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# Fire management in the boreal forest of Swedish Sápmi: prescribed burning and consideration of Sami reindeer herding during 1920-1970

Sarah Cogos<sup>\*1,2</sup> · Lars Östlund<sup>2</sup> · Samuel Roturier<sup>1</sup>

## Abstract

Forest owners and Indigenous Sami reindeer herders use the same land in northern Sweden for commercial forestry and winter grazing, respectively. Fire management has been controlled by foresters since the late nineteenth century, and Sami herders have had to deal with the effects of both fire suppression and prescribed burning. However, the environmental history of fire management and reindeer herding in Sweden has never been thoroughly investigated. We therefore analyzed written archives in order to understand how reindeer herding was considered in planned burning during the mid-twentieth century, and how the effects of prescribed burning on reindeer herding were interpreted by foresters. We supplemented the interpretation of written sources by including local Sami reindeer herders' insights about prescribed burning. Written records show that reindeer herding was increasingly integrated into the planning process during the twentieth century, yet foresters failed to include important aspects of reindeer herding in their interpretation of the effects of prescribed burning. The Sami consider the effects of burning in terms of fodder availability, opportunities for reindeer to graze the fodder, and any impact on the reindeer's movement patterns and thus herd management. The Sami's historical perspective is essential in order to reconstruct a comprehensive picture of the past, and adapt forestry measures effectively in the future.

**Keywords** Forest history; fire management; northern Sweden; prescribed burning; Sami reindeer herding

## Introduction

In the boreal forests of Fennoscandia, fire regimes have been influenced by human populations in various ways over time, with consequences for the livelihoods relying on the forests. While forest fires used to occur with a mean interval of 80 years in northern Sweden (Zackrisson 1977), modernization of forestry in the twentieth century brought

an unprecedented decrease in the number and extent of forest fires since the end of the ice age, as in many other places worldwide (Zackrisson 1977; Lehtonen and Huttunen 1997; Niklasson and Granström 2000; Wallenius 2011). In Sweden, fire suppression has been used by forestry managers since the 1860s, in order to preserve timber resources (Östlund et al. 1997; Niklasson and Granström 2000;

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Granström and Niklasson 2008; Wallenius 2011). However, foresters soon realized that fire was necessary to ensure regeneration of Scots pine forests (Holmgren 1959; Granström 1991). Prescribed burning (Sw.: *hyggesbränning*), i.e. the controlled burning of clear-cut forest stands for forest regeneration purposes, was experimented with on a small scale in northern Sweden as early as the 1890s, and then applied on a larger scale during the 1950s-1960s, before being abandoned in the 1970s for mechanical soil preparation (Zackrisson 1977; Granström 1991; Östlund et al. 1997; Niklasson and Granström 2000).

With foresters no longer using fire, ecologists and preservationists realized the detrimental effects of fire suppression on ecosystem functioning and biodiversity conservation (Östlund et al. 1997; Linder 1998; Bengtsson et al. 2000; Halme et al. 2013). Since the 1990s, fire restoration measures have been implemented in response to these impacts in natural reserves and productive forestlands (Angelstam 1998; Eckerberg and Buizer 2017). This is, today, mainly encouraged by the Forest Stewardship Council certification in the forestry sector, which requires forestry companies to burn 5% of their annual clear-cut area on dry-mesic forest stands (FSC Sweden 2013), and by regional and national administrations who actively participate in prescribed burning efforts to conserve fire-dependent species and habitats (Eckerberg and Buizer 2017; Life Taiga 2020).

These shifts in fire management strategy have inevitably affected other livelihoods, such as reindeer herding by the Indigenous Sami people of northern Fennoscandia. The Sami have relied on the boreal forest for their livelihood for millennia, combining fishing, hunting, gathering and reindeer herding. Following colonization of northern Sweden in the seventeenth century by non-indigenous people, Sami reindeer herders lost their land governance rights, and only received a right to use the land as pasture for their reindeer, as well as to hunt and to fish

(Brännström 2017; Norstedt 2018). Since the mid-1900s, commercial forestry has been practiced within most of the Swedish boreal forest area, and Sami reindeer herders, being deprived of land property rights, are subject to the decisions of forest managers and private forest owners, including fire management strategies. The forest, commercially exploited, constitutes the reindeer winter grazing grounds, which are critical for the sustainability of reindeer herding and have become a focus of conflict between Sami reindeer herders and forestry during the twentieth century.

The interactions between forest fires, whether natural or artificial, and Sami reindeer herding, are complex and ambivalent. One critical aspect in these interactions is the role of fire in the availability of ground reindeer lichens (*Cladonia* spp.), which constitute up to 80% of the reindeer forage in the winter (Heggberget et al. 2002), while the rest of their diet is composed of arboreal lichens, graminoids, and other vascular plants (Åhman and White 2018). Dry pine forests with oligotrophic soil conditions are the most favorable for the growth of ground reindeer lichens, and they are also the most prone to fire, which destroys lichen resources for several decades (Kumpula et al. 2000; Crittenden 2000; Coxson and Marsh 2001). This is why it is commonly accepted that Sami people have been historically averse to fire and have never used it as a forest management tool (Granström and Niklasson 2008), unlike with other indigenous peoples in boreal regions who used fire for various purposes, including the improvement of grazing lands for hunted or herded animals (Lewis 1978; Lewis and Ferguson 1988; Pyne 2012).

However, scientific studies both in the case of reindeer in northern Europe and caribou in North America have suggested that fire maintains the availability of lichen forage in the long term (Klein 1982; Miller 1996; Kivinen et al. 2012). Without fire, lichen-rich forests tend to become denser and richer, favoring mosses and ericaceous

shrubs that eventually outcompete the ground lichens through ecological succession (Ahti and Oksanen 1990; Miller 1996; Nilsson and Wardle 2005). The role of fire in maintaining lichen pasture is present in Sami ecological knowledge as well, as exemplified by Sami toponyms connecting fire and good reindeer winter pasture (Cogos et al. 2019). Some sources actually suggest that the Sami have used fire to create reindeer pasture, perhaps repeatedly, initially to create lichen-rich forests to attract wild reindeer for hunting, and later to favor winter grazing for domesticated reindeer (Hörnberg et al. 1999, 2018). Sami may have also used fire to create summer pasture (Berglund 2013). Beyond these hypotheses, the possible historical use of fire by Sami reindeer herders in order to manage reindeer pasture has not been documented yet.

However, the use of fire by other inhabitants of the boreal forest has had consequences for Sami reindeer herding over history. Written historical sources from the eighteenth century refer to conflicts between Sami reindeer herders and southern settlers, because the latter used fire to create pasture for their cattle, and so destroyed the reindeer winter pastures, sometimes deliberately (Massa 1987; Granström and Niklasson 2008; Pyne 2012). Then, the fire suppression policy that was associated to the rise of modern forestry in the nineteenth century was most probably considered beneficial by Sami herders (Berg et al. 2008). However, it is also suggested that fire suppression during the twentieth century was detrimental to the availability of ground lichens in the longer term (Berg et al. 2008; Moen and Keskitalo 2010; Cogos et al. 2019). Helle and Aspi (1984) have also suggested that, compared with other forest regeneration methods, prescribed burning carried out by forestry could benefit reindeer pasture because fire destroyed cutting residues and avoided mechanical soil preparation, while allowing lichens to re-establish some decades after the fire.

Other than that, however, little is known about the historical implications of past fire management by forestry for Sami reindeer herders, or about how the herders were included in the planning process for the burnings carried out by the forestry sector during the twentieth century. Investigating this environmental history will allow a better understanding of the implications of prescribed burning for reindeer herding today, and of fire management strategies that could benefit reindeer herding in the future. Gaining such an understanding is essential within the context of dramatically decreasing ground lichens (Sandström et al. 2016), increasing risk of wildfires in the boreal forest induced by climate change (Krawchuk et al. 2009), and increasing restoration efforts in fire-prone forest habitats.

The main objective of this study was to reconstruct the environmental history (in a broad sense the study of past interrelations between humans and their environment) of fire management and Sami reindeer herding in Sweden during the period 1920-1970. We reconstructed this history based on written sources, which mainly convey the perspective of State institutions and representatives, and complemented this approach by including the Sami perspective, obtained from contemporary Sami ecological knowledge. More specifically, we sought to answer the following research questions: how was Sami reindeer herding included in the management of prescribed burning from the 1920s to the 1970s, according to historical written sources? How were the implications of prescribed burning on reindeer herding during this period interpreted by foresters, and by Sami reindeer herders, based on their ecological knowledge?

## **Methods**

### **Study area: forestry and Sami reindeer herding in Malå**

The State Forest Malå, Västerbotten County, and the reindeer herding community of Malå, provide an ideal case study for investigating the broader environmental history of fire, forest management and Indigenous people. Joel Ephraim Wretlind, forest manager of the National Forest Company (Sveaskog AB, formerly Domänverket) in Malå from 1920 to 1952, experimented with prescribed burning and applied it extensively during the 1940s and 1950s. Malå became the center for prescribed burning in Sweden, with the early application of prescribed burning on a large scale and almost continuously over several decades (Granström 1991; Pyne 2012; Cogos et al. 2020). Wretlind's personal archive provides an invaluable source of information regarding forest management and prescribed burning, but also historical interactions between foresters and Sami reindeer herders. The written archives of the National Forest Company also provide a rich source of information, for both the Malå State Forest and northern Sweden in general.

Sami reindeer herding is based on a system of seasonal migrations as the reindeer move from winter pasturelands in the inland forests to summer pasturelands, either located in the Scandinavian mountain range for mountain reindeer herding communities, or in the forestlands for forest communities. In one herding community, the herders follow and steer the movements of their reindeer within a delimited territory, from one patch of pasture to another, connected by migration routes. Because the reindeer need a variety of food resources along the seasons, access to a diversity of pasturelands is essential for the conduct of reindeer herding. Moreover, in the winter, reindeer must dig through snow to access any food, and grazing thus depends on snow conditions (Collins and Smith 1991; Kumpula and Colpaert 2007).

The Malå reindeer herding community is a forest community with yearly grazing lands within Malå municipality, located between

64°59' and 65°31' (Figure 1). It belongs to the historical Ume Sami language area, one of ten Sami languages. Together with the region of Arvidsjaur, Malå is considered to be the core of the forest Sami's culture and livelihood (Marklund 2015).

The first settlers arrived in the 1760s, practicing mainly cattle farming, along with fishing and hunting (Jonsson 1965; Lundgren 1989). The first commercial forestry activities in the region began in 1860, in the form of high-grading, i.e. selective logging of economically valuable trees (Table 1g). Established in the late nineteenth century, the Malå State Forest comprised forestlands owned by the Swedish National Forest Company, and covered approximately 59 800 ha in 1954 (Lappväsendet-Renforskningen 1955).

In Malå, the boreal forest's most abundant tree species are Scots pine and Norway spruce (*Picea abies*), with a smaller component of deciduous trees, including birch (*Betula* spp.), aspen (*Populus tremula*), goat willow (*Salix caprea*) and rowan (*Sorbus aucuparia*). Depending on the forest type, the ground vegetation ranges from lichen mats in poor and dry stands to feather moss mats in richer and more humid environments, with a layer of ericaceous shrubs such as bilberry (*Vaccinium myrtillus*), lingonberry (*Vaccinium vitis-idaea*), crowberry (*Empetrum nigrum*) and heather (*Calluna vulgaris*).



**Fig. 1** The location of the study area

## Written archive sources

The historical sources used in our research came from the Swedish Regional State Archives in Härnösand, Sweden: Wretlind's personal archive, and the National Forest Company's archive for Malå State Forest (Table 1). The Wretlind archive contains documents that Wretlind himself had conserved, including drafts and published versions of various reports that he had written, letters exchanged with other forest managers or institutional representatives, programs of field trips,

descriptions of surveys and experiments that he had carried out in the field, and photographs. It also contains the results of a questionnaire that Wretlind submitted to the reindeer herders of Malå in 1954, about the effects of prescribed burning on reindeer grazing (see supplementary material). Transcriptions of recordings made between 1959 and 1960 documenting Wretlind's 'forest testament' provide a detailed account of his thoughts about forestry, and some insight into his interactions with Sami reindeer herders.

**Table 1** Archive sources and references: (Archive reference code) name of the document in Swedish: description

<i>National Forest Company's archive</i>	
a.	(B,I,b) Huvudserie Malå revir Konzeptbok - 1927-1935: letters received in Malå State Forest from state institutions related to forest management, forest managers, etc., between 1927 and 1935
b.	(E,II,7; 23) Circular letter 'S.IV:235': sent by K. Fredenberg and E. Wiel-Berggren (National Forest Administration) to the chief forest managers in Skellefteå district on 20 February 1923
c.	(E,II,7;23) Letter 'S.I.224'; 9 Sept: sent by E.W. Höjer and P.-G. Hultman (National Forest Administration) in 1962
d.	(E,II,7;23): motion by Jovva Spik, Jokkmok, 8 January 1959, SSR national meeting
e.	(E,II,7;23): letter 'S.I.1918'; 12 December 1958 sent by H. Olsson and B. Mineur (National Forest Administration) to the chief forest managers in Upper Norrbotten, Lower Norrbotten, Skellefteå, Umeå, and Middle Norrland districts, as well as forest managers in Norrbotten and Västerbotten counties
f.	(E,II,7;23) angående skogsrenskötseln och skogshanteringen inom Skellefteå överjägmästarsdistrikt: letter by E. Kangas, 9 May 1955, about forest reindeer herding and forestry within the chief forest manager's district of Skellefteå
g.	(H,IV,7) Uppskattningshandlingar och avverkningsplaner till år 1959 kartlagda skogar i Malå revir; Andersson 1960: Evaluation documents and exploitation plans for the 1959 mapped forests in Malå State Forest, including a general description of the district (its forest composition and its management history)
<i>Wretlind archive</i>	
h.	Transcriptions of recordings for study areas 1, 2, 3, 4, 5, 6, forming Wretlind's 'forest testament'
i.	Tal i Malå kyrkan den 4 mars 1954 vid invigningen av detta års Samemästerskap av jägmästare J.E. Wretlind: Speech in Malå church 4 March 1959 for the inauguration of this year's Sami Championship by forest manager Wretlind
j.	Letter by G. Nordwall to Lapp bailiffs E. Kangas, E. Malmström, E. Edbäck, H. Johansson, the County Administrative Boards in Luleå and Umeå, sent on 22 June 1951
File Skogsskötselns inverkan på renbetestillgången: impacts of forestry on reindeer pasture's availability:	
k.	Program för exkursion i Malå revir den 11/9 1951 för klarläggande av hyggesbränningarnas betydelse för renskötseln: program for the fieldtrip in Malå State Forest on 11 September 1951 to clarify the implications of prescribed burnings for reindeer herding
l.	Renskötseln och den norrländska skogshanteringen: program of the popular education course held in Jokkmokk on 9-15 September 1954, Reindeer herding and the Norrland's forestry
m.	Questionnaire 1954
n.	Invitation letter and program for a course in Arvidsjaur sent to Wretlind by Wallmark

The National Forest Company's archive contains letters received by the Malå State Forest from various institutions related to forestry management, such as the National Forest Administration (Sw.: *Kungliga Domänstyrelsen*) and the County Administrative Board (Sw.: *Länsstyrelsen*). Some of the letters relate specifically to the Sami, from the National Forest Administration and Lapp bailiffs (Sw.: *lappfogde*), i.e. State representatives responsible for the interests of the Sami, as well as the National Union of Swedish Sami (Sw.: *Svenska Samernas Riksförbund*; Sami: *Sámiid riikkasearvi* – SSR). These written accounts cover the first part of the twentieth century, until the 1960s, some relating specifically to Malå State Forest and others to northern Sweden. The archive material is all in Swedish, and the excerpts presented here were translated by the authors.

### **Semi-structured interviews**

In order to supplement interpretations of the written sources with insights from Sami reindeer herders, semi-structured interviews with herders were carried out during 2018. Eight were carried out with herders, aged from 31 to 77, from the Malå reindeer herding community, one with a 71-year-old Sami woman from Malå, and one with two herders, aged 72 and 89, from the Västra Kikkejaure reindeer herding community located in the neighboring municipality of Arvidsjaur. All the reindeer herders interviewed were men. Among the herders interviewed, five were actively involved in reindeer herding, while five were retired but still participated in important activities of the reindeer-herding year.

During the interviews, the herders were asked to give their own answers to Wretlind's questionnaire from 1954 (Table 1m), provide explanations and give their own interpretation of the results. Most of the herders were directly related to those surveyed by Wretlind in 1954, although they had not heard of the questionnaire. To

broaden our understanding of the implications of prescribed burning from their point of view, we initiated an open discussion around several themes, and let the interviewees initiate new themes. The main topic was the effects of fire management and prescribed burning on reindeer herding today and in the past. All the interviews were carried out in Swedish, recorded and transcribed. Two interviews with Malå herders led to visits to forest stands that had undergone different types of forestry measures, such as mechanical soil preparation or prescribed burning, with consequences for the condition of the reindeer pasture.

## **Results and Discussion**

### **The central place of prescribed burning in Sami reindeer herding–forestry relationships (1923-1979)**

#### **1923: An early consideration of Sami reindeer herding**

Written archives provide information about the regulations that governed the implementation of prescribed burning during the twentieth century, in regard to Sami reindeer herding. These regulations were included within a wider framework, which has dictated the rights of the Sami to use the land and its resources since colonization of the Sami area by southern settlers in the 1600s (Lappväsendet-Renforskningen 1955). One instrument of this regulation was the establishment of the Lapp Administration (Sw.: *Lappväsendet*) in 1885, supposedly to facilitate communication between the Sami and the State at a regional level (Lantto 2000, 2011). The Lapp bailiffs supervised the Sami and were charged with representing their interests, until 1971, when their position was dissolved (Lappväsendet-Renforskningen 1955). The rights of the Sami over their pasturelands, and their interactions with settlers practicing

agriculture and other land uses, were regulated by the Swedish ‘reindeer grazing acts’ (Sw.: *renbeteslag*, 1886; 1899; 1928), first implemented in 1886. It has been argued that the reindeer grazing act ‘*became an instrument for control over the Sami*’, who were considered to be ‘*inferior to the Swedish agricultural and industrial society*’ (Lantto 2011). Still, within this legal framework, the National Forest Administration issued various regulations regarding forestry practices, demonstrating a willingness to consider their impact on reindeer husbandry within forests owned by the National Forest Company. Prescribed burning appeared to be the object of one of the first of these regulations. A circular letter, sent in 1923 by the National Forest Administration (Table 1b) to the chief forest managers in northern countries, stated:

*‘When it appears necessary, for regeneration purposes in districts’ forests or other public forests under the management of the Swedish National Forest Company, located within the lands where the Lapps live with their reindeer under some part of the year, to carry out burnings in conjunction with stand cleaning and other forest cultivation measures, it is the duty of the responsible forest manager to obtain the approval of the responsible Lapp bailiff before the burnings are carried out, and in the case where the Lapp bailiff would oppose the burning, the question must be submitted to your [district’s chief forest manager] for evaluation’.*

This source indicates that, as early as 1923, prescribed burning was already a central issue for Sami reindeer herding communities. It also shows that prescribed burning had a central role in reindeer herding–forestry interactions, and triggered the consideration of Sami herders in forest management.

However, further sources from the Malå State Forest show that the circular letter from 1923 had limited impact in the field. In practice, the responsible district manager

would provide an annual description of the areas for planned burnings to the Lapp bailiff, who would then ask the reindeer herders for their opinion about those areas (Table 1b). In Malå, Wretlind complied with this obligation, and sometimes abandoned his plans and employed other forest regeneration methods when the Sami contested his planned burnings (Table 1h). Nevertheless, other written documents show how, initially, he did not take the Sami’s position at face value. In a letter he sent to the Lapp bailiff in 1928, Wretlind wrote (Table 1a):

*‘If the Sami peasant community would, likewise as last spring, be proposing that, on the clear-cuts mentioned above, there would be pasture for the reindeer, then we ask that there are some surveys done to clarify this in such a time that this year’s burning will not be compromised or not be done too late’.*

Thus, Wretlind would not simply accept the claims of the Sami concerning the presence of reindeer pasture. Moreover, his written accounts show how he sometimes sought to convince the Sami to let him carry on with the burnings despite their initial opposition (Table 1h). An example from 1945 shows that Wretlind also carried out some burnings despite the disagreement of the Sami, which, he acknowledged, caused some ‘*trouble*’ and discontent (Table 1h).

The circular letter from 1923 is the oldest source we found in the archive indicating consideration of Sami reindeer herders in forest management. However, the case of Malå shows how forest managers could take liberties with the rules that were promulgated at the institutional level, and how the opinion and the interests of the Sami were sometimes overlooked. In Malå, this can be explained by Wretlind’s personal commitment to developing prescribed burning as the foremost forest regeneration method (Cogos et al. 2020). Moreover, this period corresponds with a change in Swedish forestry practices

towards more effective regeneration (Östlund et al. 1997). At both local and national levels, it is likely that Sami reindeer herding counted for little compared with the priority of regenerating forests. Although prescribed burning was an object of concern and discontent for Sami herders, it also became a trigger in the development of reindeer herding–forestry relationships during the twentieth century, as we will see in the next section.

### **1950s: Efforts to understand reindeer herding during the peak of prescribed burning**

During the 1950s, the relationship between reindeer herders and forestry became increasingly tense, principally because of the spread of clear-cut areas (Mattson 1984), but also because of the use of prescribed burning, which peaked during this decade and covered large areas in the northern counties of Norrbotten and Västerbotten (Figure 2). Modern forestry started to cause significant problems for

reindeer herding (Lantto 2000). Lennart Wallmark, rector of the Sami School ‘Samernas Folkhögskola’, wrote in a report written in 1955 that ‘worry [had] emerged from reindeer owners in several places because of some large forestry encroachments, for example prescribed burning’ (Lappväsendet-Renforskningen 1955). Issues relating to reindeer herding, including clear-cutting and burning within herding areas, began to be addressed in public debates in the 1950s (Lantto 2000), notably through the creation of SSR in 1950, which provided political representation for the Sami. During the same period, a field of research dedicated to biological aspects of reindeer herding emerged in Sweden, arising from an agronomic approach to animal husbandry (Kitti et al. 2006; Lantto 2011). This diverged from previous research on Sami people that, during the first half of the twentieth century, had been dominated by historic and ethnographic perspectives (Lantto 2011).



**Fig. 2** A burned forest stand in Malå State Forest, 1950. *Source:* Wretlind archive

In 1951, the organization ‘Lapp Administration–Reindeer Husbandry Research’ was established, led by Folke Skuncke, a former forest manager (Skuncke 1969). Among other objectives, the organization’s aims included ‘*clarifying the relationship between forestry and reindeer husbandry, which had become strained in the forties when forestry in the north underwent considerable and rapid modernization*’ (Skuncke 1969). According to the organization, it was necessary to modernize and rationalize reindeer herding according to the forestry model, to allow it to overcome the encroachments made by forestry and hydroelectric power development (Lantto 2011). Despite a willingness to ensure the sustainability of reindeer herding, such goals demonstrate the normative conception and paternalistic attitude towards Sami herders that prevailed within Swedish institutions arising from colonization (Lantto 2011), an attitude that is present in Wretlind’s writings as well (Table 1i). Within this context, the effects of prescribed burning on reindeer herding began to be addressed with a scientific approach, although scientific study of fire ecology only truly emerged in Sweden in the 1970s.

The issue of prescribed burning and its implications for Sami reindeer herding contributed to the instigation of fieldtrips organized during the 1950s to discuss the interactions between forestry and reindeer herding, gathering together representatives from both sectors. A letter sent in 1951 by the chief forest manager in Skellefteå district to the Lapp bailiffs in Luleå and Umeå (Table 1j), stated:

*‘The conduct of forestry measures, which are now recommended by the National Forest Administration, thus implies that large areas will be burned every year, especially within the Lapp areas ... In several cases, especially within Arjeplog’s and northern Arvidsjaur’s districts, the Lapps, through their responsible Lapp*

*bailiff, have directed some criticism against the burnings in question to the forest managers. Since the question of the effect of prescribed burning on reindeer pasture seems to be unclear for both parts, it would be of strong significance if a meeting between all the Lapp bailiffs and the chief forest managers within the counties of Norrbotten and Västerbotten could be organized to discuss these questions. I want to suggest Malåträsk [Malå], in Västerbotten county, as an appropriate meeting place, where former manager J. Wretlind has put himself at disposal for a demonstration of burned areas of different ages ...’*

A fieldtrip was indeed organized to visit burned areas within Malå State Forest in September 1951, ‘*For clarification of prescribed burning implications for reindeer husbandry*’ (Table 1k). Participants included Lapp bailiffs and chief forest managers, but no reindeer herders.

In the same vein, a ‘public education course’ was organized in Jokkmokk in 1954, initiated by Wallmark and the Sami organization Same Ätnam, on the theme ‘*Reindeer husbandry and Norrland’s forest management*’. It was attended by representatives of both the forestry sector and reindeer husbandry, including, for the first time, reindeer herders (Lappväsändet-Renforskningen 1955; Gustafsson and Persson 1989), although they were not invited to participate as lecturers. The course included fieldtrips and lectures given by Wretlind and Skuncke, as well as Edvin Kangas, Lapp bailiff for the region of Luleå, and Fredrik Ebeling, chief forest manager for the Lower Norrbotten district (Table 1l), with prescribed burning as a central topic. Wretlind presented the results of the questionnaire he had submitted to Malå reindeer herders in 1954 about the effects of prescribed burning on reindeer grazing (Table 1m, Table 2). The course resulted in a report published in 1955 by the Sami

Administration–Reindeer Husbandry  
Research.

In the report, the lecturers of the course stressed the need to improve the interactions between the forestry and the reindeer herding sectors, and proposed ways to do so. Skuncke (Lappväsendet-Renforskningen 1955) argued that foresters were *‘more or less ignorant about both the biological and practical conditions needed for reindeer herding’*. Thus, the report stressed the objective to *‘achieve good understanding between forestry and reindeer herding practitioners’* and argued that *‘both parts should strive to acquire reciprocal knowledge on the conditions needed for both livelihoods’* (Lappväsendet-Renforskningen 1955). The lecturers recommended teaching these issues in northern Sweden’s forestry schools, as well as nomad schools and the Sami Folk high school (Sw.: Samernas Folkhögskola). They also reaffirmed the 1923 circular letter establishing the obligation to consult Sami representatives, and demanded its scope be extended to other forestry measures, such as the use of herbicide to control the proliferation of birch. Kangas (Lappväsendet-Renforskningen 1955) argued that forestry should try to *‘spare the forest Sami’s most important spring and summer lands from more pervasive regeneration, clear-cutting and burning’*, thus recognizing the possible negative effects of such measures on reindeer herding. For his part, Wallmark (Lappväsendet-Renforskningen 1955) argued that reindeer herding practitioners should be able to take part in research about reindeer herding. Although the perspectives of the Sami were included in the report to some extent, it was through the words of foresters or State representatives, and not those of the Sami themselves. However, by the 1950s there seemed to be a resolve on the part of the forestry sector to include the interests of reindeer herders in forest management and the burning strategy. The Jokkmokk course had various outcomes, notably a map of Sami reindeer

pasturelands in Skellefteå district, to be used by managers when planning forestry work (Table 1f). The map, created in consultation with reindeer herders, depicted winter pasture with lichens, migration routes and herding infrastructure such as corrals and cabins. It represented the first attempt to integrate the requirements of reindeer herding concretely into forestry planning. The success of the 1954 Jokkmokk course inspired a similar course in 1956 in Arvidsjaur on the theme of *‘Forestry and reindeer herding in Arvidsjaur and Arjeplog’*, organized by the Sami Association of Arvidsjaur and Same Ätnam, and included the same lecturers as before (Table 1n). The invitation letter emphasized the difficulties posed by large-scale forestry for reindeer herding in northern Sweden, especially for forest Sami in Arvidsjaur and Arjeplog districts, but also for Arjeplog mountain Sami, who migrated through the forest Sami pasturelands.

Our sources show that the foundations for establishing a dialogue between reindeer herding and forestry were laid down during this period. Several institutions and processes that are still in place today were created or experimented with in the 1950s. The first known fieldtrip about the effects of prescribed burning on reindeer pastures, led by Wretlind in Malå, is one remarkable example of such initiatives that live on today. Yet, it must be noted that the arenas for discussion provided by such fieldtrips were dominated by the forestry sector, which meant that the interests and needs of Sami herders were expressed by non-Sami, non-herder individuals. While a growing concern for Sami reindeer herding can be observed in the forestry sector during this period, the place given to the actual Sami herders’ understanding of prescribed burning, and forestry in general, remained very limited.

**1960-1979: A growing concern for Sami herders in the context of a decline in prescribed burning**

Written accounts show that, despite an apparent effort to consider the interests of Sami herders in the planning of forestry and prescribed burning, complaints still emerged from the Sami community. In 1958, the main Sami reindeer herders' association, SSR, asked the Crown to instruct the National Forest Administration to stop clear-cutting and burning clear-cut areas on reindeer winter pastureland. SSR also demanded the formation of a committee to investigate the extent of damage caused by forestry measures, and to evaluate compensation for the damage (Table 1e). Subsequently, the State asked National Forest Company managers to carry out systematic consultations with the Sami Administration and reindeer herding communities when planning measures such as logging, regeneration and road construction, thus reaffirming the 1923 circular letter (Table 1e).

Despite this new measure, written documents illustrate ongoing discontent and concerns among Sami reindeer herders. During the 1959 SSR national meeting, one reindeer herder, Jovva Spik, argued that *'burning, clear-cutting and dams caused a lack of pasture within many important areas'* (Table 1d). In March 1962, the National Forest Administration forwarded a complaint from the Sami to forest managers in northern Sweden, because *'a prescribed burning had been carried out near a reindeer corral'*. The letter stated that *'due consideration was not brought to the Lapps' migration routes when some measures were planned'*. It urged the forest managers to obtain information about reindeer corrals and migration trails within their districts from the Lapp bailiffs, *'so that consideration to those [could] be taken during the planning of the forestry measures'* (Table 1c).

In response to these calls, the National Board of Agriculture (Sw.:

Lantbruksstyrelsen) organized a conference in 1970 about the effects of modern forestry on reindeer herding. This conference led to a 'consultation group' formed by representatives from the National Board of Agriculture, the National Board of Forestry (Sw.: Skogsstyrelsen), the National Forest Company and SSR. Its mission was to record the interactions between modern forestry and reindeer husbandry, and work towards common agreements in solving related issues (Gustafsson and Persson 1989). Their work introduced consultations (Sw.: *samråd*) into the forestry law of 1979, which applies to every forest owner, including the National Forest Company but also private owners of forests within reindeer herding areas<sup>3</sup>. However, the law does not specify the modalities to be followed for achieving the consultations, and limitations in practice have been pointed out by Sami reindeer herders (Sandström and Widmark 2007).

The importance of burning during this period must be understood in light of its function in Swedish forestry until the 1970s: prescribed burning progressively became the dominant forest regeneration method, notably under the influence of Wretlind (Cogos et al. 2020), before fading out and being replaced by mechanical soil preparation. The written sources available for the mid-twentieth century do show a willingness from the State and the forestry industry to recognize and consider the interests of the herders in forest management and the implementation of burning strategies. Written sources also illustrate the role of Sami political mobilization, through their organizations and associations, in raising their concerns and encompassing forestry measures other than just prescribed burning. We conclude that prescribed burning was a subject of disagreement between the reindeer herding and the forestry sectors as early as the 1920s, and increasingly so from the 1950s,

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<sup>3</sup> The Swedish Forestry Law (1979: 429) states that "before felling takes place in year-round reindeer herding areas (areas where reindeer husbandry is

permitted throughout the entire year) the Sami reindeer herding community concerned shall be given the opportunity to be consulted".

and therefore shaped the interactions between the two sectors.

### **Contrasting the perspectives of foresters and Sami herders about prescribed burning and reindeer herding in the mid-20<sup>th</sup> century**

The sources we had access to regarding the use of prescribed burning in reindeer herding areas show that intense debates took place about its effects. We argue that the knowledge underlying these debates has shaped the way prescribed burning has been managed as well as the relationships between forestry and reindeer herding. In this section, we used two types of written sources – the report of the Jokkmokk course published in 1955 by the Sami Administration–Reindeer Husbandry Research, and Wretlind’s questionnaire – to understand the knowledge base within the forestry sector in the mid-20<sup>th</sup> century. We contrasted these sources with a diachronic ethnological analysis of contemporary Sami ecological knowledge about burning and reindeer herding, to obtain an understanding of their knowledge at that time.

#### **Burning and reindeer pasture: the perspectives of foresters**

In reaction to the claims of the Sami community about prescribed burning within the reindeer herding territory, the contributors of the report published in 1955 by the Sami Administration–Reindeer Husbandry Research acknowledged that lichen-rich dry forests should not be burned. It was known by the 1950s that ground lichens might not re-establish for several decades following a fire, although investigations into lichen post-fire regeneration had not yet been carried out and there was some uncertainty among both foresters and reindeer herders.

Contributors to the Jokkmokk course also highlighted the positive effects that burning could have for reindeer herding, provided it was not applied on lichen-rich forest stands.

Thus, it was agreed that raw-humus old-growth spruce forests of mesic or humid types or bilberry–feathermoss forest types could be burned without contraindications for reindeer herding. The main and recurrent argument was the fact that, in such forest types, burning favored the growth of the grass *Deschampsia flexuosa* (L.) (Sw.: *sia* or *kruståtel*; Figure 3), which could provide good pasture for the reindeer in the summer, autumn and even early winter (Lappväsendet-Renforskningen 1955).

Wretlind in particular brought to the fore the positive effects of burning for reindeer. The favored growth of *D. flexuosa* after burning was the topic of 80% of the questions in his 1954 questionnaire (see Table 2). One could question whether Wretlind prioritized this topic over lichen pasture because he only wanted to highlight the positive effects of burning on reindeer pasture and thus promote its use further. Another hypothesis is that, while lichen pasture availability is one of the most problematic factors for reindeer herders today, because of the combined effects of forestry, land encroachment, and climate change (Heggberget et al. 2002; Berg et al. 2008; Moen and Keskitalo 2010; Furberg et al. 2011; Sandström et al. 2016), this may not have been the case during the first half of the twentieth century. Indeed, the forest included a greater proportion of old forest at the time, which favors the presence of reindeer lichens, while open areas with summer pasture may have been lacking. The role of prescribed burning in creating summer pasture may thus have been of greater importance for reindeer herders at that time. Although the questionnaire provides a glimpse of the Sami’s views about prescribed burning in the 1950s, any interpretations based on it must be used cautiously. It was written by a forester, and only addressed the biological aspects of reindeer grazing. Moreover, the closed-ended questions and pre-established answers did not allow the reindeer herders to bring any nuance or complexity to their answers. Still, Wretlind’s approach of

obtaining the Sami's views was certainly unusual at the time, and he also used Sami observations to support his conclusions (Lappväsendet-Renforskningen 1955). The growing interest in and proximity with reindeer herders that he developed during the 1950s, which is reflected in his written accounts, and confirmed by the accounts of Malå herders whose parents or grandparents knew Wretlind, exemplify Wretlind's good intentions and his efforts to highlight Sami interests.

For his part, Ebeling (Lappväsendet-Renforskningen 1995), an influential person within the forestry sector, raised doubts about the potential negative effects of prescribed burning for reindeer herding. Considering the matter from a forester's standpoint, he concluded that prescribed burning should not pose any problem for reindeer herding, as long as it was not carried out on dry, lichen-rich forest stands. He questioned the faith in reindeer herders, for example by reflecting on a disputed forest stand. The stand should have been burned according to forestry requirements but reindeer herders disagreed, arguing that it was an '*invaluable pastureland*', even though it was not a lichen-rich forest. Ebeling argued that such cases forced forest managers to '*choose between forest and reindeer*'. Moreover, he argued that the areas affected by prescribed burning in Norrbotten county were '*insignificant*' in comparison with the extent of the reindeer herding area. He affirmed that 83 km<sup>2</sup> were burned during the years 1951-1953, i.e. just 1.2% of the whole forest area over three years. He concluded that '*the apprehensions expressed towards prescribed burning seem to be somewhat exaggerated*'. Ebeling's arguments illustrate the positioning that prevailed in the mid-20<sup>th</sup> century, and still does, among many forest managers unfamiliar with the complexity of reindeer herding. In this instance, the quality of the pasture is equated to the quantity of lichen, and the forest area is considered large enough for reindeer herds to find alternative grazing

lands. Such an understanding only encompasses the biological aspects of reindeer grazing, and the impacts of forestry in terms of total loss or production of vegetation.

In addition, during the 1950s, forestry was modernizing rapidly and developing standardized regeneration methods. To that end, forest managers developed forest stand characterizations and vegetation type classifications to systematize forestry treatments. Wretlind and Ebeling (Lappväsendet-Renforskningen 1955) used such classifications to determine forest types that could be burnt systematically without destroying reindeer pastures. However, although people like Skuncke and Kangas strove for understanding the functioning and the needs of reindeer herding, written accounts show that the herders' ecological knowledge was overlooked. Notably, Sami categories for describing forest and pasture diversity were not included in the discussions transcribed in the 1955 report. The discrepancy between the foresters' and herders' definitions and classifications of forest types and corresponding reindeer pastures may explain some of the conflicts that emerged.

In contrast, Skuncke and Kangas (Lappväsendet-Renforskningen 1955), who interacted more closely with Sami herders, demonstrated a more detailed understanding of reindeer herding and nuanced the positive effects of prescribed burning. Skuncke considered it necessary to consider the time scale when evaluating the effects of prescribed burning on reindeer herding. Based on statements by mountain Sami, he reported how, on burned mesic-humid forest stands, *D. flexuosa* would disappear after a few years, to be replaced in the long term by feather mosses and other plants unpalatable to reindeer. Skuncke also considered how the effects of prescribed burning differed for mountain and forest reindeer herding communities. Coming to the forestlands in December or January, the mountain herding communities could not

take advantage of any *D. flexuosa*. He reported that mountain Sami were ‘not happy’ that large areas were burned near their migration routes and winter pasturelands. For his part, Kangas stressed how prescribed burning could prevent herders from keeping their reindeer within their herding community’s lands, by disturbing the diversity of pasture types that the reindeer needed at different times of the year. Considering all these aspects of reindeer herding, Skuncke argued that ‘the factors that decide whether a stand or a forest type gives occasional or permanent pasture, or whether it is an indispensable reindeer pasture or not, are more numerous than just the biological ones’. Thus, their greater understanding of reindeer herding allowed Skuncke and Kangas to highlight some aspects of prescribed burning that could be problematic from the Sami perspective.

Based on the available written sources, the effects of regeneration burning on Sami reindeer herding during the 1950s-1960s were generally deemed insignificant or positive by forest managers, with some questions raised regarding the durability and spatiality of these positive effects. The sources provide some information on the consequences of prescribed burning on reindeer herding at the time, but above all about how those consequences were understood within the forestry sector by ‘experts’ outside the Sami community. We strongly argue that this external point of view does not provide us with a truly *emic* understanding of reindeer herding–forestry interactions, i.e. the perspective of Sami reindeer herders.

### **Reindeer and burning: insights from Sami knowledge**

The results of the questionnaire that Wretlind presented to Malå reindeer herders in 1954, and his observations on the matter, are summarized in the report from the Jokkmokk course (Lappväsändet-

Renforskningen 1955). The answers to Wretlind’s questionnaire (Table 1m) are a valuable source of information regarding the effects of prescribed burning as perceived by reindeer herders in the 1950s. However, the results were only displayed in the form of a table, and any of the explanations that reindeer herders would have spontaneously provided have not been recorded. Presenting the same questionnaire to Malå reindeer herders today (Table 2) allowed a comparison of the answers given then and now, but above all offered the opportunity to interpret and nuance the “yes/no” answers recorded in 1954, by addressing the herders’ extensive knowledge about reindeer grazing and grazing conditions. With this process, it is also essential to admit the anachronism of the approach, because of the differences in past and present contexts related to reindeer herding, and to identify sources of discrepancy. For instance, since the 1950s the composition of the boreal forest landscape has changed, in part because of the forestry industry, while ecological functions have not. Likewise, both reindeer herds and the practice of Sami herding have changed, notably in reaction to landscape transformations and modernization. However, the knowledge held by the herders about managing reindeer in the boreal forest is still present and can help us understand these changes.



**Fig. 3** *Deschampsia flexuosa* is one of the main pioneer grasses to grow after fire in the boreal forest. *Source:* authors

**Table 2** Results of Wretlind’s questionnaire showing the answers given by the herders in 1954 and in 2018 (Source: Table 1m)

Wretlind’s question	Possible answers	% of respondents in 1954 (n=15)	% of respondents in 2018 (n=9)
1. Have prescribed burnings in Malå district improved the availability of summer pasture?	a) yes	100	78
	<i>substantially</i>	73	78
	<i>insignificantly</i>	27	0
	b) no	0	22
	<i>unchanged</i>	0	22
	<i>worsened</i>	0	0
2. On the burned stands, has wavy hair-grass been important for the reindeer even in the winter?	a) yes	80	78
	<i>substantially</i>	53	22
	<i>insignificantly</i>	27	11
	« intermediately » (category added by the herders in 2018) <i>Did not specify</i>	NA	22
	<i>Did not specify</i>	0	22
	b) no	20	22
	<i>unchanged</i>	20	22
3. On the heathlands within Malå district, has the reindeer pasture been improved through the loggings carried out during forest manager Wretlind’s time, so that the total availability of lichen pasture can be considered bigger than when he started in the district?	a) yes	73	22
	<i>substantially</i>	46	11
	<i>insignificantly</i>	27	0
	« intermediately » (category added by the herders in 2018)	NA	11
	b) no	27	44
	<i>unchanged</i>	27	0
	<i>worsened</i>	0	44
	c) did not answer	NA	34
4. During the winter, do the reindeer dig for wavy hair-grass, if the snow conditions allow it, only during the early winter, during the whole winter, or else how long? (early winter is understood as the winter period before Christmas)	a) early winter	73	55
	b) the whole winter	20	22
	c) unknown	7	0
	d) depends on weather and wind	NA	22

The questionnaire comprised four “yes/no” questions, each of them followed by a sub-question aiming to gain an indication of the degree of the “yes/no” answers. Questions 1 and 2 dealt with the effects of prescribed burning on the abundance of ‘green’, i.e. grass like wavy hair-grass (*D. flexuosa*), and other plants with palatable leaves for reindeer, suitable for summer and winter grazing. Question 3 dealt with the effects of Wretlind’s forest management – the

loggings - on lichen availability, while question 4 sought to gain a deeper understanding of the importance of wavy hair-grass for winter grazing (Table 1). Like 73% of respondents in 1954 who considered that prescribed burnings in Malå had substantially improved the availability of summer pasture (Question 1), the herders we interviewed in 2018 generally agreed that prescribed burning could help summer and also autumn grazing. They specified

that *D. flexuosa* represents an important resource for the reindeer because it is used as a transition fodder between the summer and early autumn pasture, before the first snowfalls, and winter pasture, which comprises above all reindeer lichens. This role of transition pasture also explains why so many herders considered *D. flexuosa* useful in the winter (Question 2), and especially in early winter (Question 4). The use of burned habitats during early winter due to the presence of graminoids has been suggested for caribou in North America as well (Anderson and Johnson 2014). At the same time, herders countered the positive effects of burning on green fodder by arguing that they were only positive for three to 15 years after the fire: the benefits of burning on the vegetation must be considered across all successional stages. Another interesting result from the herders' interviews was that burnings within the summer pasture area did not represent any improvement today because the availability of summer pasture was already sufficient. To one of them, the unanimous answer of the herders in 1954 could be explained by the fact that the summer pasture availability in the mid-20<sup>th</sup> century might have been lower than today, because there was more lichen-rich old forest left, and thus less grass-like vegetation. Indeed, one historical study carried out in a forest area further up north (at latitude 66° in north-western Sweden) (Berg et al. 2008) supports the idea that winter grazing in the first half of the twentieth century was not as critical as it is today.

From our interviews, it was clear that since the main effect of burning on plant communities in the short-term is to promote grasses such as *D. flexuosa*, any positive effects of burning depend on whether the reindeer can actually graze the newly burnt stands in winter or not. This depends on where the stands are located in the landscape in relation to the seasonal grazing pattern of the reindeer, but it also varies from year to year depending on weather and snow conditions. For Sami reindeer herders,

there is no 'pasture' if the reindeer cannot access it through the snow, irrespective of the presence of fodder (Roturier and Roué 2009). While some herders in both 1954 and in 2018 considered that burning did not result in any improvement in winter pasture based on wavy hair-grass (Table 2), others explained that the likelihood of reindeer being able to graze *D. flexuosa* in the winter, and how long they could do it for, varied from year to year, depending on the humidity, consistency and depth of the snow. This variability could explain the herders' differing answers to question 4: 73% of the herders in 1954 and 55% today considered that reindeer could graze *D. flexuosa* during early winter only, while 20% of the herders in 1954 and 22% today considered that the reindeer could graze the grass the whole winter. Because Wretlind's questionnaire did not allow for any nuance or personalized answer, the herders might have answered according to what they believed was the most frequent situation.

Finally, question 3 in Wretlind's questionnaire did not refer explicitly to prescribed burning, but to forest management in general, although in an area heavily affected by prescribed burning (Cogos et al. 2020). In 1954, herders deemed forest management with respect to lichen grounds to be positive. In 2018, herders were more nuanced, or simply did not know what past management included, and thus could not evaluate it. However, the 1970s marked a turning point in the effects of forestry on reindeer herding, and in particular in the decrease in ground reindeer lichens, when mechanical soil preparation replaced prescribed burning in forest regeneration. One herder we interviewed remembered that during Wretlind's time, there was no mechanical soil preparation, and regeneration relied on self-regeneration with seed trees, thus preserving, or possibly even improving the growth of ground lichens.

Because prescribed burning modifies pastureland composition, it also affects the movement of the reindeer herds, and thus

how the herders manage them, an issue that was totally absent from the discussions and the questionnaire in the 1950s. The herders explained that reindeer tend to be attracted to and gather on burned stands in the summer because the dust produced by the trampled ash deters mosquitoes and other insect pests. Herders today see this as a benefit because they have a greater chance of finding and herding the reindeer on burned fields. When prescribed burning was applied intensively in the 1950s, it induced changes in the reindeer movements that forced the herders to adapt their herding practice. For the herders we interviewed who were active during the 1950s and 1960s, the use of prescribed burning at that period, combined with other forestry operations such as clear-cutting, '*changed completely the behavior of the reindeer*', as one herder said, and their movement pattern. As a result, the herders could not find the reindeer where they used to, and they had to look for them across wider areas. At a time when travel was less motorized and the road network less developed than today, this represented a significant hindrance for the herders.

For Sami reindeer herders, the definition of the quality of the pasture is not limited to the total amount of vegetation available, but includes many other factors (Kitti et al. 2006; Roturier and Roué 2009; Roturier 2011). Food resources are essential not only for the survival of the reindeer, but also for the herders to control the movements of their herds and keep them together. Sami reindeer herding today is based on periods of free-roaming for the reindeer alternating with periods of active herding during the seasonal migrations, a general pattern shared with other reindeer-herding societies (Stépanoff et al. 2017). Although reindeer herding in the mid-twentieth century involved greater control and proximity to the herd than today, the general principles have not changed. In reindeer husbandry in general, '*animals play an active part in the pastoral mobility system*' (Stépanoff et al. 2017), and the herders thus need ways to

channel and steer this mobility. The herders rely on their ability to anticipate the vegetation composition and pasture availability at the landscape scale to manage their reindeer, as patches of fodder in the landscape act as natural enclosures that keep the reindeer stationary as long as food is available. Based on the analysis of our interviews, we argue that the effects of prescribed burning on reindeer pasture must be considered at different levels to be consistent with Sami understanding including the effects on the vegetation community and ecological succession, and the herd and the reindeer's mobility patterns.

## Conclusion

We have investigated the history of prescribed burning–Sami reindeer herding interactions in the mid-twentieth century, initially through an analysis of historical written records. As early as 1923, the written sources show that prescribed burning was one of the first forestry measures that received attention from the National Forest Company in relation to Sami reindeer herding. Tracking the development of this issue illustrates how it has contributed significantly in structuring the dialogue between foresters and herders, and the development of the current consultation framework, enacted in the 1979 forestry law. In comparison, Canadian provinces only started to include Indigenous rights, and encourage the participation of First Nations, through mechanisms of consultation and participation, in forest management in the 2000s (Wyatt 2008; Teitelbaum 2015).

The written sources also show that, despite the early attempts to include Sami reindeer herding needs in the planning of prescribed burning, foresters and scholars of the mid-twentieth century missed essential aspects of how prescribed burning could affect reindeer herding. While they discussed the positive and negative effects of prescribed burning on *Cladonia* lichens and *D.*

*flexuosa* vegetation, our interviews show that Sami herders assess the effects on the reindeer herd and its behavior. Reindeer herding functions within a complex spatiotemporal mosaic in which the reindeer move from one patch of resources to another throughout the seasons, guided by the herders to remain within the boundaries of the Sami's herding territory. Consequently, even though prescribed burning might create fodder resources at a particular point in time, it risks disturbing the movement of the reindeer within the landscape. This is true for any forestry measure that disturbs the distribution of pastureland within the landscape. Sami ecological knowledge indicates that prescribed burning, or fire, is neither good nor bad for reindeer herding *per se*, today as in the past, unlike the suggestions made by forestry practitioners who considered that burning fostered reindeer summer pasture without damaging winter pasture, and was thus overall positive for reindeer herding. Rather, the effects are relative to the overall pasture composition within the landscape, the movement pattern of the reindeer and the herders' management of the herd. Such factors were not necessarily foreseen or taken into account by foresters and scientists. Applying Sami ecological knowledge to understand the consequences of prescribed burning carried out during the mid-twentieth century on reindeer herding has thus proved essential to understanding how burning affected the reindeer herding system as a whole, and thus to understanding the position of reindeer herders towards burning across history. More broadly, investigating Indigenous knowledge in order to reinterpret historical sources can be seen as a way to shed new light on events of the past. Furthermore, knowledge of environmental history from an Indigenous perspective provides a basis for deciding how to act in the future in a way that will include Indigenous interests. Despite an apparent willingness to ensure that the Sami can continue their reindeer herding, State

institutions and their representatives in the field have failed, so far, to include the needs of Sami herders properly in forest management. This issue persists today and goes beyond the Swedish case: Ross and Smith (2003) argue that "*at international, national and local levels, Indigenous Peoples and forest managers are struggling to give practical meaning to the broad recognition of the principle of protecting Indigenous Peoples' customary land uses and rights*".

Because prescribed burning offers some potential benefits for Sami reindeer herding, in contrast to other mechanical forest regeneration methods, it represents a possible field for negotiation with the forestry sector, which is obliged to burn 5% of its regeneration area every year. However, to include Sami reindeer herding interests effectively and successfully in forestry planning or biodiversity conservation, Sami ecological knowledge must be included in the planning process. Adopting a co-management system, in which both reindeer herders and foresters can present their perspectives equally, could be a solution, as has been used in other regions (McGregor et al. 2010; Russell-Smith et al. 2013; Eloy et al. 2019). After centuries of a forest management system dominated successively by settlers and foresters, such an inclusive co-management system would, at last, restore some governance to the Sami community regarding the management of the boreal forest.

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- Conflicts of interest / competing interests: The authors have no conflicts of interest to declare that are relevant to the content of this article.
- Availability of data and material: The archive material is referenced and is accessible at the archive center (Arkivcentrum Nord in Härnösand, Sweden). The data of the interviews have been anonymized in accordance with the General Data Protection Regulation. They are kept by the authors and can be consulted on request.
- Consent to participate: Informed consent was obtained from all individual participants included in the study.
- Consent for publication: The participants have consented to the submission of the interview results to the journal.