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175 years of adaptation: North Scandinavian Sámi reindeer herding between government policies and winter climate variability (1835–2010)☆

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ABSTRACT

Unmanaged wild reindeer populations tend to follow cyclical behaviour, and domesticated reindeer populations often show cyclical behaviour, too. In this contribution, we intend to use the long-term development of two areas in northern Scandinavia to explore how externally imposed policies and winter climate variability have influenced the reindeer herd size and pasture state. We do this by comparing the development in two areas that are rather similar ecologically: Torneträsk in northernmost Sweden and Kautokeino (Vest-Finnmark) in northernmost Norway.

Climatic and ecological studies as well as commons theory have been useful tools for understanding the inherent socio-ecological dynamics. Especially the time from 1850 to 1940 includes several short periods when historical sources document combinations of events such as (1) closure of national borders to cross-border herding migrations, (2) relocations of herder households, (3) overutilization of lichen pastures, (4) catastrophic winters, and (5) forced herd reductions. The high number of incidents and actions during this era makes it challenging to disentangle causes and effects.

Our main findings are based on the documented effects of international events and consequent government policies and actions in Fennoscandia from 1852 to 1921 which had dramatic consequences, including excessive numbers of reindeer and people in northernmost Sweden, leading to more or less forced relocation southwards in Sweden with cascading effects in large parts of Sápmi. We have found clear indications that this contributed to overutilization of lichen pastures and beyond any reasonable doubt must also have reinforced the effects of several of the documented catastrophic climatic events, especially in areas like Torneträsk to where many families from Finnmark were relocated. From the first border closure in 1852 to the Second World War it thus seems as if the shocks from the political events were the main factor determining the development of reindeer herding in large parts of Sápmi. The political and administrative history is well documented. Our climate data are a unique compilation of climate events based on multiple sources during two centuries, which contribute to the validity of our findings. Our pasture state data from the late-1800s are also based on several sources which support each other.

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Two new factors influencing the general cyclical pattern have arisen more recently. Motorization has increased the possibilities for intense pasture utilization and the amplitudes between minimum and maximum herd sizes, while supplementary feeding has the potential to limit the effects of winter climate variability and lichen overutilization.

Introduction

Lands at high northern latitudes are undergoing greater climate change than most other parts of the world (ACIA, 2005; Callaghan et al., 2010; Stocker et al., 2013). Furthermore, global and regional circulation models forecast more climate change in winter than in summer (Stocker et al., 2013; Overland et al., 2011), but most knowledge of climate change impacts on the High North still comes from studies undertaken in summer. Overall, there remains major uncertainty of the consequences of winter change for northern ecosystems (Bokhorst et al., 2012) and rural communities (Adger et al., 2009). However, there are historical reports concerning winter change and reindeer husbandry communities, especially from Fennoscandia (e.g. Hamberg, 1912; Lantto, 2000; Päiviö, 2006; Eriksson et al., 2007). This material can be used for more general studies of the relations between climate change effects and effects of other changes.

Reindeer herding systems are socio-ecological systems (SES) (Ostrom, 2009). The animals are herbivores living in dynamic settings with pastures, climate and predators (Riseth et al., 2004; Tveraa et al., 2007; Tømmervik et al., 2009; Danell, 2010). The herders live in self-organized, predominantly indigenous Sámi communities in Norway and Sweden, with their culturally derived governance systems (Riseth, 2009, 2013a; Riseth and Vatn, 2009) while the nation states have performed varying policies in different historical and contemporary phases (Lantto, 2000; Lantto, 2012; Lundmark, 2007; Lantto and Mörkenstam, 2008; Brännlund, 2015). The core institution of Sámi reindeer herding is the siida (the band), which is a group of herding partners usually with family bonds (Pehrson, 1964; Paine, 1970). In Norway, reindeer herding is formally organized in reindeer pasture districts, while Sweden uses the concept "sameby" (Sámi Village).

Unmanaged wild reindeer populations tend to follow a cyclical behaviour (Syroechkovskii, 1995). A mathematical model of the dynamics of a wild reindeer population from the Kola Peninsula, Russia, shows that population size was represented by cycles of 35–40 years (Lopatin and Abaturov, 2000). Population growth during 25–30 years alternates with declines of 10 years. The cyclic dynamics is determined by trophic relations and is particularly dependent on the dynamics of lichen resources. Population growth leads to critical reductions in forage availability resulting in a subsequent decline in population size. A reduction of the population size by two times the maximum induces a period with recovery of forage resources before complete exhaustion of pastures again takes place. Malthusian catastrophes have indeed occurred. Two well-known examples are from Kongsfjorden in Svalbard (Aanes et al., 2000) and the remote St. Matthew Island in the Bering Sea (Klein, 1968). However, several mechanisms tend to dampen the rate of population growth and declines. Ingold (1976) explains these as: (1) undernourishment lowers birth and calf survival rates, (2) heavy grazing pressure reduces the total stock before ultimate carrying capacity is reached, and (3) animals tend to spread out in search of better pastures. Furthermore, herders of domesticated herds can reduce the herd size or move to alternative pastures.

Nevertheless, domesticated reindeer populations often also show cyclical behaviour (Moen and Danell, 2003; Helle and Kojola, 2006; Tømmervik and Riseth, 2011). This happens despite contemporary public policies for stabilizing reindeer herd sizes and economic outcome. In Norway, reindeer herding on the sub-Arctic tundra plateau, Finnmarksvidda, which is the autumn and winter pasture for more than two-thirds of the domesticated reindeer of Norway, continues to be rather ungovernable for the government. Its pasture situation, social dynamics and policy interventions during the last half century have been thoroughly studied (Tømmervik et al., 2009; Riseth, 2009; Riseth and Vatn, 2009; Ulvevadet, 2012; Hausner et al., 2012; Pape and Löffler, 2012). Lichen pasture overutilization still takes place and catastrophic winters still contribute substantially to herd reduction. However, a technological revolution starting with the introduction of the snowmobile has made pasture utilization more intense than before 1960, leading to unprecedented levels of undulation between peaks and bottoms (Tømmervik et al., 2009). Furthermore, government subsidies and wage labour incomes have stimulated a shift to larger herds despite government intentions to maintain stable, lower density herds (Tømmervik et al., 2009; Riseth and Vatn, 2009; Ulvevadet, 2012). Very recent policies have in fact led to herd reductions, but it is still too premature to say whether this is permanent or temporary (Riseth and Lie, 2016). Notwithstanding this, reindeer herding districts in East Finnmark and southern Norway are clear exceptions to this pattern of herd size undulation, as they, at least until recently when increased predator pressure has become a threat in southern areas (Danell, 2010), have a balanced and sustainable management and good profits in line with public policy goals (Riseth, 2009, 2014).

Climate effects of difficult winters with snow and ice conditions blocking access to forage resources are an important part of the ecological dynamics and herder adaptability (Riseth et al., 2011). One of the challenges in this research is to distinguish climate impacts from impacts of other factors. In general, this is easier to accomplish in longer time series with more data sources and more accurate data than we have. In this paper, we have chosen to focus on the Torneträsk area in northernmost Sweden and compare the development over a period of 175 years with a target period from 1880 to the 1930s. The reasons for this selection of area and time period are that the ecology is similar to that of Finnmarksvidda and there are numerous

historical sources documenting the combined impacts of events such as: (1) closure of national borders to cross-border herding migrations, (2) relocations of herder households, (3) overutilization of lichen pastures, (4) catastrophic winters, and (5) forced herd reductions. Our objective is to discern the roles of winter events and political "shocks" in cause-effect chains and as cascading effects.

External impacts can have contrasting effects on reindeer population dynamics. We find it relevant to differentiate between, firstly, factors that decide the direction of the dynamics and, secondly, factors that strengthen or weaken already ongoing developments. Our hypothesis is that political shocks belong to the first category of impacts, while climate effects like severe winters belong to the second category. We want to test this hypothesis on established historical data and our own collection of historical climate impacts (cf. Table 1) and pasture state data. Our research question is: *How much of the reindeer population history in northernmost Scandinavia can be explained by external shocks, such as political events?*

Studies of such multilayered dynamics require broad overall frameworks. A vulnerability framework (Tyler et al., 2007) focused on how climate change and other impacts influence reindeer herding and the reindeer herders' abilities to cope with these impacts. However, this framework did not include pasture state evaluation. Here we construct our framework on Commons Theory and the Institutional Analysis and Development (IAD) framework (Ostrom, 1990). Instead of using the more sophisticated socio-ecological systems framework (Ostrom, 2007), we use a specialized framework developed for reindeer herding (Riseth, 2009; Riseth and Vatn, 2009). Fig. 1 presents an analytical framework which is modified to include the effects of climate events and political changes on both the production system and the institutional system.

The framework is based on the assumption that a balanced common-pool resource (CPR) situation requires a balance between the production system that requires coordination and the institutional system that provides a capacity for coordination. The management strategies performed by the herders, which are influenced by both subsystems, are in the centre of the framework scheme. Critical factors for the case studies are marked with bold letters. In the production subsystem, climate influences the accessibility of lichen forage which, in difficult winters, dramatically influences herd size by blocking access to the forage by, for example, ground icing in late autumn or midwinter rain-on-snow freezing events. In the institutional subsystem, political "shocks" change external institutions and thereby the operating regime. The management strategies of the herders are thus affected from two sides, and the CPR situation (pasture state) will be an outcome of the management strategy and the capacity for institutional transformation.

Material, methods and context

This study is a variant of a transdisciplinary and a comparative study with links to historical ecology (Santomauro et al., 2012). Transdisciplinarity connotes a research strategy that crosses many disciplinary boundaries to create a holistic approach. The authors are an institutional economist and two ecologists, all working across disciplinary boundaries and within a larger framework in order to undertake a holistic analysis. Comparative studies are generally used to examine similarities and differences across a moderate number of cases. Knowledge of each case is important, and the primary objective is to explore diversity, interpret cultural and historical significance, and advance theory (Ragin, 1987, 1994). We do not have

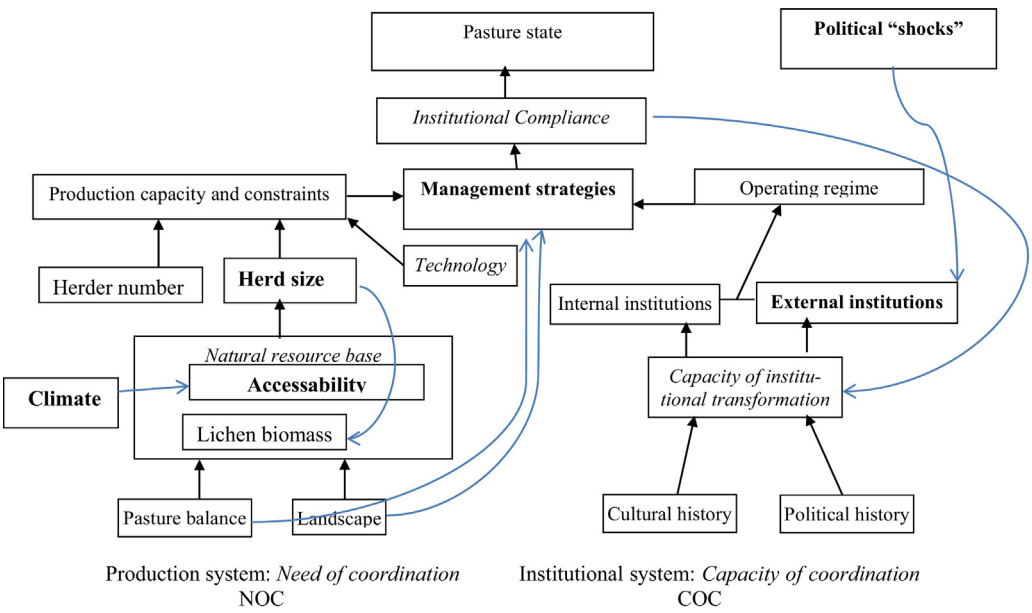

Fig. 1. A resource adaptation framework constructed for reindeer herding systems (based on Riseth and Vatn, 2009, p. 91).

material for a standard comparative study of two cases, but compare historical periods from both areas in cases where we have material, which in the end provide us with six subcases (Table 2).

The historical sources used are extensive, including social, geopolitical and natural sciences. Extensive investigations of the state of the reindeer winter pastures in Kautokeino and Torneträsk were first performed by the Reindeer Grazing Commission of 1909 (Anon, 1912). Eriksson et al. (Eriksson et al., 2007) reviewed many of the sources in the natural sciences. They also included bailiff[1] reports and, not least, personal accounts of Turi (2011a), who was known as the first Sámi author. This is a unique source as Turi was an experienced Sámi herder who gave his account to the Danish author Emelie Demant-Hatt who wrote his book. Meteorological data from 1913 onwards were retrieved from the Abisko Scientific Research Station, which is in the Torneträsk area. Before that, we rely greatly on local climatic observations retrieved by Hamberg (1912). In the EWWA research project[2], we compiled data on winter climatic events from 1800 to 2013 based on all available written sources (unpublished manuscript). Obviously, this material is of uneven quality, but its strength is that point observations (meteorological stations) are combined with accounts of impacts for wider areas, providing an overall much more relevant and reliable material. This material also includes interviews with current senior reindeer herders from the Torneträsk area (cf. Table 1). We have also compiled all historical data on lichen cover (e.g. Eriksson et al., 2007; Tømmervik et al., 2009; Anon, 1912; Hult, 1881; Fries, 1913; Lyftingsmo, 1965; Anon, 1967; Tømmervik et al., 2011).

We have performed two sets of regression analyses for the overall relations between reindeer herd size and lichen pasture cover.

Study area

Whereas altitude largely is ecologically equivalent to latitude on the vast continents of North America and Siberia, the rugged topography in North Scandinavia weakens this relationship. This is to a large extent due to the mountain range which forms the border between Norway and Sweden. Geologically, most of northern Scandinavia is part of the Baltic Shield, and is extensively covered by glacial sediments. The mountain range consists mainly of metamorphic rocks of Cambro-Silurian and Precambrian age (Ramberg et al., 2008). Moraines and rolling rocky hills, forest and scrubland, mires, and numerous lakes and tarns make up much of the landscape. The inland tundra comprises an undulating upland plateau with low mountains, birch-covered hills, stunted pine forest, and open lichen heath and tundra.

The reindeer is adapted to maximize nutritional intake in summer and economize with limited resources in winter (Warenberg et al., 1997). Because of this adaptation, it has very specific requirements for each season. The considerable regional variation in temperature, precipitation, bedrock and vegetation forms the basis for annual migration patterns.

Climate trends

Climate analyses for the period from 1913 to 2006 from the Abisko Scientific Research Station indicate a warm period in the region in the 1930s. Over the whole period of 1913–2006, the mean annual air temperature increased by 2.5 °C, winter and spring temperatures each increased by 2.9 °C and the autumn temperature increased by 1.6 °C. Summer temperatures have not, however, risen significantly in the recent warming or through the 20th century despite an overall increase of 1.7 °C (Callaghan et al., 2013). Temperature extremes in the Torneträsk area have been most notable in winter when extreme warming events for just a few days have resulted in brief episodes above 0 °C, snow thaw and re-freeze to create layers of ice (Bokhorst et al., 2009). Such extreme winter weather conditions have regularly led to crashes in the reindeer populations of northern Sweden and also Norway (Hamberg, 1912; Riseth et al., 2011; Lie et al., 2008).

A typical weather pattern leading to a population crash is a winter thaw event after the first snowfall, but similar crashes can occur later in the winter. The thaw causes ice encapsulation of the ground vegetation (*bodnivihki*), blocking the reindeer's access to fodder resources. Snow accumulation after ground icing, together with wind, hardens the snowpack, reducing the accessibility of reindeer fodder and perhaps leading to reindeer starvation and death (Riseth et al., 2011). Herders may move their reindeer to other pastures or feed them to avoid loss of animals, thereby leading to large losses such as during the crisis winters of 1905–1906 and 1934–1935 (Lie et al., 2008) and 1884–85 and 1894–95 (Hamberg, 1912). Despite the modernization of reindeer husbandry, this type of winter climate continues to cause population crashes in reindeer herds (Lie et al., 2008), especially in the most heavily grazed area (Tømmervik et al., 2009).

Torneträsk area

The Torneträsk area is located in the northwestern part of Norrbotten County in Sweden, on the border to northern Norway and Finland (Fig. 2). The area is topographically diverse, ranging from 342 m a.s.l. to ca. 1900 m a.s.l., and climatically varied with a NW-SE oceanic-continental gradient and local rain shadow effects due to the mountain range (Callaghan et al., 2013). Low winter temperatures and relatively little precipitation, which falls as snow during half of the year, characterize the area. Permafrost, in the form of palsa hummocks, is abundant (Eriksson et al., 2007). Currently (2002–2011), the mean annual temperature is +0.49 °C, while the seasonal mean temperatures from spring to winter are −0.82, +10.9, +1.1 and −9.2 °C,

[1] Bailiff, i.e. Lapp sheriff (Sw. Lappfogde, No. Lappefogd), an official with policing authority, who had control tasks with respect to reindeer herders.
[2] http://www.nina.no/Forskning/Prosjekter/Vinterklima/EWWA.

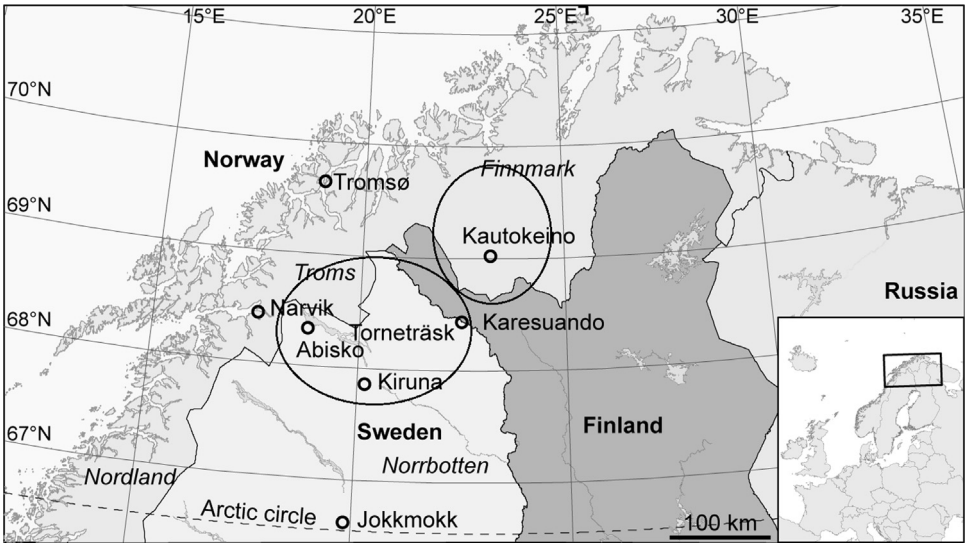

Fig. 2. Study area.

respectively, at Abisko (Callaghan et al., 2013). The summer pastures are in the Norwegian-Swedish border mountain range, while winter pastures are mainly in Swedish inland pine forests.

Finnmarksvidda

Finnmarksvidda is Norway's largest upland plateau, and is situated in the Arctic-alpine-boreal transition zone between 68–70° N and 22–26° E, from ca. 100 to 500 m a.s.l. The Precambrian bedrock forming Finnmarksvidda was affected and reshaped by repeated glaciations during the Pleistocene. Finnmarksvidda is now covered with thick ground moraine forming rounded and gentle landscape forms with nutrient-poor soils (Wielgolaski, 2001). The plateau includes extensive lichen-covered mountain heaths, mountain birch forests, pine forests, barren land, mires and glacially formed lakes. Finnmarksvidda is also located in the transition zone between sub-oceanic and continental climates (Moen, 1999). The continental influence is strongest, and is expressed through the annual extremes like warm summer periods and winters with strong radiation weather conditions. The standard normal annual precipitation in Kautokeino is 325 mm, 50% of which falls in summer (Alm, 1991). During the last decades, the annual mean precipitation rates have increased, while evapotranspiration has been reduced due to increased cloudiness (Tveito et al., 2001; Thannheiser et al., 2005). The increasing maritime climatic buffering has impacted large parts of the northern and western parts of Finnmarksvidda (Alm, 1991; Thannheiser et al., 2005; Tømmervik et al., 2004). In Finnmark, the usually mountainous summer pastures are situated on or near the Arctic coast and fjords, while the winter pastures are in the continental inland, where lichen beds are under a relatively light snow cover. This is generally considered an ideal situation for reindeer pasturing.

Early pasture state studies

In 1821, Professor W. Zetterstedt visited both our study areas. For Torneträsk, his observation was that "*the mountains on either side of the south end of Lake Torneträsk were covered with reindeer lichen (***Cladonia rangiferina***) and* **Stereocaulon paschale**" (Zetterstedt, 1822). For Kautokeino, he reported:

> "Open, dry areas were covered by *Cetraria nivalis* [current name Flavocetraria nivalis]. Those areas and hills covered by this plant show up white even at a long distance. In these mountains, it is incomparably taller and thicker, and the separate lichen stands richer than in more southerly areas" (Zetterstedt, 1822).

Thus, we note that the winter pasture state was optimal in both areas before the changes we are studying started. Our next source comments on the situation when the changes had started. In his book written in 1908, Johan Turi describes what he remembered from before 1870:

> "Forty years ago [i.e. around 1868], there was still beautiful white lichen here in the Kattavuoma area [east of Lake Torneträsk], so that the whole ground was white. At that time there were not many nomad villages in Talma, nor in the whole of Jukkasjärvi parish; but when more Lapps began to move in from Karesuando and Kautokeino, the reindeer lichen cover decreased year by year. . .when you go 25 years back [i.e. around 1883], there were still ample lichens in Talma and the whole of Jukkasjärvi parish . . .now it is as if it was burnt, so that the tundra cannot sustain even the reindeer that are here" (Our translation) (Turi, 2011b, p.92).

Thus, according to Turi, in the late-1860s the pasture state in Jukkasjärvi was much the same as in 1821, whereas it had become dramatically worse from then into the next century. The bailiff reports from Norrbotten (Eriksson et al., 2007) confirm that in the 1830s the reindeer numbers in Jukkasjärvi were so limited that there was sufficient winter grazing west of Jukkasjärvi, while in 1892: "the majority of reindeer were compelled to move to winter grazing far down in Pajala parish (east of Jukkasjärvi, Our comment) (Eriksson et al., 2007).

When these sources are viewed together, they provide good indications of *increasing reindeer numbers and reduced winter pasture capacities during the 1870s and 1880s*. In addition, the bailiffs reports describe a similar development in the following decades, with not only higher grazing pressure, but also *accelerating out-of-season misuse of lichen pastures* which "*caused the grazing areas to be so heavily grazed and trampled that scarcely a trace of reindeer lichen (***Cladonia** *spp.) could be seen*" (Eriksson et al., 2007, p.42). This helps us to understand Turi's description "as if it was burnt". The accounts in these sources are also confirmed by the 1909 Commission on Reindeer Grazing Lands (Anon, 1912), both as regards the pasture state before 1850: "*Elderly Lapps relate that in their youth (before the mid-19th century) the land was still white with lichens*" (Eriksson et al., 2007), and why it had changed:

> "The representatives of the Saami villages interviewed by the commission claimed, quite unanimously, that the ruined pastures on the Swedish side of the border were the result of the hordes of reindeer that had poured in from the north two or three decades after the incursion of the Kautokeino Lapps in the 1850s and 1860s" (Eriksson et al., 2007, pp.46–47).

The same authors comment:

> "Still more striking was the deterioration of the lichen pastures after the closure of the Finnish border (1889). Then, the large herds of the Rommavuoma and Suondavaara Saami, which in former times had regularly spent the winter in Finland, could no longer be taken there. . .These reindeer, too, must now graze in Sweden" (Eriksson et al., 2007, pp. 47–48).

Political and historical context

In the long period from 1328 to 1852, the geopolitical situation in northern Scandinavia was ambiguous. The national borders between Norway, Sweden, Finland and Russia were unclear in some areas and not always strictly enforced (Sandberg, 2008). The nomadic Sámi reindeer herders could move relatively freely with their herds between the territories claimed by the separate nation states. The first national border was established between Denmark–Norway and Sweden–Finland in 1751. This is the second oldest unchanged national border in Europe. The Lapp Codicil, an addendum to the border treaty, codified that national borders were not to become an obstacle to Sámi migration that had taken place from time immemorial, though the Sámi had to become citizens of one of the states and property rights in the "other" country were confiscated (Pedersen, 2006).

The explicit motivation of the Codicil was "the Conservation of the Sámi Nation", i.e. the states took on a common duty to provide a fundament for the eternal existence of Sámi culture and livelihood (Pedersen, 2006). Thus, although the border meant colonization, the Lapp Codicil probably deserved the name "the Sámi Magna Carta", providing tolerable conditions for the Sámi (Ravna, 2010). The ecological advantages of preserving the traditional migration patterns are obvious. Norway has excellent summer pastures in the nutrient-rich, sub-oceanic, tundra heaths and deciduous lowland forests, while Sweden and Finland have excellent winter pastures in the more continental coniferous forests. At a regional level, the two relatively similar areas, which we compare here, were split by the Codicil. Finnmarksvidda became part of Norway, while the Torneträsk area remained part of Sweden. However, with the Codicil openness for border-crossing reindeer herding, both areas could still be used as before, with summer pastures in the mountain range and winter pastures in the interior, and the annual migration routes following the big river valleys (Pedersen, 2007).

The relative freedom enjoyed by Sámi herders lasted for about a century after the border establishment. In the wake of the Napoleonic Wars, the political map of Europe underwent several changes, which later led to international events that contributed to undermine the treaty and thus create political "shocks" in the governance system (Pedersen, 2006). In 1809, Sweden had to surrender Finland to Russia. In 1826, the border between Russia and Norway was established. In 1814, Denmark had to surrender Norway, which went into a union with Sweden, and, finally, Norway and Finland gained independence in 1905 and 1917, respectively.

Border closures

In 1852, the border between Norway and Finland was closed for cross-migration. This was an outcome of Russia–Finland and Sweden–Norway no longer accepting the basic rights of the Sámi to perform their livelihoods in the areas where these states had drawn their borders:

> "The interests of the separate states, not least from the Norwegian side, justified by nationalistic regards, became superior to the interests of the stateless nation – the Sámi. In other words, a complete change of attitude had taken place during the century since 1751" (Our translation) (Pedersen, 2006, p. 11).

This immediately created turbulence in the reindeer herding systems of northern Scandinavia. A total of 50 000 reindeer from the Norwegian side had winter pastures in Finland, and 15 000 reindeer from the Finnish side had summer pastures in Norway (Pedersen, 2007). The rearrangement became demanding. As we are studying Finnmarksvidda and the Torneträsk area here, we focus on the implications for the Kautokeino Sámi. We do not discuss the problems created for Sámi in eastern Finnmark. One of the strategies chosen by the Kautokeino Sámi was to register as Swedish citizens in Karesuando, northernmost Sweden, to be able to continue using winter pastures in Finland and summer pastures in Norway. Similarly, Sámi in the Finnish Enontekiö region changed citizenship to continue their practice. The explanation is that the Codicil was still in force between Norway and Sweden and the border between Sweden and Finland was still open (Lantto, 2010).

However, in 1889, the border between Finland and Sweden was closed too (Pedersen, 2007). This terminated possibilities for the circumvention strategies used since 1852. Kautokeino herders in Karesuando now had to make a choice. Some moved back to Kautokeino, while others became Swedish citizens permanently. After the border closure, the regional authorities in Norrbotten considered that there were far too many reindeer in the Torneträsk area, and in 1890 they ordered 14 families from Karesuando to move to Arjeplog. Due to stubborn resistance from these families, this was not effectuated immediately. Following the very severe winter of 1893–94, when many reindeer were lost, the forced family relocation was cancelled altogether (Lantto, 2006, 2008).

Oral traditions and church archives confirm a massive immigration of Kautokeino Sámi to Karesuando (Finland) and Jukkasjärvi (Sweden) after the closure of the Finnish border for Norwegian Sámi in 1852 and for Swedish Sámi in 1889 (Ruong, 1937). An estimated 200 persons (family members included) with 20 000 reindeer immigrated to Karesuando before 1867. In 1883, the 15 Kautokeino Sámi households with 12 000 reindeer were settled in Jukkasjärvi, which made up more than 40% of the reindeer there. The immigration also created much tension:

> "The mixture of different [herding] methods caused chaotic conditions in Troms County [summer areas in Norway] and the Jukkasjärvi area. That the immigrant Sámi used ruthless and unfair means in the competition especially contributed to the tension and confusion. In particular, they lacked respect for property rights. . .theft of reindeer became usual" (Our translation) (Ruong, 1937, p. 28).

Ruong (1937) added that Jukkasjärvi herders with small herds lost out in this competition and many had to abandon herding. Jukkasjärvi church protocols show that emigration exceeded the numbers immigrating from Kautokeino, leading to a considerable decrease in herder numbers in Jukkasjärvi in the period 1860–1890. Most of these settled as farming and/or fishing peasants in Norway (Ruong, 1937). The historian Lennart Lundmark summarized the consequences of the border closures:

> "Besides the summer pastures in Troms, the Kautokeino herders had to utilize autumn, winter and spring pastures in Sweden. Norway could have taken them back, but refused Russian initiatives to negotiate as Norwegian policy was preferably to eradicate reindeer herding and Sámi culture. Soon the reindeer pastures in northernmost Sweden became overloaded and Sweden was forced to move 400 Sámi to pasture land further south in Sweden. Most of them had their origin in Kautokeino, Norway. Hence, Sweden had to carry a considerable part of the burden for Norway's hostile policy towards reindeer herding" (Our translation) (Lundmark, 2005, p. 1).

Border conventions

The union between Norway and Sweden ended in 1905, and Norway saw this as an opportunity to eliminate all Swedish claims on Norway (Lundmark, 2005; Pedersen, 2001; Päiviö, 2007). Norway also aimed to terminate the Lapp Codicil, but did not succeed (Lae, 2003). The explanation for this is that since the 1840s Norway had tried to reduce or, preferably, eliminate the Swedish Sámi reindeer herding rights. This became *a long-term trend in Norwegian foreign policy* and was based on an ideology of extreme nationalism (Pedersen, 2001). Leading academics had started to classify Sámi as inferior human beings, and government policy was to relocate a surplus farming population to northern Norway as settlers (Pedersen, 2001), particularly to Troms. This increase in the area used for farming led to conflicts between settlers and reindeer herders, as the farmers settled on sites traditionally used for reindeer herding. Norway and Sweden had already in 1883 passed new legislation known as the Common Lapp Law, which introduced a number of means[3] to control and regulate reindeer herding in favour of the settlers (Lundmark, 2005; Pedersen, 2001; Päiviö, 2007). In addition, the Norwegian government wanted to expel Swedish citizens who were herders from Norway. Sámi rights were not seen as part of the issue, which was reduced to a political case between the two countries. In practice, the reindeer herding Sámi were not regarded as having any real property rights; on the contrary reindeer herding was only seen as tolerated use (*precario*), which meant a duty to give way for other users, such as agricultural settlers (Lundmark, 2005; Pedersen, 2001; Päiviö, 2007).

In 1905–1919, "*hardly any other foreign policy issue achieved such broad public attention*" (Berg, 1996). This created a serious conflict between Norway and Sweden, which led to several commissions and international law arbitrations between the two countries (Lae, 2003). Norway lost the case, and the Codicil is therefore still in force, at least formally (Ravna, 2010). In 1919, the two countries agreed upon the first Norwegian-Swedish reindeer pasture convention, which had dramatic consequences for herders who were Swedish citizens. Extensive presentations of the land-use of some of these herding districts are given

[3] Strict herd control duties, joint responsibility for damage on agricultural land, strict district designation, bailiffs and supervision.

by Walkeapää (2009, 2012), this convention banned Swedish herders from large areas in Norway, including extensive summer grazing areas in Troms (Ringvassøya, Kvaløya, Senja, four peninsulas and some inland areas), and strictly limited the number of reindeer and the timing of spring entry and autumn exit. An estimated 60–80 000 reindeer were reduced to a legal access of 39 000 reindeer (Lundmark, 2005; Pedersen, 2001; Päiviö, 2007). As access to Troms was severely curtailed, there was an over-accumulation of herders in northernmost Sweden, especially in Karesuando, but also in Jukkasjärvi (Päiviö, 2007). The border closures and the convention forced 75 herder families with 20 000 reindeer, mostly from Karesuando, to permanently move to more southerly locations in Sweden during the period from 1898 to 1928, creating conflicts with already established herders there. The North Sámi were very unwilling to leave their traditional areas and the original Sámi were equally unwilling to receive them, but they were threatened with large penalties. Eighty families with about 20 000 reindeer remained in Karesuando. The family emigration southwards lasted until the 1950s (Päiviö, 2007).

The Swedish Sámi policy was based on a view of the Sámi as culturally inferior to the majority population, unable to determine their own future (Lantto, 2000, 2012; Mörkenstam, 1999). In contrast to Norway, the Swedish Sámi policy aimed at preserving the Sámi as reindeer herders, as this was considered the only livelihood they could master and survive on. Prior to 1919, a regional administrative organization, the Lapp Administration, focusing on Sámi issues in general and reindeer herding issues in particular, was in operation. This administration was strengthened following the convention, and given authority to forcibly reduce reindeer herds if deemed necessary. In order to adhere to the regulations of the convention, control over the reindeer herders was strengthened and more attempts were made to micromanage reindeer herding (Lantto, 2000, 2012; Mörkenstam, 1999). The belief in the feasibility of the Lapp Administration to steer reindeer herding in a positive direction was strong; in 1926, it was argued that the development of the administrative organization had eliminated "the risk of bad 'reindeer years'" (quoted in Lantto, 2000, p. 141). The catastrophic winters during the 1930s would show how completely unrealistic this conclusion was.

The 1919 convention was prolonged several times until a new convention was signed in 1972 for thirty years (Pedersen, 2007). A primary motivation of the Norwegian government for a new convention was to gain access to more areas in Troms for herders from Finnmark (Riseth, 2013a; Sara and Storli, 1997). According to Lars Norberg, the chief Swedish negotiator from 2003 to 2005, the 1972 convention had two fundamental flaws: firstly, the Swedish government had negotiated an agreement on the property rights of the Swedish Sámi against their will, which the government had no right to do, and secondly, the Swedish government had accepted encroachments without claiming any compensation (Norberg, 2007). The negotiator characterized the 1972 convention as "a millstone around the neck" of the Swedish Sámi (Norberg, 2007). The 1972 convention was prolonged until 2005 in expectation of the outcome of negotiations (Ravna, 2010). A mixed commission had made a proposal for a new convention, but the negotiations failed, and in 2005, Norway unilaterally passed a new act that prolonged the rules of the convention (Ravna, 2010). This is not recognized by Sweden and Swedish Sámi and created many conflicts in Troms (Hågvar, 2008; Rettens Gang, 2013). Early in 2016, there is still no new convention in place.

Other changes

Besides these three major political events directly regulating reindeer herding, the Second World War affected the regions differently. It significantly reduced the use of Norwegian territory for Swedish herders (Walkeapää, 2009, 2012), while Norwegian and Finnish reindeer herds were reduced because herders were compelled to supply reindeer meat to German troops (Riseth, 2013b). Moreover, illegal hunting contributed to the declining herd sizes in Finnmark (Riseth, 2013b).

From the late-1960s onwards, the introduction of the snowmobile led to a revolution in transport which was to change reindeer herding significantly by stimulating far more intensive pasture utilization (Tømmervik et al., 2009). Unplanned ad hoc reforms, including subsidy schemes, contributed to extensive herd growth on Finnmarksvidda until the 1980s (Riseth, 2009). During the 1990s, herd sizes declined due to a series of severe winters, but they started to increase again after the turn of the millennium (Riseth, 2009, 2013a; Ulvevadet, 2012; Hausner et al., 2012; Riseth and Lie, 2016).

Results and interpretations

Fig. 3 shows the variation in the reindeer population from 1835 to 2010 in Kautokeino (synonymous with Vest-Finnmark) (Norway), the Torneträsk area and the whole of Norrbotten County (including Torneträsk).

As for the lichen cover before 1890, we rely on the above-mentioned descriptions and coinciding indications of reduction through several decades (cf. 2.1.4). We have interpreted the pasture state in 1835 as a lichen cover of more than 60% (Fig. 3); hence, the potential lichen cover was reached (Lyftingsmo, 1965; Tømmervik et al., 2012). We assume that the average lichen cover might have been reduced from more than 60% in the 1860s to less than 30% in 1890–92 (cf. Table 1 and Fig. 3).

For the whole period from 1835 to 2010, the relationship between lichen cover and herd size in Kautokeino (Fig. 4) was highly significant and negatively correlated ($R^2 = 0.74$, $P < 0.01$). For Torneträsk, the relationship for the same period was weaker (Fig. 4), but significant ($R^2 = 0.26$, $P < 0.02$).

The relationship between the reindeer population size and the lichen cover in Kautokeino for the period from 1949 to 2000 was highly significant and negatively correlated ($R^2 = 0.74$, $P < 0.01$), while there was a significant and negative correlation in Torneträsk ($R^2 = 0.56$, $P < 0.02$).

Table 1 lists both major external events (mainly political shocks) and climatic events as impact columns and herding implications as the output column.

Table 1
Political and climatic events 1852–2007 and their implications for reindeer herding.

Year	Political event	Ref. in Fig. 3	Climatic event(s)	Geographical extent	Implications for reindeer herding	References
1852	Border closure Norway-Finland (Russia)	A		Counties of Finnmark (Norway) and Lapland (now in Finland)	In 1852, the border between Norway and Finland was closed for cross-boundary migration. The winter (lichen) pastures were considered to be in very good condition before 1852 in Kautokeino and Torneträsk with a lichen cover between 60 and 70%.	(Eriksson et al., 2007; Zetterstedt, 1822; Pedersen, 2006)
1853–1860	Migration of reindeer herding siidas			Western Finnmark and Torneträsk	Migration of reindeer herding siidas from Kautokeino in Norway to Torneträsk in Sweden. The winter (lichen) pastures in Torneträsk were threatened.	(Eriksson et al., 2007; Pedersen, 2006; Lantto, 2010)
1860–1880					The reindeer population in Torneträsk increased from 36 000 in 1855 to more than 100 000 in 1879. The winter (lichen) pastures in Torneträsk were depleted.	(Eriksson et al., 2007; Tømmervik and Riseth, 2011; Anon, 1912)
1883–84		1	Catastrophic winter	Mainly Swedish Lapland	The 1883–84 reindeer population crash in Torneträsk and the whole of Norrbotten County was caused by a thick ice crust on the ground, formed as early as 29 September. In addition, trees were draped in ice, blocking the reindeer access to epiphytic lichens. This lasted the entire winter. Many herders lost so many reindeer that they had to abandon herding. The reindeer population in Norrbotten decreased from ca. 190 000 to 140 000. Lichen pastures around Torneträsk were reduced to about a third of the original cover.	(Hamberg, 1912; Eriksson et al., 2007; Turi, 2011a; Johansson, 1960)
1889	Border closure Sweden-Finland (Russia)	B		Finnmark and Lapland	In 1889, the border between Sweden and Finland (Russia) was closed for cross-boundary migration. The drastic decrease of Torneträsk herd sizes from 1890 to 1900 was partly due to the closure of the Swedish-Finnish border in 1889 that forced many families to return to Kautokeino or to move further south in Norrbotten and even to Västerbotten.	(Pedersen, 2006; Lantto, 2010; Lantto, 2006; Lantto, 2008)
1893–1900		2	Several winters with severe grazing conditions	Torneträsk	Several winters with ice-blocked pastures from 1893 to 1896 clearly amplified this reduction. More than half of the reindeer in the Torneträsk area either died or were forced away. Lichen pastures were further reduced to 8% of the original cover, which is the lowest cover ever recorded for this area.	(Hamberg, 1912; Eriksson et al., 2007; Anon, 1912; Fries, 1913; Ruong, 1937; Lantto, 2006; Lantto, 2008; Lönnberg, 1909; Det norske meteorologiske institutt, 1958)
1911–1920		3	Several winters with severe grazing conditions: ice crust on the pastures	Counties of Finnmark, Troms, and Norrbotten	The next comprehensive herd size reductions took place from 1911 to 1921. Torneträsk and the whole of Norrbotten lost about 40% of their reindeer during this period. On the Norwegian side, the two most severe winters were 1916–17 and 1917–18. Moen and Danell (2003) suggest that this decline was caused by disease (a *Clostridium* infection). However, this unprecedented minimum came after a decade of severe winters, but with few historical accounts from Sweden. Perhaps high *Clostridium* infection rates were caused by poor reindeer fitness due to poor availability of nutrients. Lichen pastures were considered sparse (15–20% cover).	(Hamberg, 1912; Eriksson et al., 2007; Moen and Danell, 2003; Lie et al., 2008; Tengwall, 1928; Villmo, 1978; Prestbakmo, 2002; Moen, 2008)

Table 1 (*Continued*)

Year	Political event	Ref. in Fig. 3	Climatic event(s)	Geographical extent	Implications for reindeer herding	References
1923	The 1919 Reindeer Grazing Convention	C		Norway-Sweden	The 1919 Reindeer Grazing Convention entered into force in 1923 (C in Fig. 3). It compelled many herders from Torneträsk to keep their reindeer in Sweden the whole year instead of migrating into Troms for summer grazing (Ringvassøya, Kvaløya, Senja, four peninsulas and some inland areas), which had been their nomadic lifestyle until then.	(Pedersen, 2006; Lantto, 2010)
1920–30	Forced slaughter				Increase in the reindeer population in Sweden (Norrbotten) was followed by forced slaughter and strict bailiff practices.	(Lantto, 2000; Ruong, 1937; Skum, 1955; Rensund, 1968; Rensund, 1984; Labba, 1966; Vikhamar-Schuler et al., 2015)
1932–39		4	Catastrophic winters	Norrbotten, Troms and Finnmark	This period is in the middle of the 'Early-20th Century Warming', which was characterized by anomalously warm summers and winters. Winters in this period were hard for reindeer, because mild periods led to ice crusts on the ground and vegetation (*bodnivihki*), on the snowpack (*geardni)* and as layers within the snowpack (*gaskageardni*). The reindeer population in the whole of Norrbotten was reduced to nearly a half over five years, and the herd size crashed even more dramatically in the Torneträsk area, being reduced to a third (arrow 4 in Fig. 3). Lichen pastures were considered sparse (15–20% cover).	(Päiviö, 2006; Eriksson et al., 2007; Ruong, 1937; Lundmark, 2005; Villmo, 1978; Rensund, 1968; Rensund, 1984; Vikhamar-Schuler et al., 2015)
1940–45	World War II	D		Norway, Sweden	Cross-border migration from Sweden was somewhat reduced due to uncertainty because of the German occupation, but also led to a temporary price increase for reindeer meat and gave an impetus to freedom from strict bailiff practices in Sweden. Forced slaughtering and poaching by German troops led to severe reductions of reindeer herds in Finnmark, particularly in Kautokeino and further south (Nordland). Siidas in Sweden also lost reindeer due to poaching. Swedish lichen pastures to some extent recovered during WWII.	(Lyftingsmo, 1965; Walkeapää, 2012; Lyftingsmo, 1974; Idivuoma, 1990; Evjen, 2007; Berg, 2008)
1955–58		5	Catastrophic winters	Torneträsk area	Severe grazing problems during the 1955–56 and 1957–58 winters were reported for the Torneträsk area and the whole of Norrbotten (arrow 5 in Fig. 3). The reindeer population in Torneträsk, which increased considerably after WWII, was reduced by a third.	(Päiviö, 2006; Eriksson et al., 2007; Lyftingsmo, 1965; Lie et al., 2008; Lyftingsmo, 1974; SSR, 1956; Park, 1958) Bailiff's yearly reports 1955–58 (unpublished on CD), Erik Anders Niia (pers. comm. 2013)
1965–70		6	Severe winters	Finnmark, Troms, Norrbotten and Lapland (Finland)	In Kautokeino, the reindeer population increased in the early-1960s and decreased from 1965 to 1968 (arrow 6 in Fig. 3) due to severe winters with early snowfalls (rutting period) and cold winters with ice crust development (*bodnivihki* and *cuohki*). Lowland pastures in Troms, Norrbotten and Lapland were also blocked during some of these winters. The lichen pastures were in good condition after significant reduction of the herds since the mid-1930s (Kautokeino: 60–70% lichen cover; Torneträsk: 39–47% lichen cover).	(Päiviö, 2006; Eriksson et al., 2007; Tyler et al., 2007; Lyftingsmo, 1965; Anon, 1967; Lie et al., 2008; Lyftingsmo, 1974; Kortesalmi, 2008; Vikhamar-Schuler et al., 2013)

Table 1 (*Continued*)

Year	Political event	Ref. in Fig. 3	Climatic event(s)	Geographical extent	Implications for reindeer herding	References
1965–70		E		Finnmark, Troms and Torneträsk area	Snowmobile revolution started in the mid- to late-1960s and was followed by the use of ATVs in summer and helicopters for herd round-ups and occasional personell transport. More intense pasture use became possible.	(Tømmervik et al., 2009; Riseth, 2009; Linkola and Sammallahti, 1968; Anon, 1969–1979; Pelto, 1973; Nilsen and Mosli, 1994; Paine, 1994)
1972–73		7	Catastrophic winter	Norrbotten, Torneträsk, Nordland, Troms, and Kautokeino	Ground cing over large areas in Torneträsk: "*This led to severe grazing problems for the four northernmost Sámi villages in Sweden (including Saarivuoma and Gabna), and more than half of the stock was lost. The remainder of the reindeer survived in high mountain areas in Norway where the ground cover conditions were better*" (Villmo, 1973). The winter of 1972–73 was very difficult in all the siidas, and difficult snow conditions led to extensive reindeer starvation in the northernmost herding cooperatives. This was one of the first winters when supplementary feeding of the reindeer was arranged. Lichen pastures were good in Kautokeino (38–63% lichen cover) and fairly good in Torneträsk (26–47% lichen cover).	(Tømmervik et al., 2009; Riseth et al., 2011; Villmo, 1973; Eriksson et al., 1981; Johansen and Karlsen, 2005)
1990s		8	Severe winters (1996–97, 1997–98)	Kautokeino, Torneträsk, Norrbotten and Troms	Several winters with poor grazing conditions combined with excessive numbers of reindeer caused large declines in population sizes. Riseth et al. (2011, p. 213) described it as follows: "*An increasing frequency of more or less difficult winter conditions since the early 1990s has made the use of mountain areas a more relevant strategy, and in the 1990s such areas have been used to some degree approximately every other year just before 2000 and for part of the winter in most years since 2000*." Some winters during the 1990s were characterized by very hard snow layers and ground ice. Lichen pastures were severely reduced in Kautokeino (historic low of c. 20%) and Torneträsk (16–20%) during the 1990s.	(Päiviö, 2006; Eriksson et al., 2007; Tømmervik et al., 2009; Riseth et al., 2011; Tømmervik et al., 2012; Johansson et al., 2011; Johansen et al., 2013; Bjerke et al., 2015)
1999–2000		9	Severe winter	Nordland, Troms and Finnmark, Torneträsk	High losses of adult reindeer and calves in most regions, but no details on climatic factors causing these losses are given in the literature. However, we can assume that the very deep snow combined with hard snow layers was the major factor.	(Lie et al., 2008; Johansson et al., 2011)
2001–2002		9	Catastrophic winter	Nordland, Troms Finnmark, and northern Sweden	Record-high losses of calves in western Finnmark (65%), eastern Finnmark (50%) and Troms (50%). Also high losses of adult reindeer. The reindeer population crash was probably caused by a combination of poor condition at the start of the winter, much ice (*bodnivihki*) and a cold spring leading to delayed access to snow- and ice-free vegetation. The size of the winter reindeer herd in Norrbotten reached its lowest since around 1983. Lichen coverage in Kautokeino was 24% and in Torneträsk 21%.	(Lie et al., 2008; Moen, 2008)
2006–07		10	Severe winter	Torneträsk, Troms	Snow and ice conditions were severe for most of the reindeer in Sweden owing to rain-on-snow in late November and early December. Ground ice blocked access to the vegetation, and most reindeer herding communities became dependent on supplementary feeding financed through government catastrophe support. Lichen pastures recovered in Kautokeino (to 27% cover) and were stable (18.5–21%) in Torneträsk (during the first decade of 2000).	(Bokhorst et al., 2012; Eriksson et al., 2007; Tømmervik et al., 2009; Riseth et al., 2011; Tømmervik et al., 2012; Reindriftsnytt, 2007; SOU, 2007; SMHI, 2015) Erik Anders Niia and Håkan Kuhmunen (pers. comm. 2013)

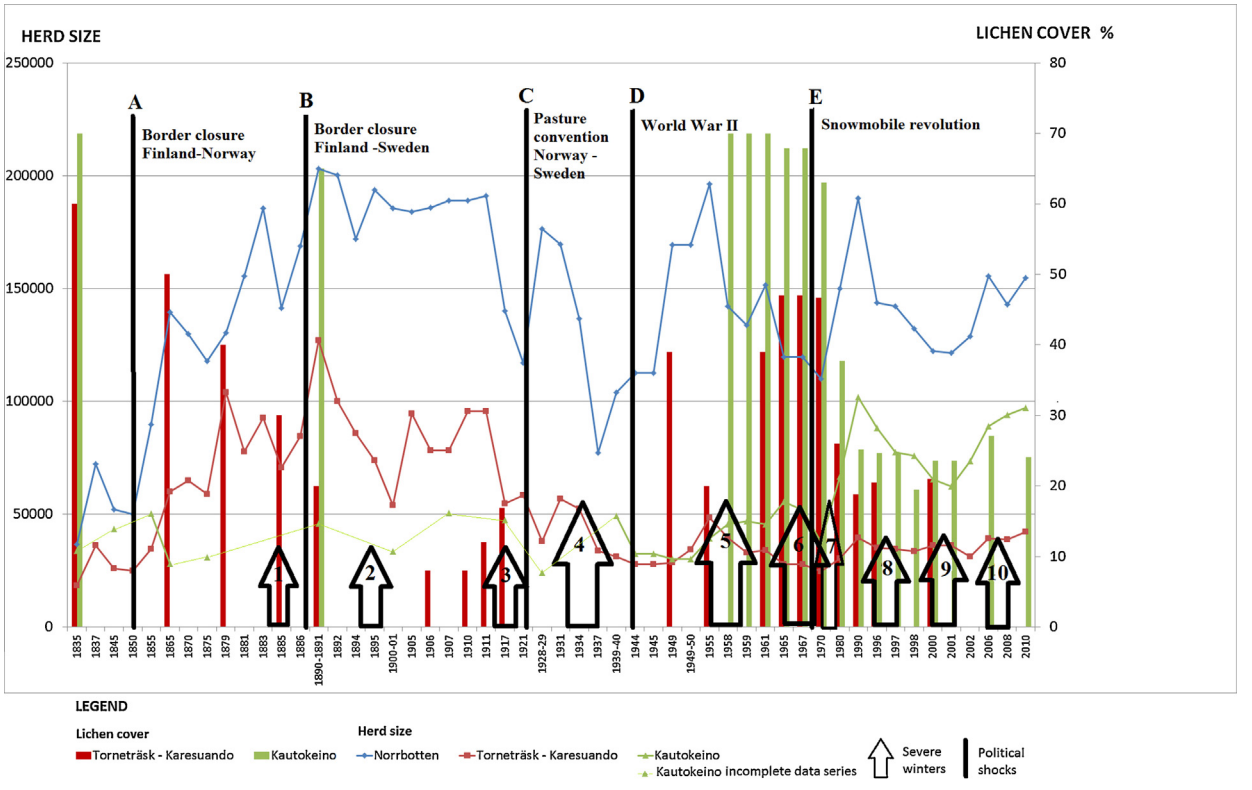

Fig. 3. Changes in the reindeer population in relation to the average lichen cover (%) from 1835 to 2010 in Kautokeino (Norway), and the Torneträsk area and Norrbotten (Sweden). Major external events are indicated. The thin line for Kautokeino before 1939–40 indicates inadequate data. The assessments of lichen cover, where they exist, are included as vertical bars. The figure also includes the major external impacts of political "shocks" (thick vertical black lines) and severe winters (arrows). The lichen cover estimates are based on evaluation of multiple sources; see the text. No data are available where bars are lacking. Climatic events are based on an extensive list of severe winters (unpublished). The figure also partly includes information from Table 1.

The 1852 closure of the border between Norway and Finland for reindeer cross-border migration (A in Fig. 3) directly caused a decrease in the reindeer population in Kautokeino from 1855 to 1865 and a very strong increase in Torneträsk and Norrbotten in the following decades (Table 1). The decrease in the reindeer population from 1883–1884 in Torneträsk and Norrbotten was caused by a thick ice crust on the ground already 29–30 September (arrow 1 in Fig. 3) and had severe impacts, forcing many herders to leave their occupation.

The next major event was the closure of the Swedish-Finnish border in 1889 (B in Fig. 3). The drastic decrease in Torneträsk herd sizes from 1890 to 1900 is partly connected with that, many families being more or less forced to either move back to Kautokeino or move even further south in Norrbotten.[4] Several bad winters in 1893–1896 (arrow 2) clearly amplified this reduction. Combinations of difficult grazing conditions[5] caused massive losses; more than half of the reindeer in the Torneträsk area died (Lantto, 2006, 2008). The next major herd size reduction in both areas took place in 1911–1921; both Torneträsk and the whole of Norrbotten lost about 40% of their reindeer during that period. On the Norwegian side, the two most severe winters were 1916–18 (arrow 3).

The 1919 pasture convention, implemented in 1923 (C in Fig. 3), forced a large number of herders from Torneträsk to reside in Sweden instead of moving into Troms for summer grazing. Herd sizes increased both in Torneträsk and the whole of Norrbotten up to the early-1930s and the late-1920s, respectively (cf. Table 1 and Fig. 3). Furthermore, dramatic herd reductions in the mid-1930s in both areas were caused by a series of winters with severe grazing conditions from 1932 to 1937 (arrow 4 in Fig. 3 and Table 1). The reindeer population in Norrbotten was almost halved in five years, while the reduction to a third in the Torneträsk area was even more dramatic.

Several catastrophic winters clearly caused major problems for reindeer grazing by blocking access to vegetation, and thus led to huge herd reductions. Both Ruong (1937) and Johansson (1960) provide details of these winters. Lantto (2000) provides the statistics on the district level documenting serious herd reductions in Norrbotten (SOU, 1966). Several districts lost two-thirds of their herds. Torkel Tomasson, the editor of the Sámi journal SET,[6] forecasted already in 1930 that reindeer

[4] We note that the total herd size in Norrbotten is relatively stable, while Torneträsk is considerably reduced.
[5] Ice crust on the vegetation (*bodnivihki*) and hard snowpack (*bodniskartan*, *cuohki*) (Hamberg, 1912; Ruong, 1937; Johansson, 1960).
[6] Samefolkets Egen Tidning (The Sámi Peoples Own Newspaper).

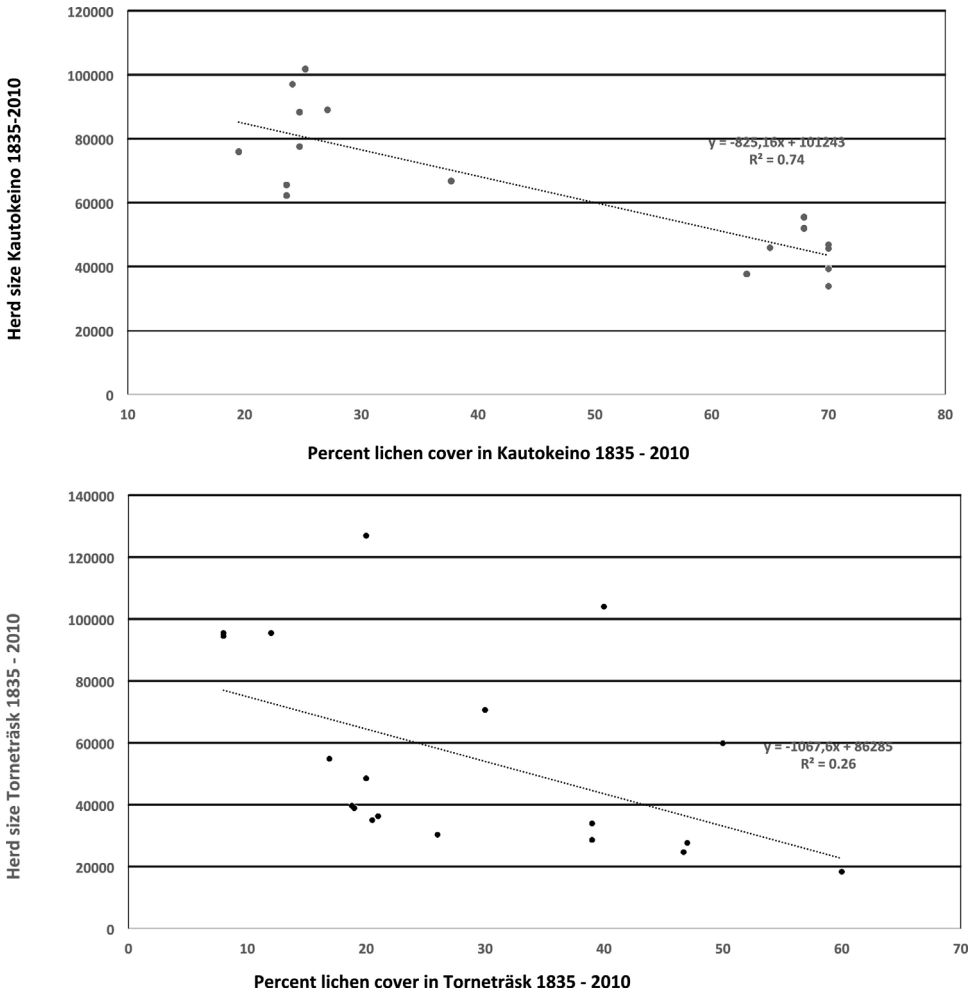

Fig. 4. Herd size and lichen cover assessments for Kautokeino and Torneträsk for the period 1835–2010.

numbers in Norrbotten had reached a ceiling and would soon start to decrease, and indeed they did already the very same year. In 1932, SET published several articles on the "*overcrowding*" problem and for areas in northern Sweden it concluded that "*the lichen fields are totally grazed down*" (Eriksson et al., 2007, p. 47). Ruong (1937) also asserts that the Jukkasjärvi grazing crisis was preceded by two decades of good grazing years leading to strong increases in herd size and a concomitant severe degradation of the lichen pastures. These sources clearly indicate that lichen pasture overutilization was a significant factor for the herd decline in northernmost Sweden in the 1930s. Accordingly, the lichen pastures were probably in a poorer state than during the overpopulation period of the 1910s.

The next reduction in the reindeer populations in both areas happened during World War II (D in Fig. 3), but was most pronounced in Kautokeino with a loss of about 17 000 reindeer (30% reduction) due to forced slaughter by the Germans and poaching.

The strong decline in herd size led to reduced grazing pressure and permitted lichen recovery during the 1940s and 1950s. In the Torneträsk area, the lichen cover increased to 29–47%, depending on the district or Sameby (Anon, 1967; Johansson, 1960). In 1956, a committee appointed by the Swedish Sámi Association presented a report concerning the Torneträsk area. The reindeer pasture in the area was described very positively: "*The overall impression of the Lapp Villages'* [reindeer herding districts] *reindeer grazing land north of Torneträsk is very favourable. There are widespread upland areas with mainly good lichen grazing*" (Our translation) (SSR, 1956).

Another period of severe grazing conditions occurred during the winters from 1955 to 1958 (arrow 5 in Fig. 3). Erik Anders Niia reported that his Talma siida lost several thousand reindeer, and this led to a total population crash (cf. Table 1). Severe reindeer loss was once again the case in the late-1960s (arrow 6 in Fig. 3), in particular on the Swedish side. In contrast to previous crashes, lichen forage was considered sufficient. However, thick ice crusts blocked the reindeers' access to this food resource.

Table 2
Pasture and herd size development in different periods and areas. T = Torneträsk, N = Norrbotten, K = Kautokeino. For Events, see Table 1 and Fig. 3.

Period	Event	Area	Lichen pasture state	Herd size development	Interpretation and explanation
1852–1888	A	T/N	From optimal to clearly reduced	Strong increase with temporary declines	Clear reduction of pasture state due to heavy grazing pressure
		K	Very good pastures	Decreased (incomplete data)	Data incomplete
1889–1922	B	T/N	Reduced and deteriorated pasture state	Two abrupt declines	Persistently high grazing pressure and much trampling damage due to "out-of-season" grazing on lichen pastures
		K	Very good pastures (early in period)	Minor changes	Too limited data
1923–1939	C	T/N	Reduced to deteriorated pasture state	Catastrophic losses several consecutive years	Combination of deteriorated pastures and severe winters probably increased the losses
		K	No data	Herd increase	No data
1940–1970	D	T/N	Improved pastures	Herd increase, but several phases of decline	Low pasture utilization promoted pasture improvement
		K	Very good pastures	Moderate herd size variations	Moderate pasture utilization
1971–2012	E	T/N	Reduced pasture state	Strong increase and decrease, followed by another increase	Data incomplete
		K	Pasture quality reduction, improvement and yet another reduction phase		Technological revolution made more intense pasture use possible, but also more vulnerable

For post-war Norway, Lyftingsmo (Lyftingsmo, 1965) reported that the state of the pasture in Kautokeino was good with a calculated lichen cover of 63%. However, during the decades towards the millennium shift, Kautokeino experienced a reduction from 63% to 19.5% (Lyftingsmo, 1965; Tømmervik et al., 2012). The lichen cover in Kautokeino then increased for a short period, reaching 27.1% in 2005, but this was followed by yet another decline, to 24.1% in 2010 (Fig. 3 and Tømmervik et al., 2011, 2012).

More recent surveys in the Torneträsk area indicate that the lichen cover varied from 16% to 35% from the 1970s to 2000 and 18.5% to 21% in 2000–2010 (Fig. 3, Table 1, Eriksson et al., 2007, 1981).

During the 1990s, several winters with poor grazing conditions caused severe declines in reindeer populations (Päiviö, 2006; Riseth et al., 2011). In the late-1990s and around and beyond the millennium shift, several difficult winters caused considerable losses (cf. Table 1 and arrows 7, 8 and 9 in Fig. 3).

To analyze the impacts of the external shocks, we have divided our data into subcases covering periods after external impacts. Table 2 summarizes the results.

Discussion

The state of the pastures in Torneträsk during the 1910s was evaluated by the 1909 Commission (as well as in pasture inventories through interviews of reindeer herders) and several scientists (Fries, 1913[7]; Lönnberg, 1909[8]; Holmboe, 1912). These sources confirm an extensive deterioration of the pastures (cf. our assessments in Fig. 3). Several sources cited by Eriksson et al. (2007, pp. 42, 46) indicate *out-of-season grazing and trampling of dry and fragile lichens*[9] as explanations.

An immediate outcome of the considerable losses in Torneträsk was that the Swedish use of summer districts in Norway strongly declined. Some convention districts were not utilized at all for a number of years. During the late-1960s and early-1970s, preparations and negotiations for a renewed Norwegian-Swedish border convention took place. The Norwegian government still had clear ambitions to reduce "Swedish" grazing in Norway as part of its plan for herders to immigrate from Finnmark to Troms; it thus wanted to argue that these districts were abandoned and should be used by herders from Norway (Sara and Storli, 1997; Idivuoma, 1990). The new convention was prepared by a commission established in 1964,

[7] Also in Troms.
[8] Very low to low lichen cover.
[9] The effects can most effectively be demonstrated by studying a recent aerial photograph or satellite image of the Norwegian-Finnish border, where the Finnish side is grazed all year around and the Norwegian side only in winter.

which had only one Sámi member, who felt like a hostage and had to accept changes which he really opposed (Idivuoma, 1990). The final convention was adopted in 1972 and enforced extensive restructuring of reindeer herding Sámi in both countries. Swedish reindeer herders lost 72% of their summer pastures in Norway (Reinbeitekommisjonen, 2001). This provides good indications that difficult winter conditions during a number of crucial years may also have influenced the design of the 1972 pasture convention.

Initially, we asked whether much of the reindeer population history in northernmost Scandinavia can be explained by external shocks, such as political events. As a basis for our overall analysis, our results show a strong relationship between lichen cover and herd size for Kautokeino, but a weaker, though still significant, one for Torneträsk. Lack of, or inadequate, data mean that only six of ten subcases are available for analysis. On the other hand, these include those with the most extensive impacts and are therefore the most interesting for analysis. We have compared the subcases using the framework introduced in Fig. 1. This consists of two main parts, the production system and the institutional system, connected by a core including management strategies and pasture state. In general, we see that *external shocks* change institutions and in the next instance management strategies, which then influence both herd size and pasture utilization. *Climate effects* influence access to pasture, but not pasture state. In practice, they do to some extent, as a thin snow cover gives access to lee slopes that are inaccessible during normal winter snow conditions.

As regards the pasture state in the Torneträsk area, we note that it became worse during at least the first two periods (until 1922), and probably also through the third (into the 1930s). Going back to our data, we recall that the pasture state seemed fully optimal before the changes started in 1852, and a number of sources provide very good documentation that the pasture state in the decades around 1900 was inferior due to not only long-lasting high grazing pressure, but also out-of-season trampling of fragile, dry lichens.

Though we have too little information from the 1930s to draw a firm conclusion on the pasture state, the indicated poor state is supported by the forecast of the Reindeer Pasture Commission of 1909 which had predicted "catastrophic overgrazing" as a certain outcome of delayed entry to summer pastures in Troms (Päiviö, 2007). The implementation of the 1919 pasture convention (C in Table 1) was a far more comprehensive action. Anyhow, the available information strongly indicates that the great reindeer losses probably were not only a result of extreme weather events.

If severe blocking snow and ice conditions develop in winters when the pastures are in a reduced state, especially on the most readily available grazing (the ridges), then major population crashes are likely to be the result (Tømmervik et al., 2011, 2012). This helps to explain the overall weaker relationship between lichen cover and herd size for Torneträsk than for Kautokeino; pastures in Torneträsk became so reduced that recovery took very long.

The good pasture situation in the Torneträsk area in the 1950s is well documented and a probable outcome of low grazing pressure since the late-1930s and World War II. The considerable losses in Torneträsk and Norrbotten in the late-1950s and late-1960s break with the previous pattern, as losses are not linked with poor pasture states. Instead, the small Swedish post-war herds were used as a government policy argument to reduce the extent of Swedish Sámi herding in Norway.

For Kautokeino, pasture utilization was moderate up to the 1970s. Helle and Kojola (2006) found synchrony in population trends in a number of regions, including our study areas. These authors point to a general agreement among authors that winter conditions for reindeer were favourable from the mid-1970s to the late-1980s in all three Nordic countries. We do not disagree, but we do not think this is the full explanation. We find it relevant to see climate trends as a necessary, but not sufficient condition for herd size variation in this period. Moreover, for Kautokeino, and also Karasjok, Tømmervik et al. (2009) found that the snowmobile and transport revolution that started in the late-1960s (cf. E in Table 1) provided a new possibility for expansion and introduced a period of more intense pasture use than before, herd size minima higher than former maxima. Important enough, this development is connected with high costs. Without a high level of subsidies, it has the potential to force smaller herders out of business due to low profitability (Riseth, 2009).

For Sweden, we note that the herd size trends in Norrbotten are broadly the same as in Kautokeino. For Torneträsk, the variation in this period is clearly less than for Norrbotten, but reduced lichen biomass may have increased vulnerability to climate impacts. As we do not have data beyond the year 2000 for Torneträsk and Norrbotten we cannot conclude for this subcase. From Finland, we have good data for the 1990s and the 2000s. Using remote sensing, Colpaert and Kumpula (2012) compared the reindeer lichen biomass in Finland between 1995–1996 and 2005–2008. They found that old-growth forests with lush lichen cover had declined by 5% during this period due to forestry. On the basis of field site data, the measured lichen biomass had declined significantly in 19 of the 20 reindeer management districts while only one district showed a slight improvement. Kumpula et al. (2013) found that the lichen biomass was strongly affected by the grazing system; the lowest biomass level measured was found in areas grazed also in the snow-free seasons. Importantly, supplementary feeding seems to have reduced the impact of extreme winter conditions. Sámi reindeer herders in northernmost Finland have developed new winter pasturing strategies that include supplementary feeding (Vuojala-Magga et al., 2011). Hence, inadequate lichen resources for Finnish reindeer are largely compensated for by supplementary feeding, but at a high cost that is partially compensated for by government and EU subsidies.

Remarkably, the reduction in pasture state on Finnmarksvidda during the period from about 1970 to 1998 seems to have evolved in the same manner as in the Torneträsk area a century earlier; lichen pastures were utilized by reindeer out-of-season (during the snow-free period) so that trampling may have contributed more to the reduction than the grazing per se (Tømmervik et al., 2009; Riseth, 2009, 2015). When Kautokeino and Torneträsk are compared, it seems that the negative relationship between high reindeer population sizes and the amount of lichen fodder is significant for both areas (Fig. 4) for the whole period considered in this study. However, with reduced lichen and winter pastures in concert with hard winters,

measures like supplementary feeding in both areas have resulted in more moderate crashes in the reindeer populations in recent decades compared with the situation from the 1850s to the 1930s.

Summary and conclusions

We have analyzed considerable data covering nearly two centuries as subcases connected with regions and periods following external shocks. We found that six out of ten subcases had sufficient data to draw clear conclusions. Of these, one did not show clear links between impact and effect on pasture state. In four subcases, external events clearly influenced pasture adaptations by promoting pasture use that reduced the carrying capacity of the winter pastures. Three of these subcases are from Torneträsk and Norrbotten. We have shown how a series of political events, two border closures and one border convention, during eight decades aggravated the pasture state and made reindeer herding more vulnerable to climate impacts. The last subcase with conclusions is Kautokeino during the decades from 1970 to 2010. Here we confirm earlier findings. There are clear parallels between Torneträsk a century ago and Kautokeino around the turn of the millennium since out-of-season grazing on dry, fragile lichens played a role in exacerbating pasture wear and tear.

We show that weather events had a decisive influence on herd-pasture dynamics independent of pasture state in one of the studied subcases (post-war Torneträsk). It seems as if the outcome (reduced pasture use) provided the Norwegian government with new arguments when, in the 1960s, it continued its policy of limiting Swedish Sámi reindeer herding in Norway. This would be compatible with Pedersen's (2007) question of whether Norway still advances the same policy as it initiated in the 1840s.

Our main findings are based on the documented effects of the international events and government policies and actions in Scandinavia from 1852 to 1921. These led to a dramatic over-accumulation of reindeer and herder families in northernmost Sweden and subsequent jurisdiction allowing forced southward relocation of families and reindeer. This had cascading effects on Sámi relations outside Sweden.

The political and administrative history is well documented. Our environmental data are a unique compilation of weather and biological events based on multiple sources during two centuries, which contribute to the validity of our findings. Our pasture state data from the late-1800s also build on several sources that support each other. Our analyses show that the over-accumulation of reindeer and herder families contributed to overutilization of lichen pastures. Beyond any reasonable doubt, this must have reinforced the effects of several of the documented catastrophic climatic events, especially in areas like Torneträsk to where many families from Finnmark were relocated. For the period from the first border closure in 1852 to the Second World War it thus seems as if the shocks from the political events were the main drivers of the pasture utilization of reindeer herding for large parts of northern Scandinavia.

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References

Aanes, R., Sæther, B.-E., Øritsland, N.A., 2000. Fluctuations of an introduced population of Svalbard reindeer: the effects of density dependence and climatic variation. Ecography 23 (4), 437–443.
ACIA, 2005. Arctic Climate Impact Assessment. Cambridge University Press, New York and Cambridge.
Adger, N., Lorenzono, I., O'Brien, K.L. (Eds.), 2009. Adapting to Climate Change. Thresholds, Values, Governance. Cambridge University Press, Cambridge.
Alm, T., 1991. Floraen in Finnmark. Polarflokken 15, 45–98.
Anon, 1912. Renbeteskommissionen af år 1909 handlingar (Proceedings of the 1909 Reindeer Grazing Commission), Helsingfors.
Anon, 1967. Den norsk-svenske reinbeitekommisjonen av 1964. Innstilling (The Norwegian-Swedish Reindeer Grazing Commission of 1964 Proceedings), København.
Anon, 1969–1979. Lappefogdenes årsmeldinger 1968–1978 (Bailiff's Annual Reports, Finnmark, Troms, Nordland) Reindriftsnytt, Tromsø.
Berg, R., 1996. Norge på egen hånd 1905–1920, vol. 2. Norsk utenrikspolitisk historie, Oslo.
Berg, B.A., 2008. Utviklingen av reindriften i nordre Nordland 1750–2000. In: Evjen, B., Hansen, L.I. (Eds.), Nordlands kulturelle mangfold. Etniske relasjoner i historisk perspektiv. Pax, Oslo, pp. 151–190.
Bjerke, J.W., Tømmervik, H., Zielke, M., Jørgensen, M., 2015. Impacts of snow season on ground-ice accumulation, soil frost and primary productivity in a grassland of sub-Arctic Norway. Environ. Res. Lett. 10, 095007, http://dx.doi.org/10.1088/1748-9326/10/9/095007.
Bokhorst, S., Bjerke, J.W., Tømmervik, H., Callaghan, T.V., Phoenix, G.K., 2009. Winter warming events damage sub-Arctic vegetation: consistent evidence from an experimental manipulation and a natural event. J. Ecol. 97, 1408–1415.
Bokhorst, S., Bjerke, J.W., Tømmervik, H., Preece, C., Phoenix, G.K., 2012. Ecosystem response to climatic change: the importance of the cold season. Ambio 41 (Suppl. 3), 246–255.
Brännlund, I., (Ph.D. dissertation) 2015. Histories of Reindeer Husbandry Resilience. Land Use and Social Networks of Reindeer Husbandry in Swedish Sápmi 1740–1920. Skrifter från Centrum för Samisk forskning No. 21 Vaartoe, Centre for Sami research, Umeå University, Umeå.
Callaghan, T.V., Bergholm, F., Christensen, T.R., Jonasson, C., Kokfelt, U., Johansson, M., 2010. A new climate era in the sub-Arctic: accelerating climate changes and multiple impacts. Geophys. Res. Lett. 37, L14705.
Callaghan, T.V., Jonasson, C., Thierfelder, T., Zhenlin, Y., Hedenås, H., Johansson, M., Molau, U., Bogaert, R.V., Michelsen, A., Olofsson, J., Gwynn-Jones, D., Bokhorst, S., Phoenix, G., Bjerke, J.W., Tømmervik, H., Christensen, T.R., Hanna, E., Koller, E.K., Sloan, V.L., 2013. Ecosystem change and stability over multiple decades in the Swedish sub-Arctic: complex processes and multiple drivers. Philos. Trans. R. Soc. B 368, http://dx.doi.org/10.1098/rstb.2012.0488.
Colpaert, A., Kumpula, J., 2012. Detecting changes in the state of reindeer pastures in northernmost Finland, 1995–2005. Polar Rec. 48 (1), 74–82 (special issue).

Danell, Ö., 2010. Renskötseln och rovdjuren. Rangifer Rep. 14, 78–79.
Det norske meteorologiske institutt, 1958. Lufttemperaturen i Norge 1861–1955. II. Måneds- og middeltemperaturer, maksimums- og minimumstemperaturer. Det norske meteorologiske institutt, Oslo.
Eriksson, O., Palo, T., Söderström, L., 1981. Renbetning vinterstid. Växtekologiska studier 13. Svenska Växtgeografiska Sällskapet, Uppsala, Sweden.
Eriksson, O., Niva, M., Caruso, A., 2007. Use and abuse of reindeer range. Acta Phytogeogr. Suec. 87.
Evjen, B., 2007. Custodial reindeer and custodial goats – part of reindeer herding and animal husbandry. Rangifer 27, 79–91.
Fries, Th.C.E., 1913. Botanische Untersuchungen im Nordlichsten Schweden. Uppsala, Vetenskapliga och praktiska undersökningar i Lappland anordnade af Loussavaara-Kirunavaara Aktiebolag.
Hågvar, G., 2008. Svenske samers rett til reindrift i Troms. Lov og rett, pp. 27–32.
Hamberg, H.E., 1912. Om skare och flen i Lappland. Kungliga Svenska Vetenskapsakademiens Årsbok 10, 225–303.
Hausner, V., Fauchald, P., Jernsletten, J.-L., 2012. Community-based management: Under what conditions do Sámi pastoralists manage pastures sustainably? PLoS ONE 7 (12), e51187.
Helle, T., Kojola, I., 2006. Population trends of semi-domesticated reindeer in Fennoscandia – evaluation of explanations. In: Forbes, B.C., Bölter, M., Müller-Wille, L., Hukkinen, J., Müller, F., Gunslay, N., Konstantinov, Y. (Eds.), Reindeer Management in Northernmost Europe, Ecol. Stud., vol. 184. Springer, Berlin, pp. 319–340.
Holmboe, J., 1912. Vegetationen ovenfor barskogsgrensen i Karesuando og Jukkasjarvi Nord for Torneträsk særlig med sikte på renbeitet. John Griegs Boktrykkeri, Bergen.
Hult, R., 1881. Forsök till analytisk behandling af växtformationerna. Meddel. Soc. pro Fauna et Flora Fenn. 8 (1), 1–155.
Idivuoma, P., 1990. Minnesbilder. Sápmi/SSR, Vänersborg.
Ingold, T., 1976. The Skolt Lapps Today. Cambridge University Press, Cambridge.
Johansen, B., Karlsen, S.-R., 2005. Monitoring vegetation changes on Finnmarksvidda, Northern Norway, using Landsat MSS and Landsat TM/ETM plus satellite images. Phytocoenologia 35, 969–984.
Johansen, B., Tømmervik, H., Bjerke, J.W., Karlsen, S.-R., 2013. Finnmarksvidda – kartlegging og overvåking av reinbeiter – status 2013. Northern Research Institute – Norut.
Johansson, C., 1960. Svåra perioder för renskötseln. Samefolkets Egen Tidning 6–7, 103–106.
Johansson, C., Pohjola, V.A., Jonasson, C., Callaghan, T.V., 2011. Multi-decadal changes in snow characteristics in sub-Arctic, Sweden. Ambio 40, 566–574.
Klein, D.R., 1968. The introduction, increase and crash of reindeer on St. Matthew Island. J. Wildl. Manag. 32, 350–367.
Kortesalmi, J.J., 2008. Poronhoidon synty ja kehitys Suomessa. Suomalaisen kirjallisuuden seura (The Origins and Development of Reindeer Management in Finland). Helsinki.
Kumpula, J., Kurkilahti, M., Helle, T., Colapert, A., 2013. Both reindeer management and several other land use factors explain the reduction in ground lichens (*Cladonia* spp.) in pastures grazed by semi-domesticated reindeer in Finland. Reg. Environ. Change 14, 541–559.
Labba, A., 1966. Nödår. Samefolket 47, 43.
Lae, E., 2003. Fra Karlstadkonvensjon til reinbeitekonvensjon, Dieđut 4/2003 [1977].
Lantto, P., (Ph.D. dissertation) 2000. Tiden börjar på nytt. En analys av samernas etnopolitiska mobilisering i Sverige 1900–1950 (Time Begins Anew. An Analysis of the Ethnopolitical Mobilization among the Sami in Sweden 1900–1950). Department of Historical Studies, Umeå University, Umeå.
Lantto, P., 2006. Rotlösa nomader? De första försöken att tvångsförflytta samer i Sverige. Oknytt 27 (3–4), 38–63.
Lantto, P., 2008. "Att det för lapparne skulle vara likgiltigt hvar han flyttade": Tvångsförflyttningar som problemlösning i svensk samepolitik. In: Sköld, P. (Ed.), Människor i Norr: Samisk forskning på nya vägar. Centrum för Samisk forskning, Umeå universitet, Umeå, pp. 141–166.
Lantto, P., 2010. Borders, Citizenship and Change: The Case of the Sami People, 1751–2008. Citizsh. Stud. 14 (5), 543–556.
Lantto, P., 2012. Lappväsendet: Tillämpningen av svensk samepolitik 1885–1971. Centrum för Samisk forskning, Umeå universitet, Umeå.
Lantto, P., Mörkenstam, U., 2008. Sami rights and Sami challenges: the modernization process and the Swedish Sami Movement, 1886–2006. Scand. J. Hist. 33 (1), 26–51.
Lie, I., Riseth, J.Å., Holst, B., 2008. Samisk reindrift i et skiftende klimabilde. Rapport 8. Norut Alta, Alta.
Linkola, M., Sammallahti, P., 1968. The snowmobile revolution in Lapland. J. Finno-Ugric Soc. 69, 3–42.
Lönnberg, E., 1909. Om renama och deras lefnadsvanor – Attachment to: Forhandlingama infer skiljedomstolen af 1909 i renbetesfragan, Avdelning 1, Svensk inlaga no. 3, Uppsala.
Lopatin, V.N., Abaturov, B.D., 2000. Mathematical modelling of trophically dependent cycle of reindeer (*Rangifer tarandus*) population. Zool. Zh. 79, 452–460.
Lundmark, L., 2005. Samepolitik och renars nationalitet. In: Nilsson, T., Sörensen, Ö. (Eds.), Goda grannar eller morska motståndare. Sverige och Norge från 1814 till i dag, Stockholm, http://www.lennartlundmark.se/file/PROJ2005kort.pdf/PROJ2005kort.pdf (accessed 01.03.16).
Lundmark, L., 2007. Reindeer pastoralism in Sweden 1550–1950. Rangifer Rep. 12, 9–16.
Lyftingsmo, E., 1965. Oversyn over Fjellbeite i Finnmark. Norske fjellbeite, vol. XIV. Det Kgl. Selskap for Norges Vel, Mosjøen, Norway.
Lyftingsmo, E., 1974. Oversyn over fjellbeite i Troms og nordre del av Nordland, Norske fjellbeite Vol. XIV. Det Kgl. Selskap for Norges Vel, Oslo.
Moen, A., 1999. National Atlas of Norway: Vegetation. Norwegian Mapping Authority, Hønefoss.
Moen, J., 2008. Climate change: effects on the ecological basis for reindeer husbandry in Sweden. Ambio 37, 304–311.
Moen, J., Danell, Ö., 2003. Reindeer in the Swedish mountains: an assessment of grazing impacts. Ambio 32, 397–402.
Mörkenstam, U., 1999. Om "Lapparnes privilegier": Föreställningar om samiskhet i svensk samepolitik 1883–1997. Statsvetenskapliga institutionen, Stockholms universitet, Stockholm.
Nilsen, R., Mosli, J.H., 1994. Inn fra vidda. Hushold og økonomisk tilpasning i reindrifta i Guovdageaidnu 1960–1993, BAJOS and NORUT. Guovdageaidnu and Tromsø.
Norberg [Udtja Lasse], L., 2007. Begrav mitt hjärta vid Udtjajaure. Emma, Stockholm.
Ostrom, E., 1990. Governing the Commons. The Evolution of Institutions for Collective Actions. Cambridge University Press, Cambridge, USA.
Ostrom, E., 2007. A diagnostic approach for going beyond panaceas. Proc. Natl. Acad. Sci. USA 104 (39), 15181–15187.
Ostrom, E., 2009. A general framework for analyzing the sustainability of social–ecological systems. Science 325, 419–422.
Overland, J.E., Wang, M., Bond, N.A., Walsh, J.E., Kattsov, V.M., Chapman, W.L., 2011. Considerations in the selection of global climate models for regional climate projections: the Arctic as a case study. J. Climate 24, 1583–1597.
Paine, R., 1970. Lappish decisions. Partnerships, information management, and sanctions. A nomadic pastoral adaptation. Ethnology 9 (1), 52–67.
Paine, R., 1994. Herds of the Tundra. A Portrait of Saami Reindeer Pastoralism. Smithsonian, Washington and London.
Päiviö, N.J., 2006. Sirkas sameby:om konsekvenser av beitekatastrofer. Ottar 259, 10–17.
Päiviö, N.J., 2007. Gränsöverskridande renskötsel. Historisk belysning. In: NOU 2007:14 Oslo, pp. 499–544.
Pape, R., Löffler, J., 2012. Climate change, land use conflicts, predation and ecological degradation as challenges for reindeer husbandry in northern Europe – what do we really know after half a century of research? Ambio 41, 421–434.
Park, G., 1958. Svenska renar hotas av svältdöden. Samefolket egen tidning 1, 3.
Pedersen, S., 2001. Fra bruk av naturgodene etter samiske sedvaner til forbud mot jordsalg til ikke-norsktalende. In: NOU 2001:34. Samiske sedvaner og rettsoppfatninger, Oslo, pp. 289–421.
Pedersen, S., (dr. philos.) 2006. Lappekodisillen i nord 1751–1859: Fra grenseavtale og sikring av samenes rettigheter til grensesperring og samisk ulykke, Avhandling. Institutt for historie, Det samfunnsvitenskapelige fakultet, Universitetet i Tromsø, Tromsø.
Pedersen, S., 2007. Lappekodisillen av 1751- «samene det grenseløse folket». In: Broderstad, E.G., Niemi, E., Sommerseth, I. (Eds.), Grenseoverskridende reindrift før og etter 1905. Skriftserie, nr. 14. Senter for samiske studier. Universitetet i Tromsø, Tromsø, pp. 9–20.

Pehrson, R.N., 1964. The Bilateral Network of Social Relations in Könkömä Lapp District, Samiske Samlinger, vol. VII. Norsk Folkemuseum, Oslo.
Pelto, P.J., 1973. The Snowmobile Revolution: Technology and Social Change in the Arctic. Cummings, California.
Prestbakmo, H., 2002. Samisk bruk av Dividalen nasjonalpark og tilgrensende områder. Rapport til Fylkesmannen i Troms.
Ragin, C., 1987. The Comparative Method. Moving behind Qualitative and Quantitative Strategies. University of California Press, Los Angeles, London and Berkeley.
Ragin, C., 1994. Constituting Social Research. The Unity and Diversity of Method. Sociology for a New Century. Pine Forge Press, Thousand Oaks, London and New Delhi.
Ramberg, I.B., Bryhni, I., Nøtvedt, A., Rangnes, K., 2008. The Making of a Land – Geology of Norway. Norsk Geologisk Forening, Trondheim.
Ravna, Ø., 2010. Lappekodisillen av 1751 og dens rettslige betydning i dag. Lov og Rett 7, 392–406.
Reinbeitekommisjonen, 2001. Innstiling, Norsk-Svensk reinbeitekommisjon av 1997 (Proceedings. Norwegian-Swedish Reindeer Grazing Commission of 1997), Alta.
Reindriftsnytt, 2007. Reports on Bad Grazing Conditions in Sweden and Norway in Several Articles, 1/2007.
Rensund, L., 1968. Med Jon-Erik på renstigarna. Norrbottens Museum.
Rensund, L., 1984. Renen i mitten. Norrbottens Museum, Arjeplog.
Rettens Gang, 2013. Hålogaland Lagmannsrett LH-2013-100881-RG [Rettens Gang] 2013-1420.
Riseth, J.Å., 2009. Modernization and Pasture Degradation. A Comparative Study of Two Sámi Reindeer Pasture Regions in Norway 1960–1990. VDM Verlag, Saarbrücken [2000].
Riseth, J.Å., 2013a. Reindrifta i Nord-Norge: Fra vikeplikt til bærekraft? In: Jentoft, S., Nergård, J.I., Røvik, K.A. (Eds.), Hvor går Nord-Norge? Politiske tidslinjer. Orkana Akademisk, Svolvær, pp. 401–416.
Riseth, J.Å., 2013b. Bruk og rettsoppfatninger i reindriften. In: Myrvoll, M., Riseth, J.Å., Thuestad, A., Evjen, B., Dalsbø, E.T., Samuelsen, T., Hansen, H. (Eds.), Felt 4 Kárášjohka/Karasjok, Sakkyndig utredning for Finnmarkskommisjonen. NIKU Oppdragsrapport10/2013. Norsk Institutt for Kulturminneforskning, pp. 115–154.
Riseth, J.Å., 2014. Ceavzilis boazoealáhus?/Ei bærekraftig reindrift? In: Todal, J. (Ed.), Sámi logut muitalit 7 Čielgaduvvon sámi statistihkka 2014/Samiske tall forteller 7. Raporta/Rapport 1. Sámi Allaskuvla/Samisk Høgskole, pp. 53–103, pp. 52–100.
Riseth, J.Å., 2015. Reindrift og ressursforvaltning. Drammen, Vett & Viten.
Riseth, J.Å., Lie, I., 2016. Reindrifta i Finnmarks betydning for næringsutvikling og samfunnsutvikling. Chapter 8. In: Selle, P., Angell, E., Eikeland, S. (Eds.), Brems eller drivkraft? Samepolitikken i den nye utviklinga i nord (Brake or powerhouse? Sámi Politics in the New North Development). Gyldendal Akademisk, Oslo (in press).
Riseth, J.Å., Vatn, A., 2009. Modernization and pasture degradation. A comparative study of two Sámi reindeer pasture regions in Norway. Land Econ. 85 (February (1)), 87–106.
Riseth, J.Å., Johansen, B., Vatn, A., 2004. Aspects of a two-pasture-herbivore model. Rangifer 1, 65–81 (special issue).
Riseth, J.Å., Tømmervik, H., Helander-Renvall, E., Labba, N., Johansson, C., Malnes, E., Bjerke, J.W., Jonsson, C., Pohjola, V., Sarri, L.-E., Schanche, A., Callaghan, T.V., 2011. Sámi traditional ecological knowledge as a guide to science: snow, ice and reindeer pasture facing climate change. Polar Rec. 47, 202–217.
Ruong, I., 1937. Fjällapparna I Jukkasjärvi socken. Geographica 3, 1–76.
Sandberg, A., 2008. Collective rights in a modernizing North – on institutionalizing Sámi and local rights to land and water in northern Norway. Int. J. Commons 2, 269–287.
Santomauro, D., Johnson, C.J., Fondahl, G., 2012. Historical–ecological evaluation of the long-term distribution of woodland caribou and moose in central British Columbia. Ecosphere 3 (5), 37.
Sara, O.K., Storli, I., 1997. Reindrift før og nå. Landbruksforlaget, Oslo.
Skum, N.N., 1955. Valla renar – Olika sätt att sköta renarna – i ord och bilder skildrade av Nils Nilsson Skum. Almqvist & Wiksell/Gebers Förlag AB, Stockholm.
SMHI, 2015. Hur var vädret?, http://www.hurvarvadret.se/stationer/146 (accessed 20.06.15).
SOU 1966:12, 1966. Renbetesmarkerna. Jordbruksdepartementet, Stockholm.
SOU 2007:60, 2007. Sverige inför klimatförändringarna – hot och möjligheter, http://www.regeringen.se/rattsdokument/statens-offentliga-utredningar/2007/10/sou-200760-/ (accessed 01.03.16).
SSR, 1956. Rapport av S.S.R.s kommittérade för undersökning av vissa frågor ang. renskötseln i de s.k. nordlappbyarna i Norrbottens län, 27 februari 1956, Lappfogden i Norrbottens norra distrikt arkiv, B I:23. Landsarkivet i Härnösand, Härnösand.
Stocker, T.F., Qin, D., Plattner, G.-K., Tignor, M., Allen, S.K., Boschung, J., Nauels, A., Xia, Y., Bex, V., Midgley, P.M. (Eds.), 2013. IPCC Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
Syroechkovskii, E.E., 1995. Wild Reindeer. Smithsonian Institution Libraries, Washington.
Tengwall, T.A., 1928. Renlavarnas tillvaxt och biologi i Torne och Lule lappmarker. Svensk Bot. Tidskr. 22, 18–32.
Thannheiser, D., Tømmervik, H., Wehberg, J., 2005. The vegetation changes and recent impact on the Mountain Birch forest during the last 40 years. In: Wielgolaski, F.E. (Ed.), Plant Ecology, Herbivory, and Human Impact in Nordic Mountain Birch Forests, Ecol. Stud. 180. Springer-Verlag, Berlin, pp. 235–254.
Tømmervik, H., Riseth, J.Å., 2011. Naturindeks. Historiske tamreintall i Norge fra 1800-tallet fram til i dag. NINA Rapport 672.
Tømmervik, H., Johansen, B., Tombre, I., Thannheiser, D., Høgda, K.A., Gaare, E., Wielgolaski, F.E., 2004. Vegetation changes in the mountain birch forests due to climate and/or grazing. Arct. Antarct. Alp. Res. 36, 322–331.
Tømmervik, H., Johansen, B., Riseth, J.Å., Karlsen, S.-R., Solberg, B., Høgda, K.A., 2009. Above ground biomass changes in the mountain birch forests and mountain heaths of Finnmarksvidda, Northern Norway, in the period 1957–2006. For. Ecol. Manag. 257, 244–257.
Tømmervik, H., Johansen, B., Karlsen, S.-R., Ihlen, P.G., 2011. Overvåking av vinterbeiter i Vest-Finnmark og Karasjok 1998–2005–2010. Resultater fra feltrutene. NINA Rapport 745. Norsk institutt for naturforskning (NINA), Tromsø.
Tømmervik, H., Bjerke, J.W., Gaare, E., Johansen, B., Thannheiser, D., 2012. Rapid recovery of recently overexploited winter grazing pastures for reindeer in northern Norway. Fungal Ecol. 5, 3–15.
Turi, J., 2011a. Min bok om samene [Muitalis samiid birra]. ČálliidLágádus, Karasjok [1910].
Turi, J., 2011b. Min bok om samene (My Book About the Sámi). ČálliidLágádus, Karasjok [1910].
Tveito, O.E., Førland, E.J., Alexandersson, H., Drebs, A., Jonsson, T., Tuomenvirta, H., Laursen, E.V., 2001. Nordic Climate Maps. DNMI-Report 06/01, Oslo, pp. 1–28.
Tveraa, T., Fauchald, P., Yoccoz, N.G., Ims, R.A., Aanes, R., Høgda, K.A., 2007. What regulate and limit reindeer populations in Norway? Oikos 116, 706–715.
Tyler, N.J.C., Turi, J.M., Sundset, M.A., Strøm Bull, K., Sara, M.N., Reinert, E., Oskal, N., Nellemann, C., McCarthy, J.J., Mathiesen, S.D., Martello, M.L., Magga, O.H., Hovelsrud, G.K., Hanssen-Bauer, I., Eira, N.I., Eira, I.M.G., Corell, R.W., 2007. Saami reindeer pastoralism under climate change: applying a generalized framework for vulnerability studies to a sub-Arctic social-ecological system. Global Environ. Change 17, 191–206.
Ulvevadet, B., (Ph.D. dissertation) 2012. The Governance of Sami Reindeer Husbandry in Norway. Institutional Challenges of Co-management. University of Tromsø, Tromsø.
Vikhamar-Schuler, D., Hanssen-Bauer, I., Schuler, T.V., Mathiesen, S.D., Lehning, M., 2013. Use of a multilayer snow model to assess grazing conditions for reindeer. Ann. Glaciol. 54 (62), 214–226.
Vikhamar-Schuler, D., Isaksen, K., Haugen, J.E., Tømmervik, H., Luks, B., Schuler, T., Bjerke, J.W., 2016. Changes in winter warming events in the Nordic Arctic Region. J. Climate, http://dx.doi.org/10.1175/JCLI-D-15-0763.1 (in press).
Villmo, L., 1973. Rennäringsnytt forteller. Reindriftsnytt 4.

Villmo, L., 1978. Derfor har jeg advart. Reindriftsnytt 6, 2–4.
Vuojala-Magga, M., Turunen, M., Ryyppö, T., Tennberg, M., 2011. Resonance Strategies of Sámi Reindeer Herders in Northernmost Finland during Climatically Extreme Years. Arctic 64 (2), 227–241.
Walkeapää, L.J., 2009. Könkämä-samernas renflyttningar till Norge- om sommarbosättningar i Troms fylke på 1900-talet. Tromsø Museums skrifter XXXI, Tromsø Museum. Universitetsmuseet, Tromsø.
Walkeapää, L.J., 2012. Lainivuomasamernas gamla renflyttningar till Norge- om sommarbosättningar i Troms fylke på 1900-talet. Centrum för biologisk mångfald, Uppsala.
Warenberg, K., Danell, Ö., Gaare, E., Nieminen, M., 1997. Flora i reinbeiteland. Nordisk Organ for Reinforskning (NOR)/Landbruksforlaget, Tromsø.
Wielgolaski, F.E., 2001. Vegetation sections in Northern Fennoscandian mountain birch forests. In: Wielgolaski, F.E. (Ed.), Nordic Mountain Birch Ecosystems. Man and the Biosph. Ser. 27. , pp. 115–126.
Zetterstedt, J.W., 1822. Resa genom Sveriges och Norriges Lappmarker, förrättad år 1821, Lund.