

1 **175 years of adaptation:**
2 **North Scandinavian Sámi reindeer herding between**
3 **government policies and winter climate variability**
4 **(1835-2010)**

5
6 **Abstract**

7
8 Unmanaged wild reindeer populations tend to follow cyclical behaviour, and domesticated reindeer populations
9 often show cyclical behaviour, too. In this contribution, we intend to use the long-term development of two areas
10 in northern Scandinavia to explore how externally imposed policies and winter climate variability have influenced
11 the reindeer herd size and pasture state. We do this by comparing the development in two areas that are rather
12 similar ecologically: Torneträsk in northernmost Sweden and Kautokeino (Vest-Finnmark) in northernmost
13 Norway.

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

20 Our main findings are based on the documented effects of international events and consequent government
21 policies and actions in Fennoscandia from 1852 to 1921 which had dramatic consequences, including excessive
22 numbers of reindeer and people in northernmost Sweden, leading to more or less forced relocation southwards in
23 Sweden with cascading effects in large parts of Sápmi. We have found clear indications that this contributed to
24 overutilization of lichen pastures and beyond any reasonable doubt must also have reinforced the effects of several
25 of the documented catastrophic climatic events, especially in areas like Torneträsk to where many families from
26 Finnmark were relocated. From the first border closure in 1852 to the Second World War it thus seems as if the
27 shocks from the political events were the main factor determining the development of reindeer herding in large
28 parts of Sápmi. The political and administrative history is well documented. Our climate data are a unique

1 compilation of climate events based on multiple sources during two centuries, which contribute to the validity of
2 our findings. Our pasture state data from the late-1800s are also based on several sources which support each other.

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

7

8 **1. Introduction**

9 Lands at high northern latitudes are undergoing greater climate change than most other parts of
10 the world [1,2,3]. Furthermore, global and regional circulation models forecast more climate
11 change in winter than in summer [4,3], but most knowledge of climate change impacts on the
12 High North still comes from studies undertaken in summer. Overall, there remains major
13 uncertainty of the consequences of winter change for northern ecosystems [5] and rural
14 communities [6]. However, there are historical reports concerning winter change and reindeer
15 husbandry communities, especially from Fennoscandia [e.g.7,8,9,10]. This material can be used
16 for more general studies of the relations between climate change effects and effects of other
17 changes.

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19 Reindeer herding systems are socio-ecological systems (SES) [11]. The animals are herbivores
20 living in dynamic settings with pastures, climate and predators [12,13,14,15]. The herders live
21 in self-organized, predominantly indigenous Sámi communities in Norway and Sweden, with
22 their culturally derived governance systems [16,17] while the nation states have performed
23 varying policies in different historical and contemporary phases [8, 18,19,20,21,22]. The core
24 institution of Sámi reindeer herding is the siida (the band), which is a group of herding partners
25 usually with family bonds [23,24]. In Norway, reindeer herding is formally organized in
26 reindeer pasture districts, while Sweden uses the concept “sameby” (Sámi Village).

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2 Unmanaged wild reindeer populations tend to follow a cyclical behaviour [25]. A mathematical
3 model of the dynamics of a wild reindeer population from the Kola Peninsula, Russia, shows
4 that population size was represented by cycles of 35-40 years [26]. Population growth during
5 25-30 years alternates with declines of 10 years. The cyclic dynamics is determined by trophic
6 relations and is particularly dependent on the dynamics of lichen resources. Population growth
7 leads to critical reductions in forage availability resulting in a subsequent decline in population
8 size. A reduction of the population size by two times the maximum induces a period with
9 recovery of forage resources before complete exhaustion of pastures again takes place.
10 Malthusian catastrophes have indeed occurred. Two well-known examples are from
11 Kongsfjorden in Svalbard [27] and the remote St. Matthew Island in the Bering Sea [28].
12 However, several mechanisms tend to dampen the rate of population growth and declines.
13 Ingold [29] explains these as: (1) undernourishment lowers birth and calf survival rates, (2)
14 heavy grazing pressure reduces the total stock before ultimate carrying capacity is reached, and
15 (3) animals tend to spread out in search of better pastures. Furthermore, herders of domesticated
16 herds can reduce the herd size or move to alternative pastures.

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18 Nevertheless, domesticated reindeer populations often also show cyclical behaviour [30,31,32].
19 This happens despite contemporary public policies for stabilizing reindeer herd sizes and
20 economic outcome. In Norway, reindeer herding on the sub-Arctic tundra plateau,
21 Finnmarksvidda, which is the autumn and winter pasture for more than two-thirds of the
22 domesticated reindeer of Norway, continues to be rather ungovernable for the government. Its
23 pasture situation, social dynamics and policy interventions during the last half century have
24 been thoroughly studied [16,17,14,33,34,35]. Lichen pasture overutilization still takes place
25 and catastrophic winters still contribute substantially to herd reduction. However, a

1 technological revolution starting with the introduction of the snowmobile has made pasture
2 utilization more intense than before 1960, leading to unprecedented levels of undulation
3 between peaks and bottoms [14]. Furthermore, government subsidies and wage labour incomes
4 have stimulated a shift to larger herds despite government intentions to maintain stable, lower
5 density herds [17,14,33]. Very recent policies have in fact led to herd reductions, but it is still
6 too premature to say whether this is permanent or temporary [36]. Notwithstanding this,
7 reindeer herding districts in East Finnmark and southern Norway are clear exceptions to this
8 pattern of herd size undulation, as they, at least until recently when increased predator pressure
9 has become a threat in southern areas [15], have a balanced and sustainable management and
10 good profits in line with public policy goals [16,37].

11

12 Climate effects of difficult winters with snow and ice conditions blocking access to forage
13 resources are an important part of the ecological dynamics and herder adaptability [38]. One of
14 the challenges in this research is to distinguish climate impacts from impacts of other factors.
15 In general, this is easier to accomplish in longer time series with more data sources and more
16 accurate data than we have. In this paper, we have chosen to focus on the Torneträsk area in
17 northernmost Sweden and compare the development over a period of 175 years with a target
18 period from 1880 to the 1930s. The reasons for this selection of area and time period are that
19 the ecology is similar to that of Finnmarksvidda and there are numerous historical sources
20 documenting the combined impacts of events such as: (1) closure of national borders to cross-
21 border herding migrations, (2) relocations of herder households, (3) overutilization of lichen
22 pastures, (4) catastrophic winters, and (5) forced herd reductions. Our objective is to discern
23 the roles of winter events and political “shocks” in cause-effect chains and as cascading effects.

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

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10 Studies of such multilayered dynamics require broad overall frameworks. A vulnerability
11 framework [39] focused on how climate change and other impacts influence reindeer herding
12 and the reindeer herders' abilities to cope with these impacts. However, this framework did not
13 include pasture state evaluation. Here we construct our framework on Commons Theory and
14 the Institutional Analysis and Development (IAD) framework [40]. Instead of using the more
15 sophisticated socio-ecological systems framework [41], we use a specialized framework
16 developed for reindeer herding [16,17]. Fig. 1 presents an analytical framework which is
17 modified to include the effects of climate events and political changes on both the production
18 system and the institutional system.

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20 The framework is based on the assumption that a balanced common-pool resource (CPR)
21 situation requires a balance between the production system that requires coordination and the
22 institutional system that provides a capacity for coordination. The management strategies
23 performed by the herders, which are influenced by both subsystems, are in the centre of the
24 framework scheme. Critical factors for the case studies are marked with bold letters. In the
25 production subsystem, climate influences the accessibility of lichen forage which, in difficult

1 winters, dramatically influences herd size by blocking access to the forage by, for example,
2 ground icing in late autumn or midwinter rain-on-snow freezing events. In the institutional
3 subsystem, political “shocks” change external institutions and thereby the operating regime.
4 The management strategies of the herders are thus affected from two sides, and the CPR
5 situation (pasture state) will be an outcome of the management strategy and the capacity for
6 institutional transformation.

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8 FIGURE 1 ABOUT HERE
9

10 **2. Material, methods and context**

11 This study is a variant of a transdisciplinary and a comparative study with links to historical
12 ecology [42]. Transdisciplinarity connotes a research strategy that crosses many disciplinary
13 boundaries to create a holistic approach. The authors are an institutional economist and two
14 ecologists, all working across disciplinary boundaries and within a larger framework in order
15 to undertake a holistic analysis. Comparative studies are generally used to examine similarities
16 and differences across a moderate number of cases. Knowledge of each case is important, and
17 the primary objective is to explore diversity, interpret cultural and historical significance, and
18 advance theory [43,44]. We do not have material for a standard comparative study of two cases,
19 but compare historical periods from both areas in cases where we have material, which in the
20 end provide us with six subcases (Table 2).

21
22 The historical sources used are extensive, including social, geopolitical and natural sciences.
23 Extensive investigations of the state of the reindeer winter pastures in Kautokeino and
24 Torneträsk were first performed by the Reindeer Grazing Commission of 1909 [45]. Eriksson

1 et al. [10] reviewed many of the sources in the natural sciences. They also included bailiff¹
2 reports and, not least, personal accounts of Johan Turi [46], who was known as the first Sámi
3 author. This is a unique source as Turi was an experienced Sámi herder who gave his account
4 to the Danish author Emelie Demant-Hatt who wrote his book. Meteorological data from 1913
5 onwards were retrieved from the Abisko Scientific Research Station, which is in the Torneträsk
6 area. Before that, we rely greatly on local climatic observations retrieved by Hamberg [7]. In
7 the EWWA research project², we compiled data on winter climatic events from 1800 to 2013
8 based on all available written sources (unpublished manuscript). Obviously, this material is of
9 uneven quality, but its strength is that point observations (meteorological stations) are combined
10 with accounts of impacts for wider areas, providing an overall much more relevant and reliable
11 material. This material also includes interviews with current senior reindeer herders from the
12 Torneträsk area (cf. Table 1). We have also compiled all historical data on lichen cover (e.g.
13 [45,47,48,49,50,10,14,51] and our own unpublished data from Torneträsk (2010).

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

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18 **2.1 Study area**

19 Whereas altitude largely is ecologically equivalent to latitude on the vast continents of North
20 America and Siberia, the rugged topography in North Scandinavia weakens this relationship.
21 This is to a large extent due to the mountain range which forms the border between Norway
22 and Sweden. Geologically, most of northern Scandinavia is part of the Baltic Shield, and is
23 extensively covered by glacial sediments. The mountain range consists mainly of metamorphic

¹ Bailiff, i.e. Lapp sheriff (Sw. Lappfogde, No. Lappfogd), an official with policing authority, who had control tasks with respect to reindeer herders

² <http://www.nina.no/Forskning/Prosjekter/Vinterklima/EWWA>

1 rocks of Cambro-Silurian and Precambrian age [52]. Moraines and rolling rocky hills, forest and
2 scrubland, mires, and numerous lakes and tarns make up much of the landscape. The inland tundra
3 comprises an undulating upland plateau with low mountains, birch-covered hills, stunted pine
4 forest, and open lichen heath and tundra.

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6 The reindeer is adapted to maximize nutritional intake in summer and economize with limited
7 resources in winter [53]. Because of this adaptation, it has very specific requirements for each
8 season. The considerable regional variation in temperature, precipitation, bedrock and vegetation
9 forms the basis for annual migration patterns.

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11 **2.1.1 Climate trends**

12 Climate analyses for the period from 1913 to 2006 from the Abisko Scientific Research Station
13 indicate a warm period in the region in the 1930s. Over the whole period of 1913–2006, the
14 mean annual air temperature increased by 2.5 °C, winter and spring temperatures each increased
15 by 2.9 °C and the autumn temperature increased by 1.6 °C. Summer temperatures have not,
16 however, risen significantly in the recent warming or through the 20th century despite an overall
17 increase of 1.7 °C [54]. Temperature extremes in the Torneträsk area have been most notable in
18 winter when extreme warming events for just a few days have resulted in brief episodes above
19 0 °C, snow thaw and re-freeze to create layers of ice [55]. Such extreme winter weather
20 conditions have regularly led to crashes in the reindeer populations of northern Sweden and
21 also Norway [7,38,56].

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23 A typical weather pattern leading to a population crash is a winter thaw event after the first
24 snowfall, but similar crashes can occur later in the winter. The thaw causes ice encapsulation
25 of the ground vegetation (*bodnivihki*), blocking the reindeer's access to fodder resources. Snow

1 accumulation after ground icing, together with wind, hardens the snowpack, reducing the
2 accessibility of reindeer fodder and perhaps leading to reindeer starvation and death [38].
3 Herders may move their reindeer to other pastures or feed them to avoid loss of animals, thereby
4 leading to large losses such as during the crisis winters of 1905-1906 and 1934-1935 [56] and
5 1884-85 and 1894-95 [7]. Despite the modernization of reindeer husbandry, this type of winter
6 climate continues to cause population crashes in reindeer herds [56], especially in the most
7 heavily grazed area [14].

8

9

FIGURE 2 ABOUT HERE

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11 **2.1.2 Torneträsk area**

12 The Torneträsk area is located in the northwestern part of Norrbotten County in Sweden, on the
13 border to northern Norway and Finland (Fig. 2). The area is topographically diverse, ranging
14 from 342 m a.s.l. to ca. 1900 m a.s.l., and climatically varied with a NW-SE oceanic-continental
15 gradient and local rain shadow effects due to the mountain range [54]. Low winter temperatures
16 and relatively little precipitation, which falls as snow during half of the year, characterize the
17 area. Permafrost, in the form of palsa hummocks, is abundant [10]. Currently (2002-2011), the
18 mean annual temperature is +0.49 °C, while the seasonal mean temperatures from spring to
19 winter are -0.82, +10.9, +1.1 and -9.2 °C, respectively, at Abisko [54]. The summer pastures are
20 in the Norwegian-Swedish border mountain range, while winter pastures are mainly in Swedish
21 inland pine forests.

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23 **2.1.3 Finnmarksvidda**

24 Finnmarksvidda is Norway's largest upland plateau, and is situated in the Arctic-alpine-boreal
25 transition zone between 68-70 °N and 22-26 °E, from ca. 100 to 500 m a.s.l. The Precambrian

1 bedrock forming Finnmarksvidda was affected and reshaped by repeated glaciations during the
2 Pleistocene. Finnmarksvidda is now covered with thick ground moraine forming rounded and
3 gentle landscape forms with nutrient-poor soils [58]. The plateau includes extensive lichen-
4 covered mountain heaths, mountain birch forests, pine forests, barren land, mires and glacially
5 formed lakes. Finnmarksvidda is also located in the transition zone between sub-oceanic and
6 continental climates [59]. The continental influence is strongest, and is expressed through the
7 annual extremes like warm summer periods and winters with strong radiation weather
8 conditions. The standard normal annual precipitation in Kautokeino is 325 mm, 50 % of which
9 falls in summer [60]. During the last decades, the annual mean precipitation rates have
10 increased, while evapotranspiration has been reduced due to increased cloudiness [61,62]. The
11 increasing maritime climatic buffering has impacted large parts of the northern and western
12 parts of Finnmarksvidda [60,63,62]. In Finnmark, the usually mountainous summer pastures are
13 situated on or near the Arctic coast and fjords, while the winter pastures are in the continental
14 inland, where lichen beds are under a relatively light snow cover. This is generally considered an
15 ideal situation for reindeer pasturing.

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17 **2.1.4 Early pasture state studies**

18 In 1821, Professor W. Zetterstedt visited both our study areas. For Torneträsk, his observation
19 was that “*the mountains on either side of the south end of Lake Torneträsk were covered with*
20 *reindeer lichen (**Cladonia rangiferina**) and **Stereocaulon paschale**” [64]. For Kautokeino,
21 he reported:*

22

23 “*Open, dry areas were covered by **Cetraria nivalis** [current name *Flavocetraria nivalis*].*

24 *Those areas and hills covered by this plant show up white even at a long distance. In these*

25 *mountains, it is incomparably taller and thicker, and the separate lichen stands richer than in*

26 *more southerly areas” [64].*

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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] [65, 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 [10] 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]” [10].

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*” [10, p.42]. This helps us to understand Turi’s description “as if

1 it was burnt”. The accounts in these sources are also confirmed by the 1909 Commission on
2 Reindeer Grazing Lands [45], both as regards the pasture state before 1850: “*Elderly Lapps*
3 *relate that in their youth (before the mid-19th century) the land was still white with lichens*”
4 [10], and why it had changed:

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6 “*The representatives of the Saami villages interviewed by the commission claimed, quite*
7 *unanimously, that the ruined pastures on the Swedish side of the border were the result of the*
8 *hordes of reindeer that had poured in from the north two or three decades after the incursion of*
9 *the Kautokeino Lapps in the 1850s and 1860s*” [10, pp.46-47].

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11 The same authors comment:

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13 “*Still more striking was the deterioration of the lichen pastures after the closure of the Finnish*
14 *border (1889). Then, the large herds of the Rommavuoma and Suondavaara Saami, which in*
15 *former times had regularly spent the winter in Finland, could no longer be taken there...These*
16 *reindeer, too, must now graze in Sweden*” [10, pp.47-48].

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18 **2.2 Political and historical context**

19 In the long period from 1328 to 1852, the geopolitical situation in northern Scandinavia was
20 ambiguous. The national borders between Norway, Sweden, Finland and Russia were unclear
21 in some areas and not always strictly enforced [66]. The nomadic Sámi reindeer herders could
22 move relatively freely with their herds between the territories claimed by the separate nation
23 states. The first national border was established between Denmark-Norway and Sweden-
24 Finland in 1751. This is the second oldest unchanged national border in Europe. The Lapp
25 Codicil, an addendum to the border treaty, codified that national borders were not to become
26 an obstacle to Sámi migration that had taken place from time immemorial, though the Sámi had

1 to become citizens of one of the states and property rights in the “other” country were
2 confiscated [67].

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4 The explicit motivation of the Codicil was "the Conservation of the Sámi Nation", i.e. the states
5 took on a common duty to provide a fundament for the eternal existence of Sámi culture and
6 livelihood [67]. Thus, although the border meant colonization, the Lapp Codicil probably
7 deserved the name “the Sámi Magna Carta”, providing tolerable conditions for the Sámi [68].

8 The ecological advantages of preserving the traditional migration patterns are obvious. Norway
9 has excellent summer pastures in the nutrient-rich, sub-oceanic, tundra heaths and deciduous
10 lowland forests, while Sweden and Finland have excellent winter pastures in the more
11 continental coniferous forests. At a regional level, the two relatively similar areas, which we
12 compare here, were split by the Codicil. Finnmarksvidda became part of Norway, while the
13 Torneträsk area remained part of Sweden. However, with the Codicil openness for border-
14 crossing reindeer herding, both areas could still be used as before, with summer pastures in the
15 mountain range and winter pastures in the interior, and the annual migration routes following
16 the big river valleys [69].

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18 The relative freedom enjoyed by Sámi herders lasted for about a century after the border
19 establishment. In the wake of the Napoleonic Wars, the political map of Europe underwent
20 several changes, which later led to international events that contributed to undermine the treaty
21 and thus create political “shocks” in the governance system [67]. In 1809, Sweden had to
22 surrender Finland to Russia. In 1826, the border between Russia and Norway was established.
23 In 1814, Denmark had to surrender Norway, which went into a union with Sweden, and, finally,
24 Norway and Finland gained independence in 1905 and 1917, respectively.

25

1 ***Border closures***

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

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6 *“The interests of the separate states, not least from the Norwegian side, justified by nationalistic*
7 *regards, became superior to the interests of the stateless nation – the Sámi. In other words, a*
8 *complete change of attitude had taken place during the century since 1751 [Our translation] [67,*
9 *p.11).*

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11 This immediately created turbulence in the reindeer herding systems of northern Scandinavia.
12 A total of 50 000 reindeer from the Norwegian side had winter pastures in Finland, and 15 000
13 reindeer from the Finnish side had summer pastures in Norway [69]. The rearrangement became
14 demanding. As we are studying Finnmarksvidda and the Torneträsk area here, we focus on the
15 implications for the Kautokeino Sámi. We do not discuss the problems created for Sámi in
16 eastern Finnmark. One of the strategies chosen by the Kautokeino Sámi was to register as
17 Swedish citizens in Karesuando, northernmost Sweden, to be able to continue using winter
18 pastures in Finland and summer pastures in Norway. Similarly, Sámi in the Finnish Enontekiö
19 region changed citizenship to continue their practice. The explanation is that the Codicil was
20 still in force between Norway and Sweden and the border between Sweden and Finland was
21 still open [70].

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23 However, in 1889, the border between Finland and Sweden was closed too [69]. This terminated
24 possibilities for the circumvention strategies used since 1852. Kautokeino herders in
25 Karesuando now had to make a choice. Some moved back to Kautokeino, while others became
26 Swedish citizens permanently. After the border closure, the regional authorities in Norrbotten

1 considered that there were far too many reindeer in the Torneträsk area, and in 1890 they
2 ordered 14 families from Karesuando to move to Arjeplog. Due to stubborn resistance from
3 these families, this was not effectuated immediately. Following the very severe winter of 1893-
4 94, when many reindeer were lost, the forced family relocation was cancelled altogether
5 [71,72].

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7 Oral traditions and church archives confirm a massive immigration of Kautokeino Sámi to
8 Karesuando (Finland) and Jukkasjärvi (Sweden) after the closure of the Finnish border for
9 Norwegian Sámi in 1852 and for Swedish Sámi in 1889 [57]. An estimated 200 persons (family
10 members included) with 20 000 reindeer immigrated to Karesuando before 1867. In 1883, the
11 15 Kautokeino Sámi households with 12 000 reindeer were settled in Jukkasjärvi, which made
12 up more than 40 % of the reindeer there. The immigration also created much tension:

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14 *“The mixture of different [herding] methods caused chaotic conditions in Troms County*
15 *[summer areas in Norway] and the Jukkasjärvi area. That the immigrant Sámi used ruthless and*
16 *unfair means in the competition especially contributed to the tension and confusion. In*
17 *particular, they lacked respect for property rights.... theft of reindeer became usual” [Our*
18 *translation] [57, p.28].*

19
20 Ruong [57] added that Jukkasjärvi herders with small herds lost out in this competition and
21 many had to abandon herding. Jukkasjärvi church protocols show that emigration exceeded the
22 numbers immigrating from Kautokeino, leading to a considerable decrease in herder numbers
23 in Jukkasjärvi in the period 1860-1890. Most of these settled as farming and/or fishing peasants
24 in Norway [57]. The historian Lennart Lundmark summarized the consequences of the border
25 closures:

26

1 *“Besides the summer pastures in Troms, the Kautokeino herders had to utilize autumn, winter*
2 *and spring pastures in Sweden. Norway could have taken them back, but refused Russian*
3 *initiatives to negotiate as Norwegian policy was preferably to eradicate reindeer herding and*
4 *Sámi culture. Soon the reindeer pastures in northernmost Sweden became overloaded and*
5 *Sweden was forced to move 400 Sámi to pasture land further south in Sweden. Most of them had*
6 *their origin in Kautokeino, Norway. Hence, Sweden had to carry a considerable part of the*
7 *burden for Norway’s hostile policy towards reindeer herding”* [Our translation] [73, p.1].

10 ***Border conventions***

11 The union between Norway and Sweden ended in 1905, and Norway saw this as an opportunity
12 to eliminate all Swedish claims on Norway [73,74,75]. Norway also aimed to terminate the
13 Lapp Codicil, but did not succeed [76]. The explanation for this is that since the 1840s Norway
14 had tried to reduce or, preferably, eliminate the Swedish Sámi reindeer herding rights. This
15 became *a long-term trend in Norwegian foreign policy* and was based on an ideology of extreme
16 nationalism [74]. Leading academics had started to classify Sámi as inferior human beings, and
17 government policy was to relocate a surplus farming population to northern Norway as settlers
18 [74], particularly to Troms. This increase in the area used for farming led to conflicts between
19 settlers and reindeer herders, as the farmers settled on sites traditionally used for reindeer
20 herding. Norway and Sweden had already in 1883 passed new legislation known as the
21 Common Lapp Law, which introduced a number of means³ to control and regulate reindeer
22 herding in favour of the settlers [73,74,75]. In addition, the Norwegian government wanted to
23 expel Swedish citizens who were herders from Norway. Sámi rights were not seen as part of
24 the issue, which was reduced to a political case between the two countries. In practice, the

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

1 reindeer herding Sámi were not regarded as having any real property rights; on the contrary
2 reindeer herding was only seen as tolerated use (*precario*), which meant a duty to give way for
3 other users, such as agricultural settlers [73,74,75].
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5 In 1905-1919, “hardly any other foreign policy issue achieved such broad public attention”
6 [77]. This created a serious conflict between Norway and Sweden, which led to several
7 commissions and international law arbitrations between the two countries [76]. Norway lost the
8 case, and the Codicil is therefore still in force, at least formally [68]. In 1919, the two countries
9 agreed upon the first Norwegian-Swedish reindeer pasture convention, which had dramatic
10 consequences for herders who were Swedish citizens. Extensive presentations of the land-use
11 of some of these herding districts are given by Walkeapää [78,79], this convention banned
12 Swedish herders from large areas in Norway, including extensive summer grazing areas in
13 Troms (Ringvassøya, Kvaløya, Senja, four peninsulas and some inland areas), and strictly
14 limited the number of reindeer and the timing of spring entry and autumn exit. An estimated
15 60-80 000 reindeer were reduced to a legal access of 39 000 reindeer [73,74,75]. As access to
16 Troms was severely curtailed, there was an over-accumulation of herders in northernmost
17 Sweden, especially in Karesuando, but also in Jukkasjärvi [75]. The border closures and the
18 convention forced 75 herder families with 20 000 reindeer, mostly from Karesuando, to
19 permanently move to more southerly locations in Sweden during the period from 1898 to 1928,
20 creating conflicts with already established herders there. The North Sámi were very unwilling
21 to leave their traditional areas and the original Sámi were equally unwilling to receive them,
22 but they were threatened with large penalties. Eighty families with about 20 000 reindeer
23 remained in Karesuando. The family emigration southwards lasted until the 1950s [75].
24

1 The Swedish Sámi policy was based on a view of the Sámi as culturally inferior to the majority
2 population, unable to determine their own future [8,18,80]. In contrast to Norway, the Swedish
3 Sámi policy aimed at preserving the Sámi as reindeer herders, as this was considered the only
4 livelihood they could master and survive on. Prior to 1919, a regional administrative
5 organization, the Lapp Administration, focusing on Sámi issues in general and reindeer herding
6 issues in particular, was in operation. This administration was strengthened following the
7 convention, and given authority to forcibly reduce reindeer herds if deemed necessary. In order
8 to adhere to the regulations of the convention, control over the reindeer herders was
9 strengthened and more attempts were made to micromanage reindeer herding [8,18,80]. The
10 belief in the feasibility of the Lapp Administration to steer reindeer herding in a positive
11 direction was strong; in 1926, it was argued that the development of the administrative
12 organization had eliminated “the risk of bad ‘reindeer years’” (quoted in [8, p 141]). The
13 catastrophic winters during the 1930s would show how completely unrealistic this conclusion
14 was.

15
16 The 1919 convention was prolonged several times until a new convention was signed in 1972
17 for thirty years [69]. A primary motivation of the Norwegian government for a new convention
18 was to gain access to more areas in Troms for herders from Finnmark [21, 81]. According to
19 Lars Norberg, the chief Swedish negotiator from 2003 to 2005, the 1972 convention had two
20 fundamental flaws: firstly, the Swedish government had negotiated an agreement on the
21 property rights of the Swedish Sámi against their will, which the government had no right to
22 do, and secondly, the Swedish government had accepted encroachments without claiming any
23 compensation [82]. The negotiator characterized the 1972 convention as “a millstone around
24 the neck” of the Swedish Sámi [82]. The 1972 convention was prolonged until 2005 in
25 expectation of the outcome of negotiations [68]. A mixed commission had made a proposal for

1 a new convention, but the negotiations failed, and in 2005, Norway unilaterally passed a new
2 act that prolonged the rules of the convention [68]. This is not recognized by Sweden and
3 Swedish Sámi and created many conflicts in Troms [83,84]. Early in 2016, there is still no new
4 convention in place.

5

6 *Other changes*

7 Besides these three major political events directly regulating reindeer herding, the Second
8 World War affected the regions differently. It significantly reduced the use of Norwegian
9 territory for Swedish herders [78,79], while Norwegian and Finnish reindeer herds were
10 reduced because herders were compelled to supply reindeer meat to German troops [85].
11 Moreover, illegal hunting contributed to the declining herd sizes in Finnmark [85].

12

13 From the late-1960s onwards, the introduction of the snowmobile led to a revolution in transport
14 which was to change reindeer herding significantly by stimulating far more intensive pasture
15 utilization [14]. Unplanned ad hoc reforms, including subsidy schemes, contributed to extensive
16 herd growth on Finnmarksvidda until the 1980s [16]. During the 1990s, herd sizes declined due
17 to a series of severe winters, but they started to increase again after the turn of the millennium
18 [16,21,33,34,36].

19

20 **3. Results and interpretations**

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

24

25

FIGURE 3 ABOUT HERE

1

2 As for the lichen cover before 1890, we rely on the above-mentioned descriptions and
3 coinciding indications of reduction through several decades (cf. 2.1.4). We have interpreted the
4 pasture state in 1835 as a lichen cover of more than 60 % (Fig. 3); hence, the potential lichen
5 cover was reached [49,86]. We assume that the average lichen cover might have been reduced
6 from more than 60 % in the 1860s to less than 30 % in 1890-92 (cf. Fig. 3).

7

8 For the whole period from 1835 to 2010, the relationship between lichen cover and herd size in
9 Kautokeino (Fig. 4) was highly significant and negatively correlated ($R^2 = 0.73$, $P < 0.01$). For
10 Torneträsk, the relationship for the same period was weaker (Fig. 4), but significant ($R^2 = 0.26$,
11 $P < 0.02$).

12

13 **FIGURE 4 ABOUT HERE**

14

15 The relationship between the reindeer population size and the lichen cover in Kautokeino for
16 the period from 1949 to 2000 was highly significant and negatively correlated ($R^2 = 0.74$, $P <$
17 0.01), while there was a significant and negative correlation in Torneträsk ($R^2 = 0.56$, $P < 0.02$).

18

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

21

22 **TABLE 1 ABOUT HERE**

23

24 The 1852 closure of the border between Norway and Finland for reindeer cross-border
25 migration (A in Fig. 3) directly caused a decrease in the reindeer population in Kautokeino from

1 1855 to 1865 and a very strong increase in Torneträsk and Norrbotten in the following decades
2 (Table 1). The decrease in the reindeer population from 1883-1884 in Torneträsk and
3 Norrbotten was caused by a thick ice crust on the ground already 29-30 September (arrow 1 in
4 Fig. 3) and had severe impacts, forcing many herders to leave their occupation.

5
6 The next major event was the closure of the Swedish-Finnish border in 1889 (B in Fig. 3). The
7 drastic decrease in Torneträsk herd sizes from 1890 to 1900 is partly connected with that, many
8 families being more or less forced to either move back to Kautokeino or move even further
9 south in Norrbotten.⁴ Several bad winters in 1893-1896 (arrow 2) clearly amplified this
10 reduction. Combinations of difficult grazing conditions⁵ caused massive losses; more than half
11 of the reindeer in the Torneträsk area died [71,72]. The next major herd size reduction in both
12 areas took place in 1911-1921; both Torneträsk and the whole of Norrbotten lost about 40 % of
13 their reindeer during that period. On the Norwegian side, the two most severe winters were
14 1916-18 (arrow 3).

15
16 The 1919 pasture convention, implemented in 1923 (C in Fig. 3), forced a large number of
17 herders from Torneträsk to reside in Sweden instead of moving into Troms for summer grazing.
18 Herd sizes increased both in Torneträsk and the whole of Norrbotten up to the early- 1930s and
19 the late-1920s, respectively (cf. Table 1 and Fig. 3). Furthermore, dramatic herd reductions in
20 the mid-1930s in both areas were caused by a series of winters with severe grazing conditions
21 from 1932 to 1937 (arrow 4 in Fig. 3 and Table 1). The reindeer population in Norrbotten was
22 almost halved in five years, while the reduction to a third in the Torneträsk area was even more
23 dramatic.

24

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*) [7, 57, 87]

1 Several catastrophic winters clearly caused major problems for reindeer grazing by blocking
2 access to vegetation, and thus led to huge herd reductions. Both Ruong [57] and Johansson [87]
3 provide details of these winters. Lantto [8] provides the statistics on the district level
4 documenting serious herd reductions in Norrbotten [105]. Several districts lost two-thirds of
5 their herds. Torkel Tomasson, the editor of the Sámi journal SET⁶, forecasted already in 1930
6 that reindeer numbers in Norrbotten had reached a ceiling and would soon start to decrease, and
7 indeed they did already the very same year. In 1932, SET published several articles on the
8 “overcrowding” problem and for areas in northern Sweden it concluded that “*the lichen fields*
9 *are totally grazed down*” [10, p.47]). Ruong [57] also asserts that the Jukkasjärvi grazing crisis
10 was preceded by two decades of good grazing years leading to strong increases in herd size and
11 a concomitant severe degradation of the lichen pastures. These sources clearly indicate that
12 lichen pasture overutilization was a significant factor for the herd decline in northernmost
13 Sweden in the 1930s. Accordingly, the lichen pastures were probably in a poorer state than
14 during the overpopulation period of the 1910s.

15

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

19

20 The strong decline in herd size led to reduced grazing pressure and permitted lichen recovery
21 during the 1940s and 1950s. In the Torneträsk area, the lichen cover increased to 29-47 %,
22 depending on the district or Sameby [50,87]. In 1956, a committee appointed by the Swedish
23 Sámi Association presented a report concerning the Torneträsk area. The reindeer pasture in
24 the area was described very positively: “*The overall impression of the Lapp Villages*’ [reindeer

⁶ Samefolkets Egen Tidning (The Sámi Peoples Own Newspaper)

1 herding districts] *reindeer grazing land north of Torneträsk is very favourable. There are*
2 *widespread upland areas with mainly good lichen grazing [our translation]*” [103].

3

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

10

11 For post-war Norway, Lyftingsmo [49] reported that the state of the pasture in Kautokeino was
12 good with a calculated lichen cover of 63 %. However, during the decades towards the
13 millennium shift, Kautokeino experienced a reduction from 63 % to 19.5 % [49,86]. The lichen
14 cover in Kautokeino then increased for a short period, reaching 27.1 % in 2005, but this was
15 followed by yet another decline, to 24.1 % in 2010 (Fig. 3 and Tømmervik et al. [51,86].

16

17 More recent surveys in the Torneträsk area indicate that the lichen cover varied from 16 to 35
18 % from the 1970s to 2000 and 18.5 to 21 % in 2000-2010 (Fig. 3, Table 1, [10,114]).

19

20 During the 1990s, several winters with poor grazing conditions caused severe declines in
21 reindeer populations [9,38]. In the late-1990s and around and beyond the millennium shift,
22 several difficult winters caused considerable losses (cf. Table 1 and arrows 7, 8 and 9 in Fig.
23 3).

24

1 For the whole period of 1835 to 2010, our regression analyses showed a strong relationship
2 between lichen cover and herd size for Kautokeino ($R^2= 0.73$, $P<0.01$) while it was weaker but
3 still significant for Torneträsk ($R^2= 0.26$, $P<0.02$).

4

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

7

8

TABLE 2 ABOUT HERE

9

10 **4. Discussion**

11 The state of the pastures in Torneträsk during the 1910s was evaluated by the 1909 Commission
12 (as well as in pasture inventories through interviews of reindeer herders) and several scientists
13 [48⁷,88⁸,122]. These sources confirm an extensive deterioration of the pastures (cf. our
14 assessments in Fig. 3). Several sources cited by Eriksson et al. [10, pp.42, 46] indicate *out-of-*
15 *season grazing and trampling of dry and fragile lichens*⁹ as explanations.

16

17 An immediate outcome of the considerable losses in Torneträsk was that the Swedish use of
18 summer districts in Norway strongly declined. Some convention districts were not utilized at
19 all for a number of years. During the late-1960s and early-1970s, preparations and negotiations
20 for a renewed Norwegian-Swedish border convention took place. The Norwegian government
21 still had clear ambitions to reduce “Swedish” grazing in Norway as part of its plan for herders
22 to immigrate from Finnmark to Troms; it thus wanted to argue that these districts were

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.

1 abandoned and should be used by herders from Norway [81,100]. The new convention was
2 prepared by a commission established in 1964, which had only one Sámi member, who felt like
3 a hostage and had to accept changes which he really opposed [100]. The final convention was
4 adopted in 1972 and enforced extensive restructuring of reindeer herding Sámi in both
5 countries. Swedish reindeer herders lost 72 % of their summer pastures in Norway [124]. This
6 provides good indications that difficult winter conditions during a number of crucial years may
7 also have influenced the design of the 1972 pasture convention.

8

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

22

23 As regards the pasture state in the Torneträsk area, we note that it became worse during at least
24 the first two periods (until 1922), and probably also through the third (into the 1930s). Going
25 back to our data, we recall that the pasture state seemed fully optimal before the changes started

1 in 1852, and a number of sources provide very good documentation that the pasture state in the
2 decades around 1900 was inferior due to not only long-lasting high grazing pressure, but also
3 out-of-season trampling of fragile, dry lichens.

4
5 Though we have too little information from the 1930s to draw a firm conclusion on the pasture
6 state, the indicated poor state is supported by the forecast of the Reindeer Pasture Commission
7 of 1909 which had predicted “catastrophic overgrazing” as a certain outcome of delayed entry
8 to summer pastures in Troms [75]. The implementation of the 1919 pasture convention (C in
9 Table 1) was a far more comprehensive action. Anyhow, the available information strongly
10 indicates that the great reindeer losses probably were not only a result of extreme weather
11 events.

12
13 If severe blocking snow and ice conditions develop in winters when the pastures are in a reduced
14 state, especially on the most readily available grazing (the ridges), then major population
15 crashes are likely to be the result [51,86]. This helps to explain the overall weaker relationship
16 between lichen cover and herd size for Torneträsk than for Kautokeino; pastures in Torneträsk
17 became so reduced that recovery took very long.

18
19 The good pasture situation in the Torneträsk area in the 1950s is well documented and a
20 probable outcome of low grazing pressure since the late-1930s and World War II. The
21 considerable losses in Torneträsk and Norrbotten in the late-1950s and late-1960s break with
22 the previous pattern, as losses are not linked with poor pasture states. Instead, the small Swedish
23 post-war herds were used as a government policy argument to reduce the extent of Swedish
24 Sámi herding in Norway.

25

1 For Kautokeino, pasture utilization was moderate up to the 1970s. Helle and Kojohla [31] found
2 synchrony in population trends in a number of regions, including our study areas. These authors
3 point to a general agreement among authors that winter conditions for reindeer were favourable
4 from the mid-1970s to the late-1980s in all three Nordic countries. We do not disagree, but we
5 do not think this is the full explanation. We find it relevant to see climate trends as a necessary,
6 but not sufficient condition for herd size variation in this period. Moreover, for Kautokeino,
7 and also Karasjok, Tømmervik et al. [14] found that the snowmobile and transport revolution
8 that started in the late-1960s (cf. E in Table 3) provided a new possibility for expansion and
9 introduced a period of more intense pasture use than before, herd size minima higher than
10 former maxima. Important enough, this development is connected with high costs. Without a
11 high level of subsidies, it has the potential to force smaller herders out of business due to low
12 profitability [16].

13

14 For Sweden, we note that the herd size trends in Norrbotten are broadly the same as in
15 Kautokeino. For Torneträsk, the variation in this period is clearly less than for Norrbotten, but
16 reduced lichen biomass may have increased vulnerability to climate impacts. As we do not have
17 data beyond the year 2000 for Torneträsk and Norrbotten we cannot conclude for this subcase.
18 From Finland, we have good data for the 1990s and the 2000s. Using remote sensing, Colpaert
19 & Kumpula [125] compared the reindeer lichen biomass in Finland between 1995–1996 and
20 2005–2008. They found that old-growth forests with lush lichen cover had declined by 5 %
21 during this period due to forestry. On the basis of field site data, the measured lichen biomass
22 had declined significantly in 19 of the 20 reindeer management districts while only one district
23 showed a slight improvement. Kumpula et al. [126] found that the lichen biomass was strongly
24 affected by the grazing system; the lowest biomass level measured was found in areas grazed
25 also in the snow-free seasons. Importantly, supplementary feeding seems to have reduced the

1 impact of extreme winter conditions. Sámi reindeer herders in northernmost Finland have
2 developed new winter pasturing strategies that include supplementary feeding [127]. Hence,
3 inadequate lichen resources for Finnish reindeer are largely compensated for by supplementary
4 feeding, but at a high cost that is partially compensated for by government and EU subsidies.

5

6 Remarkably, the reduction in pasture state on Finnmarksvidda during the period from about
7 1970 to 1998 seems to have evolved in the same manner as in the Torneträsk area a century
8 earlier; lichen pastures were utilized by reindeer out-of-season (during the snow-free period) so
9 that trampling may have contributed more to the reduction than the grazing per se [14, 16,128].

10 When Kautokeino and Torneträsk are compared, it seems that the negative relationship between high
11 reindeer population sizes and the amount of lichen fodder is significant for both areas (Fig. 4) for the
12 whole period considered in this study. However, with reduced lichen and winter pastures in concert with
13 hard winters, measures like supplementary feeding in both areas have resulted in more moderate crashes
14 in the reindeer populations in recent decades compared with the situation from the 1850s to the 1930s.

15

16 **5. Summary and conclusions**

17 We have analysed considerable data covering nearly two centuries as subcases connected with
18 regions and periods following external shocks. We found that six out of ten subcases had
19 sufficient data to draw clear conclusions. Of these, one did not show clear links between impact
20 and effect on pasture state. In four subcases, external events clearly influenced pasture
21 adaptations by promoting pasture use that reduced the carrying capacity of the winter pastures.

22 Three of these subcases are from Torneträsk and Norrbotten. We have shown how a series of
23 political events, two border closures and one border convention, during eight decades
24 aggravated the pasture state and made reindeer herding more vulnerable to climate impacts. The
25 last subcase with conclusions is Kautokeino during the decades from 1970 to 2010. Here we
26 confirm earlier findings. There are clear parallels between Torneträsk a century ago and

1 Kautokeino around the turn of the millennium since out-of-season grazing on dry, fragile
2 lichens played a role in exacerbating pasture wear and tear.

3

4 We show that weather events had a decisive influence on herd-pasture dynamics independent
5 of pasture state in one of the studied subcases (post-war Torneträsk). It seems as if the outcome
6 (reduced pasture use) provided the Norwegian government with new arguments when, in the
7 1960s, it continued its policy of limiting Swedish Sámi reindeer herding in Norway. This would
8 be compatible with Pedersen's [69] question of whether Norway still advances the same policy
9 as it initiated in the 1840s.

10

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

16

17 The political and administrative history is well documented. Our environmental data are a
18 unique compilation of weather and biological events based on multiple sources during two
19 centuries, which contribute to the validity of our findings. Our pasture state data from the late-
20 1800s also build on several sources that support each other. Our analyses show that the over-
21 accumulation of reindeer and herder families contributed to overutilization of lichen pastures.
22 Beyond any reasonable doubt, this must have reinforced the effects of several of the
23 documented catastrophic climatic events, especially in areas like Torneträsk to where many
24 families from Finnmark were relocated. For the period from the first border closure in 1852 to

1 the Second World War it thus seems as if the shocks from the political events were the main
2 drivers of the pasture utilization of reindeer herding for large parts of northern Scandinavia.

3

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8

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12

13

14 **FIGURE CAPTIONS**

15

16 *Figure 1. A resource adaptation framework constructed for reindeer herding systems (based on Riseth*
17 *& Vatn [17, p.91]).*

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19 *Figure 2. Study area.*

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21 *Figure 3. Changes in the reindeer population in relation to the average lichen cover (%) from 1835 to*
22 *2010 in Kautokeino (Norway), and the Torneträsk area and Norrbotten (Sweden). Major external events*
23 *are indicated. The thin line for Kautokeino before 1939-40 indicates inadequate data. The assessments*
24 *of lichen cover, where they exist, are included as vertical bars. The figure also includes the major*
25 *external impacts of political “shocks” (thick vertical black lines) and severe winters (arrows). The*
26 *lichen cover estimates are based on evaluation of multiple sources; see the text. No data are available*

1 *where bars are lacking. Climatic events are based on an extensive list of severe winters (unpublished).*

2 *The figure also partly includes information from Table 1.*

3

4 *Figure 4. Herd size and lichen cover assessments for Kautokeino and Torneträsk for the period 1835-*

5 *2010.*

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