

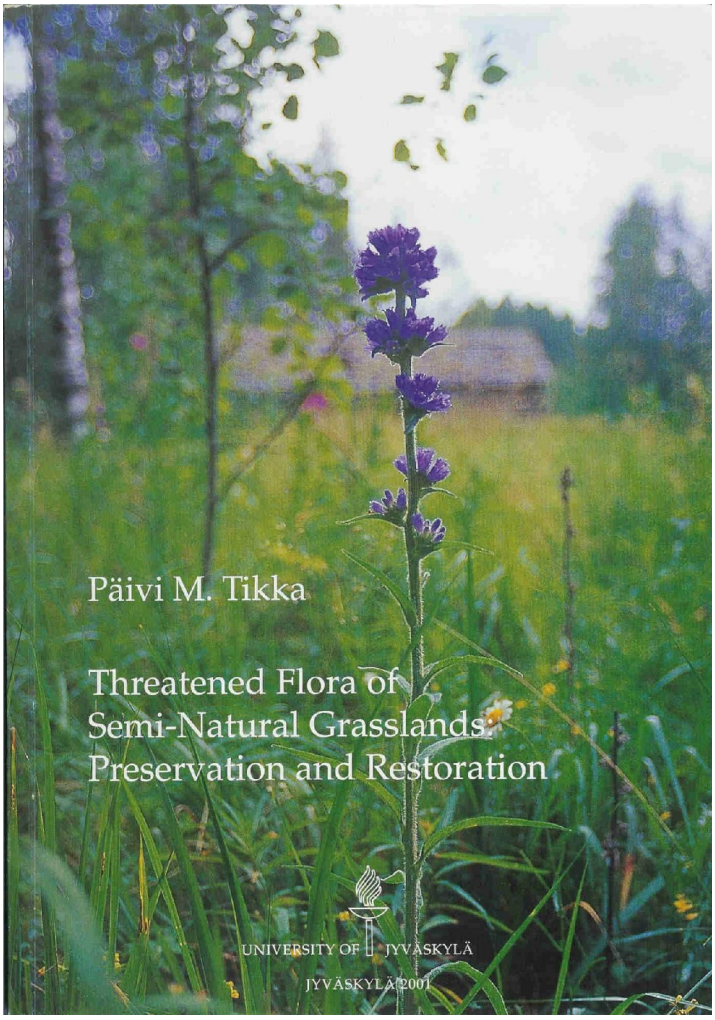
Along the Baltic shores, where the lime rich habitats were created by the glacial transport from submerged Silurian limestone beds, the lime-enriched habitats occur primarily as patches on flanks of outcropping granite rocks. These habitats have escaped reforestation, their spontaneous succession has been slow, and their use for small-scale grazing has continued to recent times. Currently, many such habitat patches are managed in collaboration between landowners and local nature protection authorities. In the surroundings of Stockholm, a new factor has entered the scene: the soaring interest of Swedish girls for horseback riding. In this area, horses are now more numerous than they ever have been, and the reaming meadow patches are natural places to keep them in summer. For the biodiversity of the cultural landscape, this has been a mixed blessing. On one hand, the meadows are kept open.

[26] For instance, Eino Leino's classical poem 'Nocturne', from about 1880, begins as follows:
"Sounds of ryebird on the hill I'm hearing. Over crop heads full moon starts to shine.
Valleys hide behind the smoke of clearing. Happiness of summer night is mine." (translated by L.O.)

[27] provinces Uppland, Västmannaland and Sörmannaland in the Stockholm-Uppsala region

On the other hand, the intensity of horse grazing and associated physical disturbance is often well above the level, which would be optimal for the majority of meadow plants[28]. Even in this area, current grazing of meadows occurs in small scale and the only output of any economical value consists of the fees paid by parents for the riding lectures of their daughters.

Fig. 11. A surviving fragment of moist boreal meadow in central Finland, and one of its characteristic plants, *Campanulla cervicaria,* now threatened in Finland. Photo from the cover of Päivi Tikka's thesis.



3. Grazing systems in arid parts of Sweden and Estonia

Along the shores of the Baltic Sea, the local climate is unexpectedly arid. The reason is the difference between the temperatures of land, which warms up rapidly in spring, and the Baltic Sea, which is littered with drift ice still in May and remains cold throughout June. The cold sea cools down passing air masses. When passing over the land, the air warms up again. Hence, practically all spring and early summer precipitation falls on the sea, while little falls on larger islands. In habitats with heavy soils, the virtual lack of spring and early summer precipitation matters little, since these soils store the water obtained from the copious winter precipitation. In rocky and sandy habitats, however, the moisture obtained from winter rains

[28] Based on unpublished work of Åsa Lindgren, Department of Botany, Stockholm University.

and/or melting snows rapidly disappears and plant growth is severely limited by the lack of water just when temperature and light conditions are optimal. In late summer, the temperature difference between land and water disappears, but then the temperatures are already sinking, nights are getting longer, and even in daytime, heavy clouds often create suboptimal light conditions. Hence, the lack of spring and early summer precipitation has much stronger impact on plant growth than indicated by annual precipitation values.

The aridifying impact of local climate on growing conditions of plants is strongest on the Baltic limestone islands (Öland, Gotland, Saarenmaa, Hiiunmaa) and on limestone flats of the Estonian coast, because these areas are surrounded by the cold waters or have the sea in west, from where the rains normally come. A contributing factor is that limestone warms up rapidly, which amplifies the thermal contrast between sea and land. Moreover, the elevated parts of these islands became washed clean by the waves of the Baltic Sea when they rose above its surface in the recent geological past. The absence of soils and the arid conditions made the primary succession so slow that the limestone flats were only covered by open woodlands, with lots of pioneer plants still present, when the islands became settled by Neolithic peoples with domesticated grazers. Increasing grazing pressure lead to deforestation, creating the widespread limestone heaths, referred to as alvars (Pettersson 1958, Sjörs 1960, Pärtel et al. 1999; see Fig. 12, left panel).

During the 1900's the gradual reduction of grazing and is total cessation in large areas triggered changes in the vegetation of alvars, but due to the arid conditions these, changes proceeded so slowly that little attention was paid to them until Pettersson (1958) documented them by comparing old descriptions, floristic records and photographs with the current situation. The importance of grazing on alvars is currently widely recognized and included in the protection schemes of this habitat (Anonymous 1993) and its unique flora and fauna, which derives directly from the post glacial pioneer vegetation and includes both endemics and endemic races and subspecies of plants currently found only much warmer and/or drier areas. The conservation value of the alvars for European biodiversity is thus obvious. On the other hand, these habitats are so unproductive and cover so limited areas that the current grazing systems used for their maintenance can hardly be regarded as economic activities.

Fig. 12. Öland alvar (left) and abandoned wooded meadow, subjected to severe shrub encroachment (right) - a typical situation on Öland today (photo Tarja and Lauri Oksanen).

Integral parts of the alvar landscape are moist depressions, to which the water percolating from the limestone flats accumulates. Small depressions have always been grazed, forming the orchid-rich meadow part of the alvar landscape. Larger depressions were normally fenced and used for haying and coppicing - i.e. for production of winter forage. Though grazed only in late summer if at all, these habitats thus formed a vital part of the grazing system. Haying and coppicing created a biodiversity hot spot: wooded meadows (Fig. 12, right panel), harboring many rare species and having very high local biodiversity (Kukk & Kull 1997). Since the wooded meadows are productive habitats, they become rapidly closed forests after abandonment, which is their typical fate today (Fig. 12). Large parts of this habitat have been lost and the remnants are dependent on continuous, active management.

The measures required maintaining alvars and wooded meadows are currently well understood and the public support for the necessary input of tax money is solid in Sweden and even in Estonia. The only destabilizing factor for these habitats is the common agricultural policy (CAP) of EU. In spite of the meager economic outputs, the maintenance of these habitats is classified as subsidized agriculture, where subsidies provided for the sake of nature protection are tied to the habitat directive. The only habitat category that suits in this context is grasslands. However, neither alvars nor wooded meadows have sufficiently much grass cover to pass EU:s definition for grasslands, and as grasses are competitors of many rare alvar plants, increasing their abundance would not be desirable, either. (Indeed, many of the changes documented by Pettersson were just invasions of tall grasses, which outcompeted prostrate alvar plants.) Moreover, wooded meadows have too high canopy cover of trees to pass as grasslands, and many of their unique plants require some shade, either directly or indirectly (shade keeping the tall, competitive grasses out). To our knowledge, the problem has not been resolved yet, providing an example how the rigid rules of CAP can interfere with maintenance of European biodiversity.

C. GRAZING SYSTEMS ON ATLANTIC AND ARCTIC ISLANDS

The EU/EES area of Europe contains four large islands or island groups: Fair Islands, Iceland, Svalbard and Greenland, which are all very different cases with respect to grazing systems. Neither Fair Islands nor Iceland has native, herbivorous mammals. Thus, by definition, grazing systems cannot contribute to the natural part of biodiversity of these islands. On the other hand, these islands have been intensely grazed by introduced domestic grazers since the Viking age. These grazing systems had a boom phase when grazers were exploiting previously untouched vegetation, followed by severe crash and fluctuations around a carrying capacity, which was probably reduced by indirect, adverse effects of grazing. These fluctuations have continued in modern times. On **Iceland**, the number of sheep has varied from between 900 000 and 400 000 during the postwar years. The number of horses and cattle has increased steadily since 1960 (when there were about 50 000 cattle and 40 000 horses) to current level of about 80 000 horses and equally many cattle (Bernes 1995). These grazing systems are regarded as vital for the economy of the Icelandic countryside but simultaneously at the limit of ecological sustainability. The literature dealing with the issue is entirely focused on the negative impacts of grazing and on ways to minimize them (Bjarnarsson et al. 2004), which is indeed an understandable approach on a volcanic island with steep topography. On Iceland, erosion is a real problem, especially in the context of grazing by horses, which form the economically most interesting part of the grazing system[29].

Svalbard, in turn, harbors just one grazing mammal, the endemic Svalbard reindeer (*Rangifer tarandus paltyrhynchos)*, with many unique properties as compared to other reindeer (e.g. very stationary habits, ability to survive on mosses). The subspecies was almost hunted to extinction. Comparison to the grazer-free islands on Svalbard (e.g. Bjørnøya, see Virtanen et al. 1997) suggest that extinction of reindeer would have had major, negative impacts on biodiversity, since in the absence of reindeer, the moss banks would probably have grown so thick that many vascular plant populations had become decimated or eliminated altogether. The ongoing recovery of Svalbard reindeer has eliminated this threat, at least for a while. However, global climate change can jeopardize the persistence of this grazing system. Mosses are low quality forage and must be readily accessible in order to be exploitable at all, because the energy yielded by mosses cannot pay for the energetic costs of removing large amounts of hard tundra snow. If global warming continues, winter precipitation will increase, which on Svalbard means more snow and, in the worst case, harder snow due to recurrent thawing and freezing. Warmer climate would even increase the risk that winter habitats will be covered by ice due to freezing rains in early winter, which has already extirpated one high arctic reindeer population (see below).

On **Greenland** domesticated grazers have only occurred in a relatively small area immediately west of the southern tip of the island (the Østerbygd of the Norse colonizers, today's Quaqortoq). This grazing system existed first from the Norse colonization (about 1000) to the extinction of the colony (about 1400), and was revived first around 1900 by Danes. In the recent past, the number of sheep on Greenland has fluctuated between 20 000 and 50 000. As the sheep are concentrated to a relatively small area their impact is likely to be locally strong, though detailed data appear to be lacking. In addition, Greenland has ecologically significant populations of wild grazers. Wild reindeer (caribou) used to exist both in northeast and on the west coast, but the former population went extinct in the late 1800's due to a winter rain that covered the lichen grounds with ice. The reindeer population on West Greenland has fluctuated between 20 000 and 100 000, probably due to a combination of

[29] The Iceland horses are bred for export and generate much income.

reindeer-lichen interactions and a time-delayed response of Inuit hunters[30]. Muskoxen exists naturally on the northern and northeastern parts of Greenland, where it has severely suffered from the current trend of warming climate, leading to increased winter precipitation and, thus, to increasing snow depths in winter habitats. Muskoxen numbers in northeast are now down on the level of 10 000 animals, which is very little for this enormous area. Muskoxen have been introduced to the arid steppe area at Kangerlussuaq, in the interior part of West Greenland, where the climate corresponds to 'mammoth steppe' climate of East Europe during the ice age. In this area, its future seems brighter (source: Bernes 1995).

Like on Svalbard, wild populations of native grazers thus primarily create the grazing systems of Greenland. The impacts of these systems on biodiversity are largely unknown, but there is no reason to expect that they would be any weaker than the impacts of semi-domesticated reindeer on the arctic-alpine biodiversity of Fennoscandia. The main destabilizing factor for these systems is the global climate change. It can hardly be a coincidence that the winter rain, killing a reindeer population that had persisted for millennia, occurred when industrialization had started to elevate the CO_2 levels in the atmosphere. The decline in muskoxen numbers due to increasing snow precipitation is clearly connected to global climate change. And this may be just the beginning. Recall that in the Greenland climate, warmer winters mean more snow, especially so on the glacier, which is high enough to grant that all winter precipitation will there fall as snow even if winter temperatures were much above their current level. The same applies for Svalbard, too. It is thus entirely conceivable that global warming will result to massive advances of glaciers on these arctic islands. Such advances would inevitably hit hardest just the areas that arctic reindeer and muskoxen populations are critically dependent on: the locally continental areas close to the glacier tips in the interior parts of the fjords, where snow precipitation is low. If glaciers cover these areas, while increasing snow cover makes other areas unsuitable for winter grazing, the reindeer and muskoxen populations of Svalbard and Greenland are in trouble.

D. TOWARDS A TYPOLOGY OF GRAZING SYSTEMS IN THE NORDIC REGION OF EUROPE.

Final typology of grazing systems should, in our opinion, be compiled first when different regional teams, allowing the search for unifying and distinguishing factors in a European scale, have covered all parts of Europe. To clarify our contribution to this process, we will summarize the main aspects of the systems, which were described in detail above.

1. Genuine LCS:s with documented positive impact on European biodiversity

The bottom line of the above survey is that the Nordic region contains just two large scale grazing systems which fulfill the LSC criteria of LACOPE: i.e. they generate a significant output of products and clearly appear to contribute (or at least used to contribute) positively to Pan-European biodiversity: the Sámi reindeer herding system in the mountain and tundra landscapes and the Norse mountain grazing system.

1.1. The Sámi reindeer herding system appears to be currently stable if stability is interpreted as resilience. The main ***stabilizing factors*** are social (***high motivation*** to own

[30] The Greenland reindeer reside primarily in the inland. Thus, reindeer hunting requires long trips from the coastal Inuit villages. Like all hunters, the Inuit use past success as an indicator of future chances, which easily leads to underutilization of increasing reindeer population and an overutilization of a declining one.

reindeer and to work with them) rather than economical, which makes the system vulnerable to cultural changes. Moreover, the livelihood is under strong pressure from competing land uses and there is also considerable social strain, due to ***conflicts with ethnic majorities***. These destabilizing factors appear to be ***strongest in the southern parts of the area***, where the Sámi are a minority even locally and where use of own language is weakened. However, there are positive signs. Snåsa municipality, Norway, recently decided to become bilingual South Sámi –Norwegian.The situation seems to be worst in Sweden where winter pasture rights for the 5 southernmost Sami villages are jeopardized by a Superior Court verdict summer 2004 stating all rights to belong to forest owners. In the Røros area the Norwegian Supreme Court, after a series of losses for the Sámi, in 2001 gave a verdict affirming Sámi pasture rights (Riseth and Gundersen, 2004).

Moreover, in terms of reindeer numbers, reindeer husbandry has had ***cyclic dynamics*** as long as reliable information has been available (and, probably, all along). Each phase of low densities of reindeer has initiated a recovery of lichen heaths, followed by increasing reindeer numbers, depletion of lichens and a new crash to low reindeer numbers. The period of this cycle is about 30 years. The nightmare scenario is that the currently ongoing cyclic decline coincides with a change in social values, causing a genuine collapse of the system. The current development in Western Finnmark deviates from the traditional cyclic behavior. After a decrease through a decade after the 1990 peak a few favorable winters have initiated a new herd increase, probably near the 1990 level, without lichen recovery. A potential threat is a sudden bad winter, which can create severe starvation and death. Another potential threat is that some ***developments*** (e.g. building activities in the mountain range, new hydroelectric projects, and not to forget wind mill parks) ***destroy summer ranges*** or limit access to them, which could have such drastic impacts on the ***productivity*** of the herds that the economic output would be perceived as unreasonably low.

1.2. The Norse mountain grazing system appears to be stable, too, if stability is interpreted in terms of persistence of large number of grazers on outback pastures. However, the nature of this system has changed so profoundly that its impacts on biodiversity are unknown. ***Stabilizing factors*** for the current system consist primarily on ***subsidies*** and on the ***cheapness*** of having sheep and heifers on mountain pastures. ***Destabilizing*** factors for the current land use are e.g. ***costs of winter forage***. Destabilization of the old, chalet-based system was a consequence of both economical factors (low hourly salary of chalet work) and social ones (loneliness of chalet life, lack of social cohesion). Restoration of chalet-based grazing is only realistic in small scale and would require radical changes in social values or novel initiatives. E.g. nature loving urban youth might find shorter periods of chalet life attractive in the same way as urban youth (us included) have found it rewarding to work periodically with reindeer without salary. Another approach is to combine chalets with lodging of hikers, which already is done in small scale.

2. Surviving or revived medium and small scale grazing systems with biodiversity value
These systems are characterized by lack of significant product output and dependence on subsidies or an urban demand on services (riding lectures). Again, two such systems appear to exist in the Nordic region

2.1. The medium-scale grazing systems on Baltic alvars are landscape protection schemes, which depend totally on government subsidies. Their stability hinges on the will of the taxpayers to pay for the activities and the ability of the EU-Commission to use common sense in interpretation of the habitat directive.

2.2. The small-scale grazing systems in eastern Sweden are a complex of pure landscape care, built on subsidies and agreements between land owners and authorities, and the expanding horse business, which generates a large revenue, though not in terms of products but in terms of services. For the former activity has similar constraints as the grazing on alvars and could be destabilized if the interest of taxpayers wanes or if the EU-Commission focuses on irrelevant details like the percent cover of grasses, instead of looking on the utility of the practices for preserving viable populations of rare species. The intense horse grazing in current scale is a new activity whose impacts should be closely monitored.

3. Extinct grazing systems whose impacts on biodiversity are simulated with various techniques include all non-reindeer grazing system within the taiga proper. Local, small scale attempts to revive them may occur, but the main emphasis appears to preserve the boreal meadow species by creating mown meadows along roadsides, under power lines or in other places unsuitable for both agriculture and forestry. The stability of these actions depends on taxpayer's support and on private desire to create backyard meadows. Except for Jämtland, these actions have limited significance for European level biodiversity but can be locally and nationally interesting.

4. Surviving large scale grazing systems based on wild ungulates is ecologically at least as interesting as systems based on domestic grazers and may have just as profound impacts on biodiversity. In the Nordic region, four such systems exist: the wild reindeer systems of Svalbard, Greenland and of the South Norwegian highlands (especially Hardangervidda) and the muskoxen system of northern and eastern Greenland. Moreover, there are even substantial numbers of (re)introduced muskoxen on West Greenland and on Dovrefjell in southern Norway. The stability of these systems depends on hunting policies and global climate.

5. Surviving large scale grazing systems without known positive impacts on biodiversity include the ***stationary reindeer herding system in the taiga*** and the raising of ***sheep, horses and cattle on Iceland and Fair Islands.*** This category needs further study, as absence of evidence cannot be taken for evidence of absence. Economically and socially, both grazing systems seem stable (at least resilient) though in both cases, economical factors drive a development, which can threaten the ecological stability of the system. On Iceland, the increase in horse numbers has created a threat of serious pasture degradation, which, if not stopped, can lower the carrying capacity of pastures for generations to come. The recent, rapid decline in Finnish reindeer numbers indicates that feeding by hay in winter is not a viable strategy in this form of reindeer husbandry, either. Adjusting numbers of reindeer to the capacity of lichen heaths to sustain them and avoiding unnecessary trampling of heaths (e.g. by separating the best lichen grounds from the rest of the district with fences) would probably be a good idea even in the taiga and is already practiced in some districts.

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Authors of the rapport:

Lauri Oksanen, Department of Ecology and Environmental Science, Umeå University, SE-901 Umeå, Sweden

Jan-Åge Riseth, NORUT Social Science Research Ltd., P.O.Box 250, N-8504 Narvik, Norway

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