Norsk Geografisk Tidsskrift–Norwegian Journal of Geography, 2015
http://dx.doi.org/10.1080/00291951.2015.1031274

Misreading the Arctic landscape: A political ecology of reindeer, carrying capacities, and overstocking in Finnmark, Norway

TOR A. BENJAMINSEN, HUGO REINERT, ESPEN SJAASTAD & MIKKEL NILS SARA

Benjaminsen, T.A., Reinert, H., Sjaastad, E. & Sara, M.N. 2015. Misreading the Arctic landscape: A political ecology of reindeer, carrying capacities, and overstocking in Finnmark, Norway. *Norsk Geografisk Tidsskrift–Norwegian Journal of Geography* Vol. 00, 00–00. ISSN 0029-1951.

Sámi reindeer pastoralism in Norway is said to be in a state of crisis that has lasted for several decades and is due to excessive numbers of reindeer. A general overstocking of the range is believed to cause widespread pasture degradation, poor economic performance, and increasing land-use conflicts. These are the main assumptions of a dominant narrative shared by key government and non-governmental actors, most scientists, and the media. The resulting policy focuses on reducing reindeer numbers to set carrying capacities in order to promote ecological sustainability and improve economic performance through the means of increasing carcass weights. The article presents a critical review of the ecological evidence behind the dominant narrative. The authors conclude that the narrative and the associated policy lead to a misreading of the Arctic pastoral landscape that neglects both alternative scientific evidence and interpretations in line with non-equilibrium ecology as well as the indigenous knowledge of the reindeer herders. Hence, such alternative perspectives generally remain invisible to the government institutions that regulate the practice of reindeer management. Further, the authors' study resonates with wider theoretical debates about state governance within political ecology and development studies in general.

Keywords: *Norway, pastoralism, political ecology, reindeer*

Tor A. Benjaminsen, Department of International Environment and Development Studies, Norwegian University of Life Sciences, NO-1432 Ås, Norway. E-mail: t.a.benjaminsen@nmbu.no; Hugo Reinert, Department of International Environment and Development Studies, Norwegian University of Life Sciences, NO-1432 Ås, Norway. E-mail: hreinert@gmail.com; Espen Sjaastad, Department of International Environment and Development Studies, Norwegian University of Life Sciences, NO-1432 Ås, Norway. E-mail: espen.sjaastad@nmbu.no; Mikkel Nils Sara, Sámi University College, Hannoluohkka 45, NO-9520 Kautokeino, Norway. E-mail: mikkel-nils.sara@samiskhs.no

Introduction

The Sámi reindeer herding industry in Norway appears to be in a state of crisis. First, the economic situation of the industry is poor: the price of reindeer meat dropped significantly in the late 1970s, following the 1976 Reindeer Herding Agreement (Reindriftsavtalen) (LMD 2001, 19), and has since remained low (Reinert 2006). Second, overstocking is said to be causing widespread pasture decline, with potential ecological cascade effects (Ims et al. 2007). Third, relations between the industry and other sectors also seem to be deteriorating, with a reported increase in conflicts between reindeer herders and actors in agriculture, tourism, and infrastructure development (e.g. Klein 2000; Eilertsen 2002; Benjaminsen et al. in press). The causes that underpin this situation are complex, but there is a marked tendency in the official discourse to link the present state of crisis to a supposed overabundance or excess of reindeer.

Reindeer herding is the primary livelihood for over 20 indigenous peoples in the Arctic and Subarctic. Throughout most of Norway, reindeer herding is reserved for persons of Sámi ethnicity and access to the practice is regulated through a system of licences formerly referred to as individual management units (*driftsenheter*) and more recently as '*siida* shares' (*siida-andeler*)[1] managed by an individual or a family within a reindeer grazing district (*reinbeitedistrikt*). Reindeer herders constitute a minority in the national Sámi population: the exact size of the latter is unknown, but depending on the criteria being used it is usually estimated as between c.40,000 and c.70,000 (e.g. Nordic Sámi Institute 2008). Since the 1970s, Norwegian reindeer pastoralism has been increasingly geared towards market-oriented production. This process is driven partly by internal changes, such as requirements imposed by motorisation and larger herd sizes, and partly by the progressive integration of pastoralism into the national production infrastructure, particularly through institutions such as the Reindeer Husbandry Act of 1978 (Lov om reindrift av 1978) and the Reindeer Herding Agreement of 1976, which is negotiated annually between the state and the Sámi Reindeer Herders' Association of Norway (Norske Reindriftsamers Landsforbund), and specifies the economic framework of pastoralism in terms of, for example, subsidies and production quotas (Reinert 2006).

Reindeer pastoralism in Norway is based on a pattern of seasonal migrations: in Finnmark these migrations take place between the winter pastures of the inland plateaus, which are dominated by lichen, and the green summer pastures on the coast (Fig. 1). The migrations bring herders and their herds into periodic contact with the land claims and practices of a wide range of other actors, and conflicts over rights and legitimate use often result. In recent years, conflicts between reindeer herders and farmers have featured particularly prominently in the media, as both parties direct public accusations at each other. Farmers accuse herders of carelessness, excessive herd sizes, and deliberately using cultivated land for grazing. Herders argue that grazing land has been taken from them, and that the lack of appropriate fences makes it impossible to keep the reindeer away from fields. In some cases, tensions have escalated into violence. Local and national politicians have become involved in the conflicts, accusing herders of driving their reindeer to graze on agricultural land, erecting illegal fences, and increasing their herds beyond the carrying capacity of their pastures, which is set by the Reindeer Husbandry Board (Reindriftsstyret).

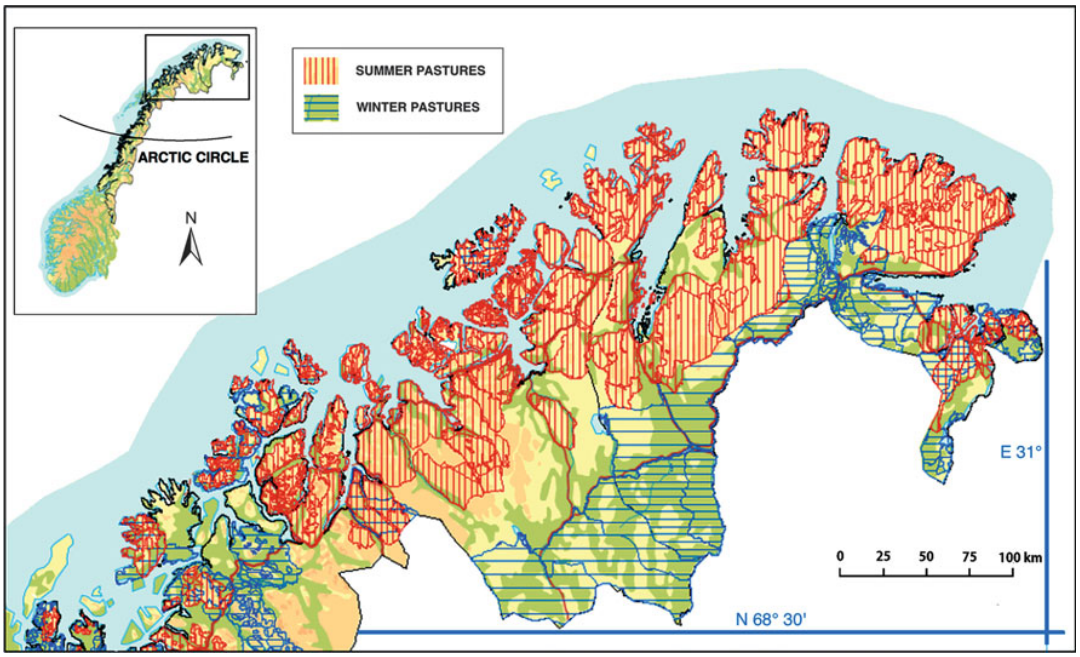

Fig. 1. Finnmark with summer (red) and winter (blue) pastures

Debates in the Norwegian Parliament have on a number of occasions linked reindeer herding conflicts to the claim that excessive reindeer numbers are causing overgrazing and desertification in Finnmark (Benjaminsen & Svarstad 2010). There seems to be a cross-party consensus that regards the size of the reindeer population as the principal driver of a series of problems, including ecological deterioration, land-use conflicts, and economic inefficiency, leading to declining carcass weights and animal welfare issues. This consensus, in turn, articulates a dominant narrative shared by politicians, the Ministry of Agriculture and Food and the Ministry of Climate and Environment, environmental NGOs, most scientists (particularly biologists), and the press (Reinert 2006; Benjaminsen & Svarstad 2010). This narrative supports policies that have been in place for decades and that focus on reducing reindeer numbers as the principal measure to achieve sustainability in the industry. In public and policy debates, politicians and government officials often reference ecological research that supports the idea of overstocking (e.g. Orvik & Prestbakmo 1990; Johansen & Karlsen 1998; Ims et al. 2007; Tveraa et al. 2007). This research serves to justify the general policy of destocking and of increasing the carcass weight of individual animals. Other researchers have suggested that the relationship between reindeer numbers and vegetation change is more complex than the overstocking narrative suggests (Bjørklund 1990; Paine 1992; 2004; Tyler 1998; Behnke 2000, Joks et al. 2006; Reinert 2006), but apparently without achieving much effect on policy.

The inspiration for our study is taken from the critical political ecology literature on people, land, and landscapes in Africa, a body of work that combines investigations of environmental processes with a focus on the environmental claims produced by influential actors, such as policymakers and scientists. Our argument is based on an examination of the evidence for claims of overstocking, based on interviews, literature analysis, and participant observation conducted within the ambit of a multi-institutional research collaboration on economics and land-use conflicts in Norwegian reindeer pastoralism; one of the authors (Mikkel Nils Sara) is also a Sámi reindeer pastoralist, with several decades of field experience.

Within the political ecology scholarship in Africa, we draw particularly on studies of African pastoralism (e.g. Turner 1993; Bassett & Koli Bi 2000; Benjaminsen et al. 2006; 2009). While researchers and policymakers have been 'misreading African landscapes' (Fairhead & Leach 1996), we ask whether there is ground for a parallel shift in thinking about the Arctic. Hence, in this article we set out to assess critically the overstocking narrative on Sámi reindeer herding in Norway in terms of its scientific evidence and policy outcomes. First, we present the historical background to the emergence of a narrative of ecological crisis caused by excessive reindeer numbers. Second, we discuss the theoretical models of ecological equilibrium and non-equilibrium in relation to pasture management. Third, we present and discuss aspects of the science that supports the narrative of overstocking relating to reindeer herding in Norway. Fourth, as an alternative to this dominant narrative, we present an indigenous perspective on the Arctic pastoral landscape, which we argue is largely compatible with the non-equilibrium model in ecosystems thinking. However, the relevance of such alternative views is made invisible in most Norwegian research on reindeer herding as well as in public debates and policy formulation.

History of a perceived ecological crisis

The idea that Sámi reindeer herders keep too many animals is not new. Since the end of the 19th century, the state has

periodically aimed at reducing the reindeer population. Initially, this was justified principally by the need to minimise land-use conflicts between pastoralists and sedentary farmers. For example, the *'Tillægslappeloven'* ('Supplementary Lapp Law') of 1897 contained sections on the reduction of reindeer numbers according to need, and the Reindeer Herding Act of 1933 (Lov om reindrift av 1933) introduced compulsory reindeer counts and reductions when the numbers were defined as too high. The aim of such reductions was to alleviate conflicts between agriculture and reindeer herding (Strøm Bull et al. 2001, 236–238).

More recently, the size of the reindeer population has been reformulated as a primarily environmental problem, a matter of overstocking and the ecological impact of excessive reindeer populations. This is a fairly novel concern: as late as the 1960s a key textbook on reindeer management did not discuss 'excessive' reindeer as an environmental problem (Skjenneberg 1965), but with the increased focus on environmental issues in the 1970s and 1980s terms such as 'overgrazing' (*overbeiting*) moved to the fore in Scandinavian research on reindeer management (Pape & Löffler 2012). Along with this increased attention, the matter of excessive reindeer was also progressively configured as a technical problem, to be 'solved' through managerial interventions (Reinert 2012). The shift coincided with increased media coverage of the problem: a keyword search in the Norwegian newspaper database Retriever for the term *reindrift* (reindeer husbandry), from 1980 to the present, revealed a large number of media articles with headlines such as 'Reindeer management threatens nature in Finnmark' and 'Resource crisis looms'.[2] Media horror stories were especially numerous in the late 1990s, coinciding with several bad winters for reindeer pastoralists. Unusually high amounts of snow and thick ice layers caused the loss of many animals in the spring migration during that period. Despite the increased mortality being caused by unusual ice and snow conditions preventing access to pastures rather than due to any scarcity in the underlying vegetation, the story about overstocking and desertification of the Finnmark plateau gained a momentum and it has since been retained, as is evident in the periodic recurrence of horror-story 'booms'.

Today, 'overstocking' is probably the dominant narrative about reindeer pastoralism in Norway, shared by Norwegian media, by all the political parties represented in Parliament (Storting), and by leading environmental organisations, as well as by large segments of the public. For example, when summing up a parliamentary debate on reindeer management on 18 June 1998, Ivar Kristiansen from the Conservative Party (Høyre) said:

> The concept of 'overgrazing' has been mentioned by all members participating in this debate. This overgrazing continues even after the [reindeer] industry for a long time has been governed [by the state], down to the details. In spite of such detailed management, a balance between reindeer numbers and pastures has not been achieved. (Benjaminsen & Svarstad 2010, 158–159)

Many politicians express frustration at this apparent lack of results, despite decades of concerted state efforts to reduce the reindeer population. Parliamentary debates echo the refrain that reindeer owners 'do not understand' the seriousness of the situation. In June 2000, the Norwegian Parliament asked the government to establish a maximum number of reindeer for each reindeer grazing district. In December of the same year, the then Ministry of Agriculture (Landbruksdepartementet) – which in 2004 became the Ministry of Agriculture and Food (Landbruks- og matdepartementet, (LMD) – followed this up with a request to the head office of the Norwegian Reindeer Husbandry Administration (Statens reindriftsforvaltning) in Alta to define the framework and method for fixing the maximum reindeer numbers for each district.

Anders Ims and Ansgar Kosmo, both of whom worked for the Alta office of the Reindeer Husbandry Administration, were assigned the task of identifying 'the biological number of reindeer that assures a long-term sustainable reindeer industry' (Ims & Kosmo 2001, 1). The main focus of their report is the West Finnmark reindeer pasture area (*reinbeiteområde*), as this area was and still is considered the most problematic in terms of reindeer numbers. To establish maximum numbers, Ims & Kosmo chose a multistage method. At the pasture area level (i.e. for the whole of West Finnmark) the maximum reindeer population was established using the estimated productivity of the lichen cover on the shared winter pastures. However, the maximum population of reindeer at the level of individual reindeer grazing districts was determined by calculating the carrying capacity of the respective summer pastures for each of these districts. The estimated capacity of the summer pastures was then adjusted to fit the total carrying capacity for the lichen layers on the winter pastures. Ims & Kosmo originally set this carrying capacity at 66,200 reindeer, but the figure was later reduced to 64,300, by the Reindeer Husbandry Board at its meeting on 30 January 2002. Curiously, the number corresponds to the actual number of reindeer in 2001 in West Finnmark. In this way, the Reindeer Husbandry Board adjusted the result of a process that was initially seen as 'scientific'.

Summer pastures in the West Finnmark pasture area are divided geographically into separate reindeer grazing districts, each of which is held exclusively by the herders of that district; their carrying capacity could therefore be established at the district level. However, the winter pastures are defined as 'common pastures' and use is shared between several districts, generally on the basis of informal agreements that are hard to enforce. The matter is further complicated by the fact that feed on the winter pastures is generally scarcer and more precarious than on the summer pastures: the winter grazing grounds are capable of supporting fewer animals, and therefore function in most years as a constraint or bottleneck within the reindeer migration system.

On the summer pastures, the maximum population (or carrying capacity) was set using an indirect method based on regression analysis of the relationship between the carcass weight of *varit* (bulls aged c.18 months) and the density of reindeer per km^2. Ims & Kosmo (2001) argue that 70% of the variation in carcass weight could be explained by density alone,[3] and that carcass weight could therefore be used as an indicator for the condition and capacity of the pastures. Previously, LMD had assessed the sustainability of reindeer populations based on studies that monitored pasture condition. However, from 1996 the carcass weight method increasingly replaced pasture monitoring, as it was perceived as more objective, capable of delivering clear boundary values, and therefore also easier to implement (Joks et al. 2006).

Adoption of the new method led to new research funding from LMD to biologists at the Norwegian Institute of Nature Research's (NINA) department in Tromsø (NINA Tromsø) and at the University of Tromsø, which in turn led to a number of publications confirming the close relationship between density and carcass weight (e.g. Fauchald et al. 2004; Tveraa et al. 2007). Based on the results of this research, the LMD established a 'criteria committee' in 2008 that would use carcass weights to establish carrying capacities for individual reindeer herding districts. The main output of the committee's work was the definition of norms for average carcass weights: 17–19 kg for calves born the same year, 25–27 kg for *varit*, and 27–29 kg for cows older than two years (LMD 2008). In addition, the calving percentage should not vary more than 10-15% between the years and each animal in a 'spring herd' (before calving) should produce at least 8–9 kg of meat per year. Values under these norms would indicate that the number of reindeer is too high in individual districts. Applying these norms throughout West Finnmark gives a total carrying capacity of c.78,000 reindeer.

However, the early 2000s were a period of excellent pastures and relatively high carcass weights. Weights for calves had hardly seen higher levels since registration of such weights began in the early 1980s (Reindriftsforvaltningen 2012). Good pastures led to a rapid increase in the number of animals and by the spring of 2005 the reindeer population in West Finnmark had increased to 91,000 (Reindriftsforvaltningen 2012).

The population issue was raised in a parliamentary debate on 14 June 2005 and several members of parliament argued that the idea of voluntary reduction as implemented did not seem to be working. In 2004 and again in 2012 the Office of the Auditor General of Norway (Riksrevisjonen) published reports on the state of reindeer herding in Finnmark, and the core message in both reports was that the carrying capacity had been exceeded and that the number of reindeer had to be reduced (Riksrevisjonen 2004; 2012). In its coverage of the 2004 report, headlined 'Reindeer herding eats up the tundra', the broadsheet *Aftenposten* stated: 'Finnmark is being destroyed by intense grazing. The cause is insufficient pasture capacity' (*Aftenposten* 2004). In 2012, the report from the Office of the Auditor General similarly stated that 'the aim of ecologically sustainable reindeer pastoralism has still not been realised. Large parts of Finnmark are overgrazed, as a consequence of an excessively high reindeer population' (Riksrevisjonen 2012, 9). Following sub-committee discussion of the report in January 2013, a Labour Party (Arbeiderpartiet (AP)) representative stated that government must now implement coercive measures to reduce the reindeer population. The Conservative Party followed up by stating that a united Parliament supported the demand from the Minister of Agriculture and Food that reindeer herders reduce the number of reindeer, 'because the authorities are charged, in the first instance, with preserving the pasture areas, but also with ensuring that reindeer herders have the means to survive in the future' (NRK Sapmi 2013). Thus, there is a cross-party agreement concerning the need to reduce the reindeer population in Finnmark, based largely on the idea that the tundra is overgrazed.

Equilibrium and non-equilibrium

Over the last few decades, critical researchers, including some with a background in reindeer herding, have contributed significantly towards a richer understanding of the Arctic pastoral landscape (e.g. Bjørklund 1990; Paine 1994; 2004; Sara 2001). For example, Paine (2004) has sharply criticised the exclusive focus on carrying capacity, which he argued was 'carved in stone' and did not take into account the complex instability of the Arctic ecology. Along similar lines, Bjørklund (1990) questioned the use of concepts such as 'carrying capacity' in the context of Sámi pastoralism. For biologists, carrying capacity defines a relationship between pastures and an animal population with an inherent drive to expand beyond its available resources. However, a reindeer herder will adjust the relationship between herd and pasture throughout the year, in continuous response to shifts in the climatic, environmental and biological circumstances of their herd, and in relation to a complex range of objectives, only some of which are linked directly to economic gain (e.g. Oskal 2000; Bostedt 2005; Reinert 2008).

In general terms, the concept of carrying capacity is based on the assumption that plants and animals are or may come to be in a state of balance or equilibrium. Two different notions of carrying capacity can be identified (Behnke et al. 1993). In an equilibrium model, growth G as a function of stock size N is habitually depicted in terms of an inverse U-shaped curve. *Ecological* carrying capacity (point *k* in Fig. 2) is reached 'when the production of forage equals the rate of its consumption by animals, and the livestock population ceases to grow because limited feed supplies produce death rates equal to birth rates' (Behnke et al. 1993, 4). By contrast, *economic* carrying capacity identifies the optimal ratio between livestock units and pastoral resources for achieving particular management objectives, such as maximum production of meat (point N_{MSY} in Fig. 2) or efficient stock size (point N_{OPT} in Fig. 2, assuming dG/dN equals the market interest rate, an absence of price differentiation, and costs that are insensitive to stock size).

Within bureaucracies responsible for governing pastoral activities, the population that results in maximum sustainable yield (N_{MSY}) is often equated either implicitly or explicitly with carrying capacity. However, insofar as the term 'carrying capacity' is

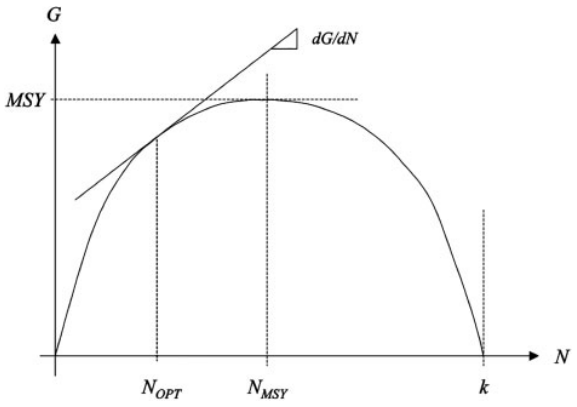

Fig. 2. Economic and ecological equilibria

supposed to indicate threshold values for sustainable management, economic definitions are misleading. Conversely, a population greater than necessary to satisfy any given economic objective does not automatically lead to overgrazing in any *ecologically* meaningful sense.

Both ecological and economic carrying capacity depend on the assumption of a stable and predictable environment, with reliable conditions that make it possible to project future rates of plant growth, succession, and availability. In such an environment (i.e. in an equilibrium system) an appropriate stocking rate will balance grazing pressure against vegetation succession to achieve the desired state of affairs, such as maximum meat production or economic efficiency.

By contrast, in a *non-equilibrium* system vegetation composition and cover will be determined largely by external factors, such as climate, rather than by grazing pressure. Within such systems, herbivore populations do not fluctuate around any stable, numerical equilibrium size, but instead fluctuate randomly between upper and lower bounds or without any form of regulation at all ('random walk'). Competition for forage at any given time is a feature of non-equilibrium systems too, but in such systems the feedback link between population size and future forage availability is either absent or present only under exceptional circumstances, such as in the case of many 'good' years in succession (Rohde 2005). It is therefore necessary to separate between *spatial* density-dependence (competition between animals for limited resources within a given area at any given time) which is ubiquitous, and *dynamic* or temporal density-dependence, which is primarily a characteristic of equilibrium systems. It is a mistake to construe spatial density dependence – an inverse relationship between animal numbers and weights at a given time – as a symptom of equilibrium ecology, as has been done for Finnmark (e.g. Holand 2003, 122).

Within non-equilibrium systems, where herbivore populations fluctuate randomly according to external influences, the concepts of carrying capacity and overgrazing have no discernible meaning (Ellis & Swift 1988). The objective of establishing a stable herbivore population with a stable outtake is not only questionable, but essentially unattainable: a futile attempt to translate lessons and practices from husbandry in controlled environments to herding in uncontrollable environments (Reinert 2006).

Although debates around equilibrium and non-equilibrium ecology tend to be polarised, the two perspectives may more usefully be seen as the extremes that define a continuum. Berryman (1987) has noted that the applicability of the different models depends on the temporal and biological scales under scrutiny. When the ecological system in question is large and the time period is short, one is more likely to observe equilibrium features. Some systems may more generally be characterised by short and unpredictable equilibria that are succeeded by stochastic transitions and system changes in the longer run. The relevance of non-equilibrium ecology to semi-arid African pastures is now generally accepted. However, the dynamics of climate, forage, and herbivore survival in Finnmark differ in important ways from those associated with semi-arid landscapes in the tropics or subtropics. In bad years, which generally equate to dry years, pasture in the semi-arid South tends to be constrained by the absence of forage. By contrast, bad years in Finnmark are generally denoted by conditions related to deep snow and thick ice, which preserve forage yet make it inaccessible to herbivores. Within a non-equilibrium perspective, this implies that the cycles of forage and herbivore survival are even more complex in the Arctic than in the semi-arid South. In the dry tropics, vegetation responds spontaneously to rainfall: the more rain, the more grass is available for livestock. In the Arctic, a cover of snow and ice may block access to pastures in the critical winter and spring seasons. Therefore, in the Arctic, in addition to precipitation and temperature impacting directly on vegetation as in the tropics, these two climatic factors as well as variations in temperature also affect the availability of pastures for reindeer.

The science of overstocking

In empirical terms, the reindeer overstocking narrative in Norway is based primarily on time-series of satellite images of the lichen layers in Finnmark (Johansen & Karlsen 1998; 2005). These time-series show a reduction in the area covered by lichen in the 1980s and 1990s. In their analysis of reindeer pastures, Johansen & Karlsen (2005) used satellite images from 1973, 1980, 1987, 1996, and 2000, and found that the lichen covered one-third of the area in 1973 and 1980 but, following a steady decrease, only 6% in 2000. During the same period, other vegetation types increased. The reduction in the quantity of lichen coincided with an increase in the reindeer population from the 1970s to c.1990. Even though reindeer numbers fell again in the 1990s, the scientific consensus still seems to be that increased reindeer numbers are the principal cause of the observed reduction in lichen (e.g. Riseth et al. 2004; Johansen & Karlsen 2005; Hausner et al. 2011). While, we do not question that there was a reduction in lichen on the inland winter, spring, and autumn pastures during the 1980s and 1990s, there are a number of uncertainties in these findings, and these uncertainties are generally undercommunicated.

Satellite image analysis is an imprecise and approximative method for vegetation surveillance, which needs to be supplemented by ground truthing to achieve a more nuanced representation of change processes. Satellite imagery has limited resolution, and this problem becomes clear when large-scale tracts of the Finnmark inlands are homogenised and designated with categories such as 'intact' and 'overgrazed', as shown in Fig. 3.

Reindeer herders and their reindeer orient themselves within a vast, complex and heterogeneous landscape, with significant local and seasonal variations in vegetation types and usage patterns (e.g. Sara 2001). From the perspective of a herder who possesses detailed experiential knowledge of the landscape and vegetation that his or her reindeer inhabit and depend upon at different times of the year, in shifting seasons and with highly variable environmental conditions, the maps shown in Fig. 3 are likely to appear absurd: the enormous complexities of the pastoral landscape are reduced to a rough colour map, with a large section labelled 'overgrazed' and a small part labelled 'intact'. Would the notion of 'intact' invoke an 'original' landscape from the 1970s that would have remained exactly the same without reindeer pastoralism? The maps in Fig. 3 seem to reflect a view of nature as static and in equilibrium if left undisturbed by people and livestock. The lack of granularity

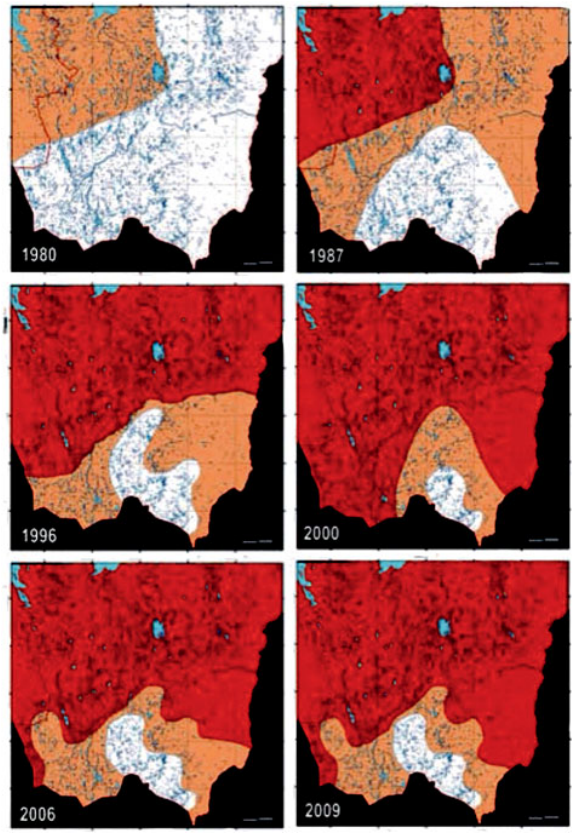

Fig. 3. Overgrazing on the winter pastures in Finnmark (modified from Riksrevisjonen 2012, 51, and reproducing Johansen & Karlsen's time series (Johansen & Karlsen 2005)); red = overgrazed, orange = moderately grazed; white = intact

also contrasts rather sharply with the more sophisticated models of reindeer land-use in use across the border in Sweden, developed using a combination of telemetry, satellite imaging, traditional knowledge, and participatory field methods (e.g. Sandström et al. 2003; Mårell & Edenius 2006; Sandström & Sandström 2008).

When Johansen & Karlsen (2005) represented the pastoral landscape in this manner on the original maps reproduced in Fig. 3, they had already simplified its complexity considerably, although the supplementary maps provided in their article still show a degree of granularity, but from that representation to the brutal decontextualised simplicity of the maps (Fig. 3) reproduced in the Office of the Auditor General of Norway's report (Riksrevisjonen 2012), the erasure of nuance has been almost complete. With their limited informational content, maps such as those in Fig. 3 illustrate the gap or tension between the knowledge of pastoralists and the extreme simplifications that underpin the overgrazing narrative. However, as pedagogical and political instruments such maps are powerful: it is not unexpected that the Office of the Auditor General of Norway should dedicate a full page of its report to such a map series, although it does beg the question why.

There is considerable uncertainty associated with not only quantification of the lichen cover but also discussions about the causes of change. Generally speaking, high grazing pressure is assumed to be the principal or only cause of the transition from lichen to other forms of vegetation observed on the tundra in the 1980s and 1990s. Reindeer pastoralism is seen to cause widespread vegetation changes on the tundra, including the encroachment of birch. For example, Tømmervik et al. (2009) found a doubling of birch on the tundra between 1957 and 2006, but report climate change with wetter summers as only one possible additional driver for these changes, while overgrazing is seen as the main cause.

Elsewhere in Norway, bush encroachment in mountain areas is treated as a consequence of an *absence* of grazing, possibly along with climate change towards warmer summers and therefore more favourable growth conditions (e.g. Bryn 2008). Hence, climate change may also play a role in the replacement of lichen with birch in parts of the winter pastures in Finnmark. However, this possible causation is largely absent from presentations of overgrazing as, for example, represented in Fig. 3.

Some researchers present high reindeer numbers as not only having a negative effect on vegetation, but also in terms of potential ecological cascade effects that may impact on the whole ecosystem. Ims et al. (2007) examined the consequences of high reindeer numbers for ptarmigan, small rodents, and hare. They found negative effects on ptarmigan populations, while large reindeer populations correlated positively with, for example, lemming. Large reindeer populations depress the density of willow on the summer pastures, thus affecting the ptarmigan population as it depends on willow. In the light of this finding, Professor Rolf Anker Ims argues that 'many reindeer give few ptarmigans' (e.g. interview in *Altaposten* 2010). However, he does not discuss the question of why the ptarmigan population in Norway as a whole is dropping, and not just in areas with reindeer herding.

When it comes to questions about bush encroachment and the ecological interplay between climate change and factors such as reindeer herding, the level of uncertainty is generally high. This uncertainty is not reflected in public debates on reindeer herding, and scientists should take much of the blame for this as they are generally far more careful in their scientific publications than they are in their statements in the media.

Both the Ministry of Agriculture and Food and the Ministry of Climate and Environment have commissioned NINA to monitor the winter pastures in West Finnmark. The monitoring has been done using a combination of satellite image analysis and field studies, and to date three analyses have been performed: in 1998, 2005, and 2010. Researchers have placed a total of 52 measuring points, evenly spaced along 5 north–south transects. At every point, cages have been placed to protect vegetation against grazing, and the vegetation has been measured both within and outside the cages. By comparing different years, a time series is established that can provide information about the development of vegetation over time.

The results of NINA's first comparative analysis (1998–2005) were published in 2006 (Gaare et al. 2006). The report shows that lichen cover had a marked increase from 1998 to 2005, from an average of 18.3% to 27.6%. Additionally, the thickness of the lichen layers had increased from an average of 22 mm to 28 mm during the same period. Gaare et al. (2006, 4)

concluded: 'the changes are unevenly distributed between fields and [reindeer grazing] districts, but recur in most of the fields. This shows a generally good development of lichen in Finnmark.' They also established that there had been a considerable increase in heather, dwarf birch, and grass-like plants during the studied period:

> There is now more heather and grass along the routes that were most worn down in 1998. The impression from 1998 concerning "heavily grazed" areas in most of Finnmark is about to change … [and] today climate factors appear to be determinant for the continued development of the balance between reindeer and the pasture basis. (Gaare et al. 2006, 5)

It is interesting to note that the positive increase in the lichen pastures and other pasture vegetation in Finnmark occurred at the same time as the reindeer population of West Finnmark increased in the period 2001–2004 (Fig. 4). This observation, which contradicts most earlier research on the subject, has not been picked up by the LMD or the Ministry of Climate and Environment. It has also been neglected by politicians in Parliament. NINA's scientists themselves have also downplayed the novelty and surprise factor of the results. Rather, in a debate in the national newspaper *Dagbladet* from 2011, Benjaminsen et al. (2011a; 2011b) point out that the lichen coverage had increased between 1998 and 2005, and that the Reindeer Husbandry Administration showed that in the same period the reindeer numbers had increased from 75,906 to 89,030 in West Finnmark, and from 127,990 to 170,156 in Finnmark as a whole. However, scientists from NINA and Norut denied that the reindeer population had increased: 'In the period 1998–2006 the reindeer population was reduced, and in the same period there was a moderate increase in the lichen coverage, something which correlates strongly with the reindeer number reduction at the turn of the millennium' (Tømmervik et al. 2011a). This clearly contradicts official reindeer numbers, as depicted in Fig. 4.

Although the reindeer population in West Finnmark dropped from 1998 to 2001, it subsequently increased until 2004 and then showed only a small decrease to 2005 (Fig. 4). This gave a clear increase in the reindeer population in the whole period 1998–2005. In the same period, there was an increase in the lichen coverage. It is also worth noting that when Tømmervik et al. discussed the matter in Norwegian media, they observed 'a moderate increase in the lichen coverage' (Tømmervik et al. 2011a), yet in in a scientific article published the following year some of the same authors described the lichen coverage as undergoing a 'significant and rapid increase' in the relevant period (Tømmervik et al. 2012). Although in the past lichen growth was thought to be slow, recent research demonstrates that it can be quite rapid (Bidussi 2014).

NINA's second comparative analysis based on the monitoring of pastures was published in 2011 (Tømmervik et al. 2011b). This report expands the time series until 2010 and concludes that during the period 2005–2010 there had been a general decline in lichen coverage from 27.1% to 24.5% and a change in average thickness of the lichen layer from 29 mm to 23 mm. This happened during a period of continued increase in reindeer numbers. Nonetheless, there was a considerable increase in both extension and thickness between the years 1998 and 2010. That there should be less lichen with more reindeer is not in itself remarkable, even though the relationship between reindeer and lichen is probably not linear and climate variation probably plays a role (Gaare et al. 2006). Grazing inevitably affects vegetation with regard to both species composition and distribution, but even with the high reindeer numbers in 2010 (i.e. c.100,000) there was no 'ecological crisis' on the tundra.

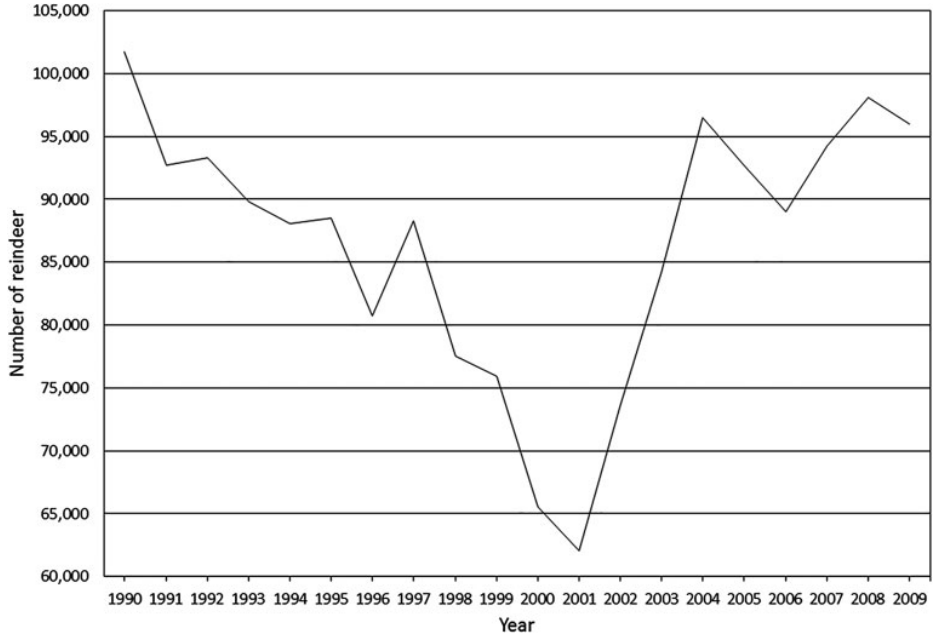

Fig. 4. Fluctuations in the number of reindeer in West Finnmark, 1990–2009

For comparison, in Sweden there was for a long time a strong discourse on 'overgrazing' caused by reindeer pastoralism. Moen & Danell (2003) took this as a starting point for their review of existing pasture studies to determine whether this discourse had a scientific basis. They found no indication of large-scale vegetation degradation or erosion by reindeer husbandry in the Swedish mountains, and concluded that 'the environmental goal of "decreasing continuous overgrazing and damage from reindeer over large areas" may not be a valid goal' (Moen & Danell 2003, 401). However, they specify that it is difficult to assess in general terms whether pastoralism is sustainable, as there is not enough information available from research. Despite this lack of information, there were very strong views on the subject among Swedish politicians and more generally in the public discourse. Today, the situation appears to have calmed down and there is a far more relaxed debate on the ecological effects of reindeer pastoralism in Sweden than there is in Norway.

An alternative view of the Arctic pastoral landscape

Compared to the narratives and analyses advanced by actors at the science–policy nexus, many reindeer pastoralists express a completely different understanding of Arctic pastoral landscape dynamics. In our experience, bureaucrats and politicians alike tend to treat this divergence as a problem of misinformation or ignorance on the part of the herders rather than of competing knowledge claims.

Herders often argue that it is first and foremost climatic and environmental factors that determine the survival and condition of their reindeer, and in this respect the concept of *jahkodat* is central (Sara 2001). Briefly stated, this northern Sámi term captures the distinctiveness of any given year, not as a mutually interchangeable unit of time, but as a particular and unique succession of specific conditions, with variable and cumulative effects. To a herder, every year will to a greater or lesser extent differ in significant ways from other years: winter may come late or early, and it may be mild or harsh, or both; spring pastures may mature as early as early April or as late as late May. On the summer pastures, important factors that vary from year to year include the maturation date of different vegetation types, the duration and extent of insect pressure and heat, as well as the influence of weather conditions on pasture vegetation and on the reindeer themselves. As the summer pastures tend to be relatively abundant and easy to manage, the specific conditions in winter are usually more decisive for reindeer survival, although factors relating to the summer pastures will determine the condition in which reindeer enter the winter season. For example, cold precipitation combined with strong winds during seasonal fur changes will adversely affect the condition of reindeer later in the autumn. Traditional knowledge and experience indicate that by contrast, during winter the combined effect of precipitation and temperature is the key factor governing access to pastures, and not, as the dominant narrative of the science–policy nexus would have it, the size of the reindeer population (Sara 2001; Marin 2003; Joks et al. 2006).

The technical language of herding includes a wide range of concepts and terms that refer to the well-being of reindeer and the condition of pastures through the year. A comprehensive review of this terminology is beyond the scope of this article (for examples of analyses by indigenous scholars, see Magga 2006; Eira 2012; Eira et al. 2013), but some examples, particularly of issues that emerge in the translation between Sámi and Norwegian, are worth mentioning. For example, the concept of *guohtun* has two meanings: the grazing activities of the reindeer; and the access to pasture under the snow (Eira et al. 2010; Eira 2012). This makes it problematic to translate *guohtun* simply as 'pasture' (Norwegian: *beite*), as the Reindeer Husbandry Administration tends to do. In the Sámi translation of the Reindeer Husbandry Act of 2007 (Lov om reindrift av 2007, also known as Reindriftsloven), the two terms – *guohtun* and *beite* – are also treated as synonyms. In most cases, herders' use of *guohtun* refers to the availability of plants for grazing, that is, the structure and quantity of the snow cover that determines access to the plants buried under it. The manner in which the snow falls and how it is transformed by wind and weather is of decisive importance for access. Mild weather and wet snow followed by sharp cold will produce a hard layer of snow or, in the worst case ice, either directly on the ground or as one or more layers further up in the snow cover. Pastures become 'locked' and the reindeer starve, regardless of how much lichen or grazing may lie under the snow. In the most extreme cases, it will not be possible to access any food below the snow, and the only available nutrition will be lichen growing on trees. Such winters are rare, and more often only some part of the pastures are 'locked' in this way. Reindeer herders may grade and describe such conditions using expressions such as *rudneguohtun*, referring to access through holes in the snow, *báikkuid guohtun* (access in certain locations), and *bieđggus guohtun* (dispersed access).

Strong mild winds may draw humidity from the snow or 'dry' it, but at the same time also convert and shift the snow, determining accessibility to the vegetation it covers. Optimal winter conditions occur sometimes, but as a rule the grazing pattern and condition of the reindeer will vary from year to year according to climatic variations. The concept of *ealát* is better suited to describe grazing conditions, but this term is not a synonym for 'pasture' either; rather *ealát* derives from the word *eallit* ('to live') and is defined as 'something to live off, particularly for reindeer' (Nielsen 1979, 861). Normally, *ealát* is not mentioned in connection with pasture conditions during the summer, but only during the autumn, spring, and winter. With summer, attention shifts from managing snow, as a limiting factor for survival, to ensuring peaceful conditions and rest for the reindeer, with the summer weather and available nutrition as factors that determine the condition of reindeer in the autumn, when the snow returns, and which, as *jahkodat* thinking suggests, will not be identical to the last autumn. Pastures may also be described using terms such as *varas eana* (fresh pastures, not grazed this year), *čilvi* (areas that have already been significantly grazed this year), *doldi* or *smurvi* (areas that have been thoroughly grazed, with no plants left to graze), *guorba eana* (pastures, particularly lichen pastures, that have been worn out over long periods of time, or where the quality of the soil

limits the grazing), and *duolmmus eana* (pastures that have been worn down by trampling rather than grazing).

Attempts have been made to codify and analyse traditional ecological knowledge in Norwegian reindeer pastoralism (e.g. Oskal et al. 2009; Sara 2009; Eira et al. 2013), including analyses of its social and epistemological dimensions (e.g. Lasko 1993; Joks 2000). It is beyond the scope of this article to recapitulate this work, but even from this brief overview it should be clear that knowledge of Sámi concepts for reindeer husbandry and pastures, as well as the experiential knowledge that these concepts reflect, should be an essential basis for assessing the development and sustainability of Sámi pastoralism. This knowledge gives a completely different image of reindeer herding in Finnmark than the one presented by most scientific research, by politicians and the administrative bureaucracy, and most certainly by the media. However, in practice this knowledge remains largely invisible.

Concluding remarks

This study has extended a political ecology of landscape reading and misreading to pastoral landscapes in the Arctic. Analogous with the 'misreading of African landscapes' (Fairhead & Leach 1996), the dominant narratives are predicated on simplified histories of the landscape that portray resource users as villains, are convenient to powerful actors, and are at best inaccurate.

Despite questionable scientific evidence, the science–policy nexus has established that there are too many reindeer compared to available pastures in Finnmark. Carrying capacities for reindeer populations have been set using a method combining analysis of satellite images of the lichen cover on the winter pastures with studies of the relationship between reindeer density and carcass mass on the summer pastures. Neither of these techniques takes into account the indigenous expertise of the herders themselves, in interpreting their own landscapes and herds, or their understanding of the complex ecological requirements and patterns of pastoralism in an Arctic environment. Alternative scientific explanations based on non-equilibrium models, which in our view are compatible with indigenous understandings of the landscape, have also largely been made invisible in the dominant narrative advanced by the science–policy nexus. Such alternative perspectives remain marginalised by the government institutions that regulate the practice of reindeer management.

The body of science that has so far focused on reindeer pastoralism in Arctic environments represents a mixed bag, both in terms of disciplinary emphasis and findings. Parts of this body have undoubtedly contributed to perpetuating the confusion that surrounds key concepts such as carrying capacity and overgrazing. At the same time, there does seem to be an increasing awareness among natural scientists of the relevance of climatic factors specifically and non-equilibrium aspects more generally. However, such awareness has yet to penetrate the political discourses and the bureaucratic institutions responsible for making the decisions that ultimately dictate the terms on which reindeer herders make their living.

In terms of *jahkodat* thinking, a reindeer population becomes 'excessive' contextually, relative to the specific conditions in a given year. As those conditions are highly variable, they are unlikely to recur from one year to another. The validity of an equilibrium approach for modelling a landscape that functions in this way is at best questionable; policies based on equilibrium assumptions – that is to say, policies premised on the goal of achieving a stable population with a predictable meat output – may be fundamentally misguided.

There is a further dimension to consider. Bjørklund & Brantenberg (1986) were the first to highlight the contrast between an administrative understanding of Sámi pastoralism and the manner in which reindeer herders themselves understand their livelihood. Historically, reindeer herding in Norway has usually been conceptualised as a form of agriculture, albeit a rather unusual one. This tendency has been particularly evident since the late 1970s, when reindeer pastoralism in Norway was formally brought into the agricultural governance system under the terms of the Reindeer Husbandry Act of 1978 (replaced by the new Reindeer Husbandry Act of 2007) and the first Reindeer Herding Agreement (Reindriftsavtalen).

Understood in the overarching terms of agricultural production, pastoralism becomes reoriented primarily towards meat production, and the more effective this production, the better. A key problem here is the assumption, more or less universal across the Norwegian administrative apparatus, that maximising production (or profit) should be the primary objective of pastoralism. Although economic gain is clearly *an* objective for pastoralists, it is often only one among many. Reindeer herding is a complex, highly social mode of life, and the objectives of pastoralists are complex: they may range from securing a particular pattern of pelt for making shoes, through ensuring enough reindeer for the next generation of herders, to expressing ethical and aesthetic ideals concerning the 'good life' (e.g. Paine 1994; Oskal 2000; Reinert 2008; 2014). In managing their herds, pastoralists take into account a range of factors beyond maximisation of meat or profit, many of which tend to become invisible in the perspective of the herding administration. As Bjørklund & Brantenberg (1986, 78) put it, a herder:

> must try to coordinate the behaviour of the reindeer with their own everyday requirements and the requirements of their families. This requires extensive knowledge, and this insight is achieved in part by gaining access to the older generation's knowledge concerning the relationship between humans, animals and terrain, partly through one's own experiences. It is this knowledge that makes it possible to coordinate animal and human behaviour over the course of the annual cycle, and which makes possible the extensive migration of over 100,000 reindeer every spring and autumn between the inland and the coast.

In other words, the administrative 'misreading' here occurs simultaneously across a number of levels: the brutal simplification of a complex and heterogeneous landscape goes hand in hand with an equally brutal simplification of the pastoral livelihood itself, a move that reduces the rich, adaptive complexity of pastoralism – as an assemblage of social forms, practices, traditions, and ethical principles – to a sterile, dysfunctional caricature of a meat factory. Bringing forward

the rich complexity of the pastoral landscape may well also require recapturing the complexity of pastoralism itself.

These issues resonate with wider debates, related for example to the long-standing confrontation in ecology between modellers and empiricists, and the various tensions associated with this: the general versus the specific, the deductive versus the inductive (Ball 2009; Kemp 2010). The problematic also echoes theories of the 'developmental state'. In line with Scott (1998), we may see the simplification and standardisation of reindeer landscapes and practices as part of the state's attempt to make society 'legible'. In order to govern an unruly reindeer industry, the state should first establish a problem that is to be solved through policy. This problem must then be purified, putting Ferguson's (1994) 'anti-politics machine' to work: it should be emptied of politics and power relations, and established as soluble only by scientific and technical means. Li (2007) calls these two steps 'problematisation' and 'rendering technical'. In the case of reindeer herding, the problem that policy solves is 'overstocking'; the technical solution involves a focus on carrying capacity in the management of reindeer landscapes.

We suggest that the narrative of overgrazing functions as a type of myth – an enduring 'social fact', whose narrative reality is in large part decoupled from its supposed scientific basis. An explanation for its uptake and persistence should therefore be sought, at least in part, elsewhere: in its compatibility with long-standing government agendas, its alignment with powerful vested interests, and the manner in which it dovetails with popular prejudices articulated and sustained by the media. Its persistence is also a function of the relative invisibility of herder knowledge and interpretations, as well as the incompatibility of these with the scientific assumptions that support the dominant narrative of 'overstocking', particularly the assumptions of an equilibrium model of ecology, which mandates that the reindeer population be stabilised at a 'sustainable' level. In practice, the prevalence of this model and its uncritical advocation in public by scientists, administrators, and politicians functions to make invisible the knowledge and strategies of reindeer herders themselves: adaptive responses, developed over centuries of experimentation, that have enabled them to survive and thrive in hostile, difficult, and unpredictable environments. In an all-too-familiar move, indigenous modalities of expertise are transformed effortlessly into ignorance and irrationality (Hobart 1993), and the landscape that these forms of expertise produce is unceremoniously dismissed.

Notes

1 *Siida* is a customary and flexible management unit including both a community and place-based resources (seasonal pastures and migration routes) (see Sara 2009 for more details).
2 All translations into English have been made by the authors of this article.
3 While Ims & Kosmo (2001) was based on data from the period 1998–2000, a recent MSc thesis replicated their study, but increased the sample to the period 1980–2012 (Borgenvik 2014). Borgenvik found that only 22% of carcass weights of *varit* and 15% of the weights of calves born the same year could be explained by densities of reindeer.

Acknowledgments – This article is a result of the *Dávggas* project 'The Economics and Land-Use Conflicts of Sámi Reindeer Herding in Finnmark: Exploring the Alternatives', which is funded by the Research Council of Norway. We are grateful to all participants in this project for exciting discussions that fed into this manuscript. We also appreciate the comments received from participants at the workshop in Trondheim in December 2013 organised by the Norwegian Network on Political Ecology. Finally, we thank two anonymous reviewers for their thorough and constructive engagement with the argument.

Manuscript submitted 4 February 2014; accepted 25 August 2014
Editors: Paul Robbins, Michael Jones, Catriona Turner

References

Aftenposten. 2004. Reindrift eter opp vidda. 14 April.
Altaposten. 2010. Mye rein gir få ryper: Forskere har funnet en klar sammenheng mellom høyt reintall og en rypebestand på bunnivå. 18 March.
Ball, P. 2009. *Nature's Patterns: A Tapestry in Three Parts: Shapes*. Oxford: Oxford University Press.
Bassett, T. & Koli Bi, Z. 2000. Environmental discourses and the Ivorian savanna. *Annals of the Association of American Geographers* 90, 67–95.
Behnke, R.H. 2000. Equilibrium and non-equilibrium models of livestock population dynamics in pastoral Africa: Their relevance to Arctic grazing systems. *Rangifer* 20, 141–152.
Behnke, R.H., Scoones, I. & Kerven, C. (eds.) 1993. *Range Ecology at Disequilibrium: New Models of Natural Variability and Pastoral Adaptation in African Savannas*. London: Overseas Development Institute & International Institute for Environment and Development.
Benjaminsen, T.A. & Svarstad, H. 2010. *Politisk økologi: Miljø, mennesker og makt*. Oslo: Universitetsforlaget.
Benjaminsen, T.A., Rohde, R.F., Sjaastad, E., Wisborg, P. & Lebert, T. 2006. Land reform, range ecology, and carrying capacities in Namaqualand, South Africa. *Annals of the Association of American Geographers* 96, 524–540.
Benjaminsen, T.A., Maganga, F.P. & Abdallah, J.M. 2009. The Kilosa killings: Political ecology of a farmer–herder conflict in Tanzania. *Development and Change* 40, 423–445.
Benjaminsen, T.A., Mathiesen, S.D. & Reinert, E.S. 2011a. Naturstridig reinsdyrpolitikk. *Dagbladet* 18 March 2011.
Benjaminsen, T.A., Reinert, E.S. & Mathiesen, S.D. 2011b. Feil om reinsdyr. *Dagbladet* 12 April 2011.
Benjaminsen, T.A., Eira, I.M.G. & Sara, M.N. (eds.) In press. *Samisk reindrift, norske myter*. Trondheim: Fagbokforlaget.
Berryman, A.A. 1987. Equilibrium or nonequilibrium: Is that the question? *Bulletin of the Ecological Society of America* 68, 500–502.
Bidussi, M. 2014. *Effects of Climate Change on Lichen Growth and Metabolism*. PhD thesis. Ås: Department of Ecology and Natural Resource Management, Norwegian University of Life Sciences.
Bjørklund, I. 1990. Saami reindeer pastoralism as an indigenous resource. *Development and Change* 21, 75–86.
Bjørklund, I. & Brantenberg, T. 1986. Samisk reindrift og norsk forståelse. Høgmo, A. & Erke, R. (eds.) *Identitet og livsutfoldelse*, 74–82. Oslo: Universitetsforlaget.
Borgenvik, J. 2014. '*When You Think Like the State*'*: The Political Ecology of Pastoral Modernization in Finnmark, Norway*. MSc thesis. Ås: Department of International Environment and Development Studies, Norwegian University of Life Sciences.
Bostedt, G. 2005. Pastoralist economic behavior: Empirical results from reindeer herders in northern Sweden. *Journal of Agricultural and Resource Economics* 30, 381–396.
Bryn, A. 2008. Recent forest limit changes in south-east Norway: Effects of climate change or regrowth after abandoned utilisation? *Norsk Geografisk Tidsskrift–Norwegian Journal of Geography* 62, 251–270.
Eilertsen, S.M. 2002. *Utlization of Abandoned Coastal Meadows in Northern Norway by Reindeer*. PhD dissertation. Tromsø: University of Troms.
Ellis, J.E. & Swift, D.M. 1988. Stability of African pastoral ecosystems: Alternate paradigms and implications for development. *Journal of Range Management* 41, 450–459.

Eira, I.M.G. 2012. *Muohttaga jávohis giella: Sámi árbevirolaš máhttu muohttaga birra dálkkádatrievdamis. The Silent Language of Snow: Sámi Traditional Knowledge of Snow in Times of Climate Change*. PhD dissertation. Tromsø: Institutt for språkvitenskap, University of Tromsø.

Eira, I.M.G., Magga, O.H. & Eira, N.I. 2010. Muohtatearpmaid sisdoallu ja geavahus. *Sámi diehtalaš áigečála* 2, 3–24.

Eira, I.M.G., Jaedicke, C., Magga, O.-H., Maynard, N., Vikhamar-Schiler, D. & Mathiesen, S.D. 2013. Traditional Sámi snow terminology and physical snow classification: Two ways of knowing. *Cold Regions Science and Technology* 85, 117–130.

Fairhead, J. & Leach, M. 1996. *Misreading the African Landscape*. Cambridge: Cambridge University Press.

Fauchald, P., Tveraa, T., Yoccoz, N.G. & Ims, R.A. 2004. *En økologisk bærekraftig reindrift*. NINA Fagrapport 76. Trondheim: NINA.

Ferguson, J. 1994. *The Anti-Politics Machine*. University of Minnesota Press, Minneapolis.

Gaare, E., Tømmervik, H., Bjerke, J.W. & Thannheiser, D. 2006. *Overvåking av vinterbeiter i Vest-Finnmark og Karasjok: Ny beskrivelse av fastrutene*. NINA Rapport 204. Trondheim: NINA.

Hausner, V.N., Fauchald, P., Tveraa, T., Pedersen, E., Jernsletten, J.L., Ulvevadet, B., Ims, R.A., Yoccoz, N.G. & Bråthen, K.A. 2011. The ghost of development past. *Ecology and Society* 16, 4. http://www.ecologyandsociety.org/vol16/iss3/art4/main.html (accessed 3 July 2014).

Hobart, M. 1993. *An Anthropological Critique of Development*. London: Routledge.

Holand,Ø. 2003. *Reindrift: Samisk næring i brytning mellom tradisjon og produksjon*. Oslo: Gan.

Ims, A.Aa. & Kosmo, A.J. 2001. *Høyeste reintall for distriktene i Vest-Finnmark*. Consultation document. Alta: Reindriftsforvaltningen.

Ims, R.A., Yoccoz, N.G., Bråthen, K.A., Fauchald, P., Tveraa, T. & Hausner, V. 2007. Can reindeer overabundance cause a trophic cascade? *Ecosystems* 10, 607–622.

Johansen, B. & Karlsen, S.R. 1998. *Endringer i lavdekket på Finnmarksvidda basert på Landsat 5/TM data*. Norut IT Rapport (IT475/1-98). Tromsø: Norut.

Johansen, B. & Karlsen, S.R. 2005. Monitoring vegetation changes on Finnmarksvidda, Northern Norway, using Landsat MSS and Landsat TM/ETM+ satellite images. *Phyocoenologia* 35, 969–984.

Joks, S., 2000. *Tradisjonelle kunnskaper i bevegelse: Om kontinuiteten i reindriftas praksiser*. Cand. Philol. thesis. Tromsø: Institutt for sosialantropologi, University of Tromsø.

Joks, S., Magga, O.H., Mathiesen, S.D. & Henriksen, I.M. 2006. *Reintallet i Vest-Finnmark: Forskningsbasert vurdering av prosessen rundt fastsettelse av høyeste reintall i Vest-Finnmark*. Kautokeino: Samisk Høgskole/Nordisk Samisk Institutt.

Kemp, M. 2010. Blessed rage for order. *Times Literary Supplement* 19 March, 23.

Klein, D.R. 2000. Arctic grazing systems and industrial development: Can we minimize these conflicts? *Polar Research* 19, 91–98.

Lasko, L.-H. (ed.) 1993. *Traditionell samisk kunnskap och forskning*. Kautokeino: Samisk Institutt.

Li, T.M. 2007. *The Will to Improve*. Durhamn NC: Duke University Press.

LMD. 2001. *Verdiskapingsprogrammet for matproduksjon*. Oslo: Landbruks- og matdepartementet.

LMD. 2008. *Kriterier/indikatorer på økologisk bærekraftig reintall*. Oslo: Landbruks- og matdepartementet.

Magga, O.-H. 2006. Diversity in Saami terminology for reindeer, snow and ice. *International Social Science Journal* 58(187), 25–34.

Marin, A. 2003. *Protean Reality: Discourses for Managing the Winter Reindeer Ranges in Finnmark, Northern Norway*. MSc dissertation. Ås: Noragric, Norwegian University of Life Sciences.

Moen, J. & Danell, Ö. 2003. Reindeer in the Swedish mountains: An assessment of grazing impacts. *Ambio* 32, 397–402.

Mårell, A. & Edenius, L. 2006. Spatial heterogeneity and hierarchical feeding habitat selection by reindeer. *Arctic*, *Antarctic and Alpine Research* 38, 413–420.

Nielsen, K. 1979. *Lappisk (samisk) ordbok grunnet på dialektene i Polmak, Karasjok og Kautokeino*. Vol. III. Olso: Universitetsforlaget.

Nordic Sami Institute. 2008. *Hvor mange samer er det egentlig …?* http://www.sami-statistics.info/default.asp?nc=2807&id=110 (accessed 19 September 2014).

NRK Sapmi. 2013. *Støtter tvangstiltak for å få ned reintallet*. http://vindpil.yr.no/kanal/nrk_sapmi/1.10886044 (accessed 3 July 2014).

Orvik, P. & Prestbakmo, H. 1990. *Beiteundersøkelser: Fellesbeiteområdene i Vest-Finnmark*. Alta: Reindriftsadministrasjonen.

Oskal, N. 2000. On nature and reindeer luck. *Rangifer* 20, 175–180.

Oskal, A., Turi, J.M., Mathiesen, S. & Burgess, P. (eds.) 2009. *EALÁT Reindeer Herders' Voice*. Kautokeino: International Centre for Reindeer Husbandry.

Paine, R. 1992. Social construction of the 'tragedy of the commons' and Saami reindeer pastoralism. *Acta Borealia* 9(2), 3–20.

Paine, R. 1994. *Herds of the Tundra*. London: Smithsonian Institution Press.

Paine, R. 2004. Saami reindeer pastoralism: Quo vadis? *Ethnos* 69, 23–42.

Pape, R. & J. Löffler. 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.

Reindriftsforvaltningen. 2012. *Ressursregnskap for reindriftsnæringen*. http://www.reindrift.no/asset/4922/1/4922_1.pdf (accessed 20 Novermber 2013).

Reinert, E. 2006. The economics of reindeer herding: Saami entrepreneurship between cyclical sustainability and the powers of state and oligopolies. *British Food Journal* 108, 522–540.

Reinert, H. 2008. *The Corral and the Slaughterhouse*. PhD dissertation. Cambridge: Scott Polar Research Institute, University of Cambridge.

Reinert, H. 2012. The disposable surplus: Notes on waste, reindeer and biopolitics. *Laboratorium* 4, 67–83.

Reinert, H. 2014. Entanglements: Intimacy and nonhuman ethics. *Society & Animals* 22, 42–56.

Riksrevisjonen. 2004. *Riksrevisjonens undersøkelse om bærekraftig bruk av reinbeiteressursene i Finnmark*. Dokument 3:12 (2003–2004). Olso: Riksrevisjonen.

Riksrevisjonen. 2012. *Riksrevisjonens undersøkelse av bærekraftig reindrift i Finnmark*. Dokument 3:14 (2011–2012). Oslo: Riksrevisjonen.

Riseth, J.Å., Johansen, B. & Vatn, A. 2004. Aspects of a two-pasture-herbivore model. *Rangifer* 15, 65–81.

Rohde, K. 2005. *Nonequilibrium Ecology*. Cambridge: Cambridge University Press.

Sandström, P. & Sandström, C. 2008. Moderna renar ger bättre samråd med skogsbruket. *Miljöforskning* 5–6 (December 2008). http://miljoforskning.formas.se/sv/Nummer/December-2008/Innehall/Tema/Etiskt-problem-skraddarsymat-efter-gen/ (accessed 7 February 2015).

Sandström, P., Pahlén, T., Edenius, L., Tømmervik, H., Hagner, O., Hemberg, L., Olsson, H., Baer, K., Stenlund, T., Brandt, L. & Egberth, M. 2003. Conflict resolution by participatory management: Remote sensing and GIS as tools for communicating land-use needs for reindeer herding in Northern Sweden. *Ambio* 32, 557–567.

Sara, M.N. 2001. *Reinen: Et gode fra vinden*. Kautokeino: Davvi Girji.

Sara, M.N. 2009. Siida and traditional Sámi reindeer herding knowledge. *The Northern Review* 30, 139–164.

Scott, J.C. 1998. *Seeing Like a State*. New Haven, CT: Yale University Press.

Skjenneberg, S. 1965. *Rein og reindrift*. Lesjaskog: Fjell-Nytt.

Strøm-Bull, K., Oskal, N. & Sara, M.N. 2001. *Reindriften i Finnmark*. Cappelen, Oslo.

Tømmervik, H., Johansen, B., Riseth, J.Å., Karlsen, S.R., Solberg, B. & Høgda, K.A. 2009. Above ground biomass changes in the mountain birch forest and mountain heath of Finnmarksvidda, northern Norway, in the period 1957–2006. *Forest Ecology and Management* 257, 244–257.

Tømmervik, H., Johansen, B. & Riseth, J.Å. 2011a. Feiltolking av reindriftsforskning. *Dagbladet* 8 April 2011.

Tømmervik, H., Johansen, B., Karlsen, S.R. & Ihlen, P.G. 2011b. *Overvåking av vinterbeiter i Vest-Finnmark og Karasjok 1998–2005–2010*. NINA Rapport 745. Trondheim: NINA.

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 Ecology* 5, 3–15.

Turner, M. 1993. Overstocking the range: A critical analysis of the environmental science of Sahelian pastoralism. *Economic Geography* 69, 402–421.

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. 1998. Reindeer pastures at disequilibrium. Haugerud, R.E. (ed.) *Den 10. nordiske reinforskningskonferansen/The 10th Nordic Conference on Reindeer Research: Program og sammendrag/Programme and abstracts. Guovdageaidnu-Kautokeino, 13.–15. mars 1998*. Rangifer Report No. 2, 67. Kautokeino: Nordic Council for Reindeer Research. http://septentrio.uit.no/index.php/rangifer/issue/view/127 (accessed 4 March 2015).