Relations between forestry and reindeer husbandry in northern Finland - Perspectives of science and practice

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Abstract

The overlapping land use of reindeer husbandry and forestry, both important livelihoods in the boreal forest zone in northern Finland, has led to disputes between the land use forms for over hundred years. In this work we reviewed the literature on impacts of forestry on reindeer husbandry and the impacts of reindeer husbandry on forestry. We studied the perspectives of practitioners in reindeer husbandry and forestry to the impacts of forestry measures on reindeer husbandry and to the relations of forestry and reindeer husbandry. To achieve a holistic understanding and new perspectives on these issues, scientific knowledge was combined with knowledge produced by practitioners, and both recent and archival data sources were utilized. The study showed that a number of conventional forestry measures either decreases the number, surface area and/or the quality of reindeer pastures, which cause mostly unfavorable impacts on reindeer husbandry. The impacts of reindeer husbandry on commercial forests were regarded either detrimental or useful, but mostly marginal. The relations between reindeer husbandry and forestry have improved during the past decades mainly due to the development of the consultations between state forestry and reindeer husbandry. A corresponding, but voluntary consultation procedure was required also for private and jointly-owned forestry. Forestry adapted to reindeer husbandry should include forestry measures aiming at e.g. uneven aged forest structure, saving of old-growth trees, harvesting of logging residues from the most lichen-rich sites, light soil preparation and natural regeneration. Planned forest sector investments in bioeconomy were regarded somewhat positive, since growing demand of wood could mean more effective thinnings of young forests, which would improve the preconditions of both forestry and reindeer husbandry. At the same time reindeer herders were afraid that the development would lead to the loss of the last old-growth forests rich in epiphytic lichens, which are critically important winter pastures of reindeer.

Keywords: boreal forest, reindeer husbandry, herding, winter pasture, forestry, dispute, reconciliation, regeneration, cutting, felling, logging, soil preparation

1. Introduction

Reindeer husbandry and forestry have used the same land in northern Finland for centuries. The spatially overlapping nature of these land use forms has led to disputes between the livelihoods for over hundred years. Reindeer management area (RMA) covers 36 % of the surface area of Finland and is divided into 54 reindeer herding districts (HDs) (**Fig. 1,** see chapter 2.1.). Ninety-one percent the total area of the RMA is classified as forestry land, from which 62% is productive forest land. Within the RMA, 58% of the productive forest land is owned by the state, 33% by private and 10% by others (e.g. municipalities, church, companies) **(Table 1).** Reindeer husbandry, in turn, is based on the free access of semi-domesticated reindeer (*Rangifer tarandus*) to pastures irrespective of land ownership (Reindeer Husbandry Act 848/1990).

Boreal forests are vital for reindeer especially in winter time, when reindeer dig ground lichens beneath the snow cover and forage epiphytic lichens in old forests (Jaakkola et al., 2006; Huusko, 2008; Hallikainen et al., 2010) **(Fig. A.1)**. Of about 200 000 reindeer within the RMA, approximately 60 000 - 70 000 animals are grazing within the boreal forest zone in northern Finland. The importance of boreal forest as a pasture land for reindeer husbandry is the greatest in the southern and central part of the RMA. The disputes between reindeer herders and forest owners have arisen due to the reduction, declining and fragmentation of pastures, particularly old-growth forests by intensive forestry from 1950s onwards (Hyppönen et al., 2010; Saarikoski and Raitio, 2013; Pettersson et al., 2017). Various protected areas, where forestry practices are limited or forbidden are important winter and spring pastures for reindeer (Nieminen, 2010). Within the RMA, the proportion of protected forestry land is about 26% of the total forest land, being highest within the Sami Home area (62%) and the area specially intended for reindeer husbandry (47%) (**Fig. 1; Fig. B.1; Table 2**).

The total volume of forests in northern Finland remained almost the same between the 1920's and the beginning of 1980's. Since then the volume of forests has increased until the present from which it is projected to grow even more mostly due to silvicultural measures and climate change. Since the beginning of 1970s' the growth of forest has been faster than its removal through loggings and natural attrition. In the provinces of Lapland, Kainuu and Northern Ostrobothnia (**Fig. 1)**, the combined total annual growth of forests has been 31 millions m^3 a^{-1} during 2009-13, from which the estimated future logging amount (log, pulpwood) is 18.03 millions m^3 a^{-1} (Salminen, 2015; Korhonen et al., 2017; LUKE, 2018). Pressures for utilizing northern forests in future have grown due to the recent plans of forest sector for the investments in bioeconomy including forest-based biomass for energy and industry purposes due to changes in international and regional energy policies.

The state forests are managed by Metsähallitus, a state-owned enterprize. In northern Finland commercial state forests are most importantly defined and guided by legislation: Forest Act (1093/1996) with its amendments (567/2014), Reindeer Husbandry Act (848/1990), Nature

Conservation Act (1996/1096) and Act on Metsähallitus (234/2016). In addition, environmental guide of Metsähallitus (Päivinen et al., 2011), plans of natural resources and criteria of forest certifications (PEFC Finland Standard 2014) play an important role in the guidance of state forestry. The Forest Act is founded on the international agreements, such as the Convention on Biological Diversity (CBD, 1992) (Lähteenoja, 2018), and its purpose is "*to promote economically, ecologically and socially sustainable management and utilization of forests in order that the forests produce a good output in a sustainable way while their biological diversity is being preserved*". According to the Reindeer Husbandry Act (848/1990), the state land located in an area specially intended for reindeer husbandry (**Fig. 1**) cannot be used so that it will cause remarkable disadvantage to reindeer husbandry. The act includes an obligation to consult representatives of reindeer husbandry: "*when planning measures concerning State land that will have a substantial effect on the practice of reindeer herding, the State authorities must consult the representatives of the reindeer herding co-operative in question*". To fulfill the commitments enacted in the act and in the Co-operation Agreement between Reindeer Herders' Association and Metsähallitus (2013), Metsähallitus organizes annual consultations with each HD. In consultations, logging practices and their timing, alignment of forestry roads, restoration of ditches and soil preparation are discussed. Logging and soil preparation plans are delivered beforehand to HDs, who then have a possibility to propose changes, to suggest additional consultations or to require extra time for their responses. This kind of consultation practice is only used for state-owned forests administered by Metsähallitus (Huusko, 2008).

In Sápmi, Saami Home area (**Fig. 1**), 88% of the total area of forest land is owned by the State (**Table 1**). Approximately 62% of the forestry land and 44% of the productive forest land belong to state-owned protected areas (e.g. national parks and strict nature reserves), wilderness areas, and private protected areas. CBD (1992) plays an important role in the land use planning in Sápmi. Act on Metsähallitus (234/2016) obligates authorities for securing the prerequisites for practicing Saami culture. The Act on the Sámi Parliament (974/1995) requires authorities to negotiate with the Sámi Parliament in "*all far-reaching and important measures which may directly and in a specific way affect the status of the Sámi as an indigenous people*". Since 2013, Metsähallitus has applied the voluntary Akwe Kon Guidelines aiming at "*respect, preserve and maintain knowledge, innovations and practices of indigenous and local communities embodying traditional life styles*" (Juntunen and Stolt, 2013; Markkula et al., 2019).

The impacts of forestry on reindeer husbandry in northern Finland have been studied earlier (Hyppönen et al., 1998; 2010; Kumpula, 2003; Kumpula et al., 2003; 2019; Huusko, 2008; Rytkönen et al.. 2013), but scientific reports are scarce, and the perspectives of practitioners in reindeer husbandry and forestry are not well known. In this study, we analyzed both practitioners' knowledge and scientific knowledge in order to achieve a holistic understanding and new perspectives on the relations between reindeer husbandry and forestry in northern Finland. Our objectives were to review

1) the impacts of forestry on reindeer husbandry, and 2) the impacts of reindeer husbandry on forestry based on recent scientific and professional literature as well as archival sources. We also analyzed 3) the impacts of various forestry practices on reindeer husbandry, and 4) the relationship between the two industries from the practitioners' perspective.

Fig.1.Reindeer management area (RMA) in Finland divided into 54 herding districts (HDs). The RMA is divided into subdivisions: the Sami Home area, the area specially intended for reindeer husbandry, and the other reindeer management area. The borders of the provinces are also marked: 1.Lapland, 2.Northern Ostrobothnia and 3.Kainuu.

Table 1. Proportion of surface area of forestry land in the reindeer management area (RMA) and its subdivisions. Forestry land classes are based on the National Forest Inventory 2015 (LUKE 2019). Forest = Forest land with the annual wood growth is over 1 m^3ha^{-1} (69472 km^2), Poorly prod. = poorly productive forest land with annual wood growth between 0.1 and 1 m^3ha^{-1} (16266 km^2), Unprod. = unproductive land with the annual wood growth below 0.1 m^3ha^{-1} (26252 km^2). The ownership proportions os productive forest land among private, state and other owners (e.g. municipalities, church, companies) are also presented.

	Forestry land of the total area (%)	**Forestry land classes (%)**			**Forest land ownership (%)**		
		Forest	Poorly prod.	Unprod.	Private	State	Other
RMA	91.2	62.0	14.5	23.4	32.5	57.8	9.7
- Sámi home area	89.9	34.4	18.2	47.5	8.2	87.7	4.1
- Area specially intended for reindeer husbandry	92.6	47.6	16.3	36.1	11.7	83.2	5.1
- Other RMA	89.9	75.2	12.9	11.9	44.5	43.2	12.3

Table 2. Proportion of the protected forestry land in the reindeer management area (RMA) and its different subdivisions. Forestry land classes are based on the National Forest Inventory 2015 (LUKE, 2019). Forest = Forest land with the annual wood growth is over 1 m^3/ha, Poorly prod. = poorly productive forest land with annual wood growth between 0.1 and 1 m^3/ha, Unprod. = unproductive land with the annual wood growth below 0.1 m^3/ha.

	Protected forestry land (%)	**Proportion of the protected forestry land (%)**			**Protected of the total class area (%)**		
		Forest	Poorly prod.	Unprod.	Forest	Poorly prod.	Unprod.
RMA	25.8	34.6	16.5	48.9	14.4	29.4	53.9
- Sámi Home area	62.0	24.5	17.6	57.9	44.2	60.1	75.6
- Area specially intended for reindeer husbandry	47.2	32.1	16.6	51.3	31.8	48.0	67.1
- Other RMA	6.4	51.4	16.3	32.3	4.4	8.0	17.3

2. Materials and methods

2.1. Reindeer management area (RMA) in Finland

In Finland, all Finnish citizens can practice reindeer husbandry in contrast to Norway and Sweden where the livelihood is mainly an exclusive right of Sami. In a reindeer herding year 2016-17, there were 193 142 reindeer and 4430 reindeer owners within the RMA (RHA, 2018). In addition to meat production, reindeer husbandry employs in processing meat products, handicraft and tourism. It also has an important position in the cultural and social intercourse of the residents in northern Finland. Environmental conditions, reindeer herding practices and culture vary within the RMA. In the Sami home area (13 northernmost HDs), reindeer herds are bigger and herding is more commonly a main source of livelihood, whereas in southern HDs (other RMA) herding is more often combined with other livelihoods, particularly forestry (Jaakkola et al., 2018).

Reindeer pastures vary from boreal conifer forests to subarctic mountain birch forests, tundra, fells, mires and river banks. Reindeer utilizes different pastures depending on the season (Huusko, 2008; Turunen et al., 2016; Jaakkola et al., 2018) (**Fig. A.1; Fig. B.1**). In winter reindeer grazes in xeric or barren heath forests, spruce forest stands and old forests. When digging lichens beneath the snow cover becomes difficult due to hard or thick snow cover, reindeer start foraging epiphytic lichens if possible. In late winter the availability of epiphytic lichens growing in old-growth pine and spruce forests of xeric, sub-xeric and mesic types is extremely important for reindeer (Jaakkola et al., 2006; Huusko, 2008; Hallikainen et al., 2010). Pine forest is richest in epiphytic lichens at the age of 150-200 years; and spruce forest at the age of approximately 250 years (Helle, 2005). The importance of winter pastures has decreased during the past years, because it is more common nowadays to keep reindeer in enclosures or provide them supplementary feeds in the field. Herders keep reindeer in enclosures not only because of decreased access to or lack of lichen pastures, but also due to predators, which cause

damage to reindeer particularly close to the border of Russia. Enclosures and feeding increase the expenses of reindeer husbandry and thus decrease the profitability of the livelihood. Winter pastures are still important in HDs particularly where reindeer graze without supplementary feeding (Turunen and Vuojala-Magga, 2014).

2.2. Literature survey

Literature survey about the relations of forestry and reindeer husbandry focusing on Finland was based on scientific articles, book chapters and reports of various projects. Searches for relevant literature were made for the period 1988-2019 using online publication databases, search engines (Google Scholar, Web of Science), specialist websites and bibliographies of literature reviews. Search terms included the combinations of the following (also in Finnish): reindeer (reindeer husbandry/reindeer herding), forest (forestry measures/commercial forest), impacts (effects/consequences), reconciliation.

2.3. Archival sources

2.3.1. Professional journals

We studied relations between forestry and reindeer husbandry also from the professional journals and the annual management reports of the HDs. The main professional journal analysed in reindeer husbandry was *Poromies* (appeared since 1931). It has been published by the Reindeer Herders' Association (RHA) (Kortesalmi, 2007). The journal is directed to herders, stakeholders, and others interested in reindeer herding. The articles are written by the executive manager, scientists, authorities and herders from different HDs, and *Poromies* is a commonly used source of information in Finnish reindeer herding research (Kortesalmi, 2007; Helle and Jaakkola, 2008; Vuojala-Magga et al., 2011; Turunen et al., 2018).

We also analysed *Suomen metsänhoitoyhdistyksen julkaisuja* (volumes 1903, 1905-13), a professional journal in forestry, which later appeared as *Metsätaloudellinen aikakauskirja* (volumes 1914-29), *Metsätaloudellinen aikakauslehti* (1938-68) and *Metsä ja Puu* (volumes 1969-1993). The journal was first published by Suomen metsänhoitoyhdistys (later metsäyhdistys, Finnish Forest Association) alone, and later in co-operation with other forestry- related associations. We also analyzed *Metsälehti* (volumes 1939, 1944, 1955, 1960, 1972, 1982, 1992, 2000, 2013), which is published by Tapio, a provider of forest management related advisory and consulting services in Finland. These journals have been directed to practitioners in forestry, forest owners, users of forest products and others interested in forests and forestry.

We read and analysed all the articles related to relations between reindeer husbandry and forestry.

About half of the articles analyzed were written by scientists in reindeer husbandry or forestry. The articles of the professional journals were analyzed using qualitative content analysis (Tuomi and Sarajärvi, 2009). Our aim was to gain a succinct and chronologically coherent, informative description of the material. We identified the following central themes of the articles in chronological order: 1. the impacts of forestry on reindeer husbandry, 2. the impacts of reindeer husbandry on forestry, 3. the reduction of the unfavorable impacts of forestry on reindeer husbandry, 4. reconciliation of forestry and reindeer husbandry, 5. the multiple use of forests, and 6. surveys of reindeer pastures within the RMA. Of these, we focused on themes 1.-4.

Part of the analysed articles have been cited in the text and listed in the References in a similar way as scientific references. In addition, complete lists of the references on the relations between forestry and reindeer husbandry of the studied volumes of the professional journals have been given in the **Appendix C.** The volumes of the analyzed professional journals can be found in, among other locations, the National Repository Library in Kuopio. *Metsänhoitoyhdistyksen julkaisuja* and *Metsätaloudellinen aikakauskirja* are available also in digital collections of the National Library of Finland (digi.kansalliskirjasto.fi).

2.3.2. Annual management reports of the herding districts (HDs)

Herding districts have been obliged to compile an annual management report to the RHA, and 1948-49 onwards the reporting has covered the whole RMA. We analyzed references in these annual reports about the impacts of forestry on reindeer husbandry. We focused on the reports compiled during the period of 1948-84, because after this the form of the report was changed, allowing less detailed explanation of grazing conditions and the effects of forestry measures. This was also the period during which intensive forest management was adopted within the RMA and its first impacts were experienced. Several name changes, merges and divisions of the HDs have taken place during the study period. These have been tracked down during the data analysis, and the present day HD division **(Fig. 1)** has been used as a baseline for the whole study period. Reports contain different writing styles (individuals, decades and districts), and data may be missing due to inexact notes-taking in some HDs during some years (empty reports, missing references on certain subjects; only few reports are totally missing per year). Nevertheless, the annual reports can be considered as valuable historical material. We present some excerpts of the management report references (with HD and herding year) in the Results. They represent authentic, contemporary voices of reindeer herders and their perspectives concerning the effects of forestry on reindeer, pastures, and herding work. We consider this as local knowledge or practitioners' knowledge (Ingold, 2000), which is a valuable source beside scientific observations.

2.4. Survey for practitioners

A survey targeted to practitioners in reindeer husbandry and forestry (n=29) was conducted during the winter 2017-18, as a part of the project "Reindeer husbandry and forestry", a co-operation between Finnish Forest Centre, RHA, Metsähallitus Metsätalous Ltd., Natural Resources Institute Finland, Rovaniemi Unit (LUKE) and The Central Union of Agricultural Producers and Forest Owners (MTK). The practitioners living in the provinces of Lapland and Kainuu were chosen and asked to participate by RHA and Metsähallitus, Metsätalous Ltd. The survey was conducted as interviews (15 practitioners) by one of the authors (JJ) and using the Webropol online survey tool (14 practitioners). We received three responses from 'the Sami Home area', nine responses from 'the area specially intended for reindeer husbandry' and 17 responses from 'the other RMA' (**Fig. 1**). Fourteen of the respondents were practitioners in reindeer husbandry (reindeer herders) and 10 were practitioners in forestry (employed by Metsähallitus or a forest industry enterprise). Five were practitioners in both livelihoods owning reindeer and being employed by Metsähallitus or a forest industry enterprise. Eighty-six percent of all practitioners were forest owners. Ninety-two percent of the forest owners had conducted silvicultural or logging measures during the past 15 years themselves or had someone to conduct work.

The practitioners were asked to estimate the impact of forestry measures on reindeer husbandry including reindeer grazing, reproduction (rut, calving), moving and behaviour of reindeer during the insect harassment period (**Appendix D**.**)**. The forestry measures studied here included different forms of regeneration fellings, thinnings, soil treatments and regeneration practices, restoration of ditches, construction of roads, tending of seedling stands and different types of felling practices as a whole (**Table 3,4**). The practitioners were also asked how reformed Forest Act (1093/1996) with its amendments up to 567/2014) and silviculture based on new recommendations have affected forest regeneration from the point of view of reindeer husbandry. Their opinion was also asked about the expected impacts of the planned investments in bioeconomy in northern Finland (Kaicel, Kaidi, Boreal Bioref) on the operational environment of reindeer husbandry.

The practitioners were asked to estimate the impact of each argument on a scale 1-5. Five means that the activity in question has a favorable (positive) impact on reindeer husbandry, and one means that the activity has an unfavorable (negative) impact. I cannot say (Ics) means that the respondent was not able to evaluate the impact. In addition, the survey included questions for which the practitioners had a possibility to respond more in detail in additional text space (**Appendix D.**).

3. Results

Based on both scientific and practitioners' knowledge we first describe the historical relations between forestry and reindeer husbandry and then focus on presenting results about the impacts of forestry on reindeer husbandry and the impacts of reindeer husbandry on boreal forests and forestry. Finally we report practitioners' perspectives to the impacts of conventional forestry measures of the past decades and those enbled by the recently reformed Forest Act on reindeer husbandry and to the relations between the livelihoods.

3.1. Historical relations between forestry and reindeer husbandry in Finland

Reindeer husbandry and forestry have used the same land in northern Finland for over 150 years. Both land use forms have experienced major changes over the last centuries. When commercial forestry started in the 1850s, it was mainly selective cuttings where the largest sawtimber trees were harvested. Logging pressure was first focused on state forests. The utilization of the northern forests was difficult before the development of road and floating network, and forestry was small-scale and labor-intensive until the World War II (1939-45). Co-existence between forestry and reindeer husbandry was mostly peaceful, and the forestry activities were seen useful for reindeer husbandry. *Poromies*, a professional journal in reindeer husbandry, reported that logging residue attracted reindeer and provided them with a short-term source of lichens in the logging sites, meat could be sold for loggers, controlled burning resulted in rich growth of wavy-hair-grass (*Deschampsia flexuosa*) preferred by reindeer and prevention of forest fires saved the inflammable lichen heath forests which are the most important winter pastures for reindeer (Axelsson, 1954; Alaruikka, 1964; Rajala, 1965; 1967; Vaara, 1972; Helle,1976; Sepponen, 1979; Nieminen, 1984). These observations were later discussed and confirmed by scientific studies (Ruuttula-Vasari, 2004; Kortesalmi, 2007; Parpola and Åberg, 2009).

Already during 1905-15, however, unfavorable impacts of reindeer on regeneration of forest were reported in professional journals in forestry (Anonymous, 1905; 1911; 1915; Reuter, 1907; 1912; Aaltonen 1915a;b; Lakari, 1915). The first disputes between Forestry Board officials and reindeer herders were about lichen tree cutting (reindeer owners assisted feeding of reindeer during difficult snow conditions by cutting trees rich in epiphytic lichens), as well as reindeer grazing, trampling, and peeling of reindeer's antlers on tree seedlings and saplings, and were reported in both professional (Alaruikka, 1964; Pohtila, 1983; Nieminen,1984; Moilanen and Helle,1987) and scientific literature (Itkonen, 1948; Ruuttula-Vasari, 2004; Kortesalmi, 2007). In 1911, the Senate of Finland appointed a commission for studying the condition of reindeer pastures ("Porolaidunkomisioni"), which reported

that forest damages were caused by high reindeer densities (Anonymous, 1914; Porolaidunkomisionin mietintö, 1914; Lindberg, 1915). In 1916 the Senate of Finland granted the herders a licence to herd on state land, but at the same time a quota was set for the maximum number of reindeer (Nyyssönen, 2004).

During the war years, careful intermediate cuttings were replaced by clear cuttings. After the war, wood was needed from the state forests for rebuilding and war indemnities (Anonymous, 1984; Helle and Jaakkola, 2008; Parpola and Åberg, 2009). Wood processing industry (sawn timber, pulp), which expanded made continuous and effective utilization of the forests possible. In addition to forestry, also new settlements and related clearance of agricultural fields decreased the amount of forests. The old-growth forests in the provinces of Kainuu, Northern Ostrobothnia and the southern part of Lapland (**Fig. 1**) came within the forestry in 1950s' (Axelsson, 1954). As logging of forests increased in the 1950s, reindeer herders started paying attention to the unfavorable impacts of forestry on their livelihood. They noticed that loggings quickly reduced the amount of old-grown spruce forests rich in epiphytic lichens and thus deteriorated the quality of winter pastures, which was the most crucial during winters of difficult snow conditions and in regions poor in lichens due to high reindeer densities. When the extensive regeneration measures began as a result of large-scale loggings in the 1960s', the herders observed that their livelihood had become threatened due to the decline of autumn and winter pastures, which forced them to change their herding practices. This was followed by a public debate and critics against forestry for endangering the prerequisites of reindeer husbandry (Huttu-Hiltunen, 1973; 1974; Anonymous, 1984; Nieminen, 1984).

As the demand for wood of northern Finland remained high, the targets of cuttings were kept high and loggings were carried out also in more northern and remote locations. Forestry measures including ditching, planting, fertilizing as well as soil preparations including harrowing and ploughing were at their most active in 1970s' (Parpola and Åberg, 2009). A prevailing perspective among practitioners in forestry was that mires which are preferred spring and summer pastures for reindeer were perceived as waste land, and epiphytic lichen pastures of old-growth spruce forests as an underproductive land. Mires were drained systematically and loggings were concentrated into "stunted spruce stands" (Alaruikka, 1971). Intensive forestry further reduced and fragmented old-growth forest pastures. The age structure of forests became younger and the tree species relations were changed. Norway spruce (*Picea abies*) was replaced by Scots pine (*Pinus sylvestris*). Downy birch (*Betula pubescens*) and Silver birch (*Betula pendula*) were removed as low-value species (Lähde, 1976). Destruction of old-growth forests by intensive forestry in the southern part of the RMA has caused major and permanent changes in the practices of reindeer husbandry since the 1970's. Due to the decline in lichen-rich pastures, reindeer have been started to keep in the enclosures and/or they have been provided with supplementary feeding in the field for several winter months (Näsi, 1992; Helle and Jaakkola, 2008; Parpola and Åberg, 2009; Turunen and Vuojala-

Magga, 2014).

The ideas for developing multiple use of forests, in which forestry and reindeer husbandry could co-exist peacefully, together with recreation, gathering, hunting and tourism emerged in *Poromies* (Huttu-Hiltunen, 1973; Hokajärvi, 1974; Pohtila, 1983; Helle, 1984; Veijola, 1992) and *Metsä ja Puu* (Anonymous, 1974; Mattila, 1983; Saastamoinen, 1984; Veijola 1985) from the beginning of 1970's onwards. Despite of this, the relationship between the livelihoods remained poor and escalated into serious disputes from the 1980s' onwards. For example, the forest conflicts in Sapmi (Inari, Kessi and Nellim) were characterized by complicated ecological, economic, social and cultural questions (Hyppönen and Helle, 2005; Kyllönen et al., 2006; Hyppönen et al., 2010; Saarikoski and Raitio, 2013; Jokinen, 2014; Pettersson et al., 2017). These conflicts from their part set the scene for the start of the multidisciplinary research for solving and improving the relations between state forestry and reindeer husbandry (Hyppönen and Helle, 2005; Mustajoki et al., 2011; Saarikoski et al., 2013).

3.2. Impacts of forestry on reindeer husbandry

3.2.1 Practitioners' perspectives (1950s-80s)

A total of 135 references were found in the annual management reports of the herding districts (HDs) on the effects of forestry on reindeer, pastures, and herding work during the period of 1948-84, (first 1951-52 and last 1983-84). Of this total number of references, 79% perceived forestry negatively and 21% positively. Positive impacts of forestry measures were reported more often in the 1950s and 1960s compared to the following decades **(Table 3, Fig. 2).**

In the 1950s and 1960s, logging sites were seen as important winter foraging areas for reindeer, especially during difficult digging conditions. Herders also reported that sunlight dries the moss and benefits the lichen growth in the clear-cut areas, and mentioned the importance of grassy clear-cut areas for summer and autumn grazing. A positive impact of logging sites on winter grazing as well as on the growth of grass and regrowth of lichen was mentioned also in the 1970s. Fertilization of forests was seen to improve autumn pastures, and regrowth of forest and recovering of pastures was reported in some of the oldest clear-cuts. In the 1980s, the positive perceptions were practically non-existing.

Table 3. The number of references in the annual management reports of the herding districts (HDs) related to the positive and negative effects of forestry on reindeer, pastures, and herding work between the 1950s and 1980s.

Decade	No of references in the management reports of the HDs	Positive effects of forestry on reindeer husbandry (%)	Negative effects of forestry on reindeer husbandry (%)
1950s	18	7 (39%)	11 (61%)
1960s	33	12 (36%)	21 (64%)
1970s	57	9 (16%)	48 (84%)

1980s	27	1 (4%)	26 (96%)
Total	135	29 (21%)	106 (79%)

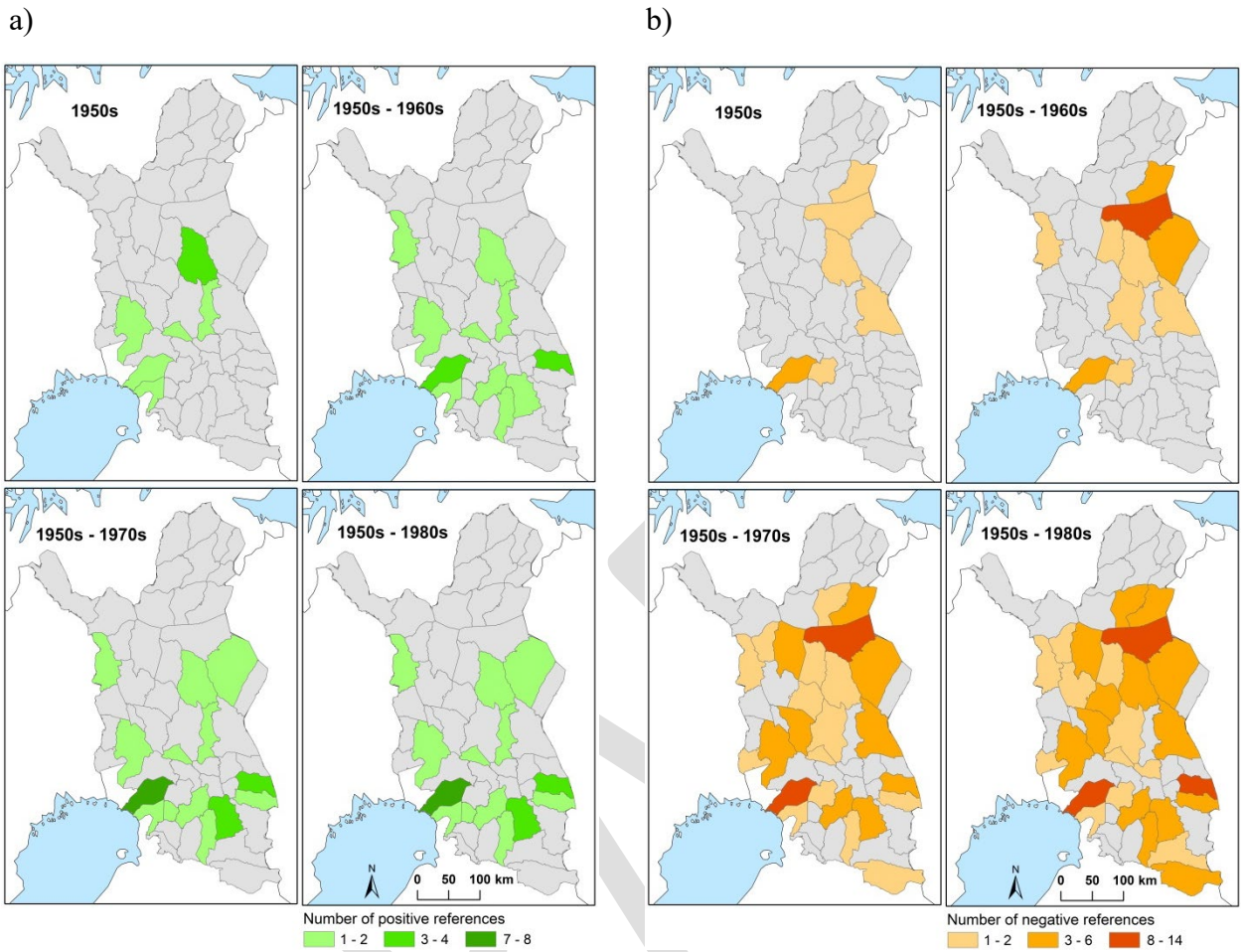

Figure 2. The cumulative number of a) positive references and b) negative references in the annual management reports of herding districts (HDs) on the impacts of forestry on reindeer husbandry between 1950s and 1980s.

A wide variety of negative impacts were listed related to reindeer behavior and well-being, seasonal pastures, and herding work. The negative impacts reported in the 1950s included the decreased area of winter pastures and loss of ground lichen and arboreal lichen due to loggings of spruce forests. Herders also reported lichen loss due to controlled burning and that logging residues left on the ground hindered reindeer foraging.

In the 1960s, loss of winter pastures was experienced in many of the HDs. The negative impacts of forestry methods of that time included for example large clear-cuts, soil scarification, and loss of summer pastures due to drying of mires. Reindeer losses were also experienced at logging sites, as animal died under falling trees (see also Saastamoinen, 1975;1978). The herders reported the following: *"Loss of calves may be due to loggings, which have destroyed forests rich in epiphytic lichens, which would have been useful supplementary feeds for reindeer during deep snow… During difficult winters forests rich in epiphytic lichens have been logged from extensive areas, which has*

resulted in reindeer moving up until the Pyhäjärvi HD which still has a lot of spruce forests rich in epiphytic lichens." (Pyhä-Kallio HD, 1960-61 and 1963-64). "*As a result of extensive clear cuttings, the size of winter pastures in the HD has been reduced by half in size compared to the years after the wars"* (Kemin-Sompio HD, 1962-63). "*Summer pastures have been deteriorated, as particularly Metsähallitus has dried substantial aapa-mires, which have been rich in horsetails and bogbean*" (Isosydänmaa HD, 1969-70).

Large clear-cuts due to the building of two reservoirs Lokka and Porttipahta were mentioned several times in the management reports in the 1950s and 1960s. *"Cuttings due to reservoirs have deteriorated the best pastures already during several years, which has aggravated reindeer herding of the HD and resulted in major damage to the economy of the shareholders of the HD"* (Lappi HD, 1965-66). *"After clear cutting, the best pastures have been ploughed and extensive areas are covered by the reservoir, which has led to the fact that reindeer herds have moved to the neighbouring HDs"* (Lappi HD, 1967-68).

Negative impacts of forestry on reindeer herding were most actively reported in the 1970s in many parts of the RMA **(Fig. 2).** Loss of old-growth forests and consequent lack of reindeer feed during the late winter was frequently mentioned in many HDs. "*There is a lack of epiphytic lichen, late winter forage of reindeer, in a large part of the HD due to extensive clear cuttings by Metsähallitus*" (Pyhä-Kallio HD, 1970-71). First references on supplementary winter feeding and keeping reindeer in enclosures because of the loss of winter pastures were found in the management reports in the early 1970s. Deterioration of pastures due to plowing, scalping, harrowing and ditching was reported. Intensive ditching of mires was seen to deteriorate summer pastures. Deep ditches in the forest caused losses of calves. Effects were also experienced in the herding work: "*As the snow deepens reindeer stop digging and are dispersed into the forests and because cuttings have destroyed old-growth spruce forests rich in lichens, reindeer herds are dispersed in late winter. Dispersed herds makes it difficult to organize supplementary feeding*" (Isosydänmaa HD, 1975-76).

In the 1980s, herders reported how the cumulative impacts of forestry actions over several decades have resulted in decline and fragmentation of pasture land. "*Due to all kinds of building and cutting and soil preparation the pastures are continuously reduced in size"* (Oraniemi HD, 1980-81). *"Winter pastures have started to run short. Spruce-dominated moist forests rich in epiphytic lichens have been cut and dry soils have been ploughed by Metsähallitus. The remaining lichen pastures have been eroded"* (Halla HD, 1981-82). "*Not many winter pastures exist due to earlier cuttings and other forestry measures.*" (Lappi HD, 1982-83). As arboreal lichen pastures were generally lost in many HDs, winter herding practices had to be adapted towards intensive supplementary feeding in enclosures: "*Winter pastures are rather weak due to cuttings. In winter, reindeer are kept in home care*" (Kuukas HD, 1980-81).

3.2.2. Scientific perspectives

Scientific studies in northern Fennoscandia have shown that majority of the forestry measures has unfavorable impact on reindeer pastures, reindeer and reindeer herding work (**Table 3).** Different forestry measures decrease the number, surface area and/or quality of pastures. Conventional regeneration methods such as clear-cutting in which all trees, except retention trees, are removed, have changed the age structure of the boreal forests. The proportion of old-growth forests rich in epiphytic lichens has decreased and the proportion of young forests of equal age has increased (Kumpula, 2003; Berg et al., 2008; Helle and Jaakkola, 2008; Roturier, 2009; Kivinen et al., 2010; 2012; Jaakkola et al., 2013; Sandström et al., 2016; Kumpula et al., 2019). Dense crown cover of young forests can limit the access of solar radiation in the bottom layer and thus decrease the growth of ground lichens (Akujärvi et al., 2014). Also moving of reindeer and reindeer herding work can become more difficult in dense young forests. Fragmentation of old forests and continuous forest cover hinders the efficient use of pasture land, as composition and configuration of the forest landscape becomes less suitable for reindeer grazing and herding (Kivinen & Kumpula, 2014; Kivinen, 2015; Kumpula et al., 2019).

Forestry machines, logging residuals and soil preparation have negative impacts on ground lichens as the soil surface is eroded and the temperature, radiation and moisture conditions as well as the availability of nutrients change. Soil preparation, such as screefing/scalping and harrowing can also result in disappearance and changes in the condition and composition of forage plants in moist forests (Roturier and Bergsten, 2006; Roturier, 2009). Changing snow and wind conditions in the clear-cuts aggravates digging conditions of reindeer, because snow is harder in open areas than in the forest (Roturier and Roué, 2009). Logging residues and high stumps also hinder reindeer winter grazing and reindeer herders' work, such as searching, gathering and moving reindeer (Kumpula, 2003; Kumpula et al., 2003). Forestry measures can also have impacts on the reproduction of reindeer, such as the availability of rut and calving places. Forestry measures may disturb pregnant reindeer and cause accidents for calves and their losses to predators as a result of more difficult moving e.g. due to logging residues and ditches close to the calving areas.

Construction of forestry roads has a negative impact on reindeer, since reindeer may move more easily to unwanted regions, and the roads can attract reindeer thieves and hunters. Disturbances can increase particularly close to the calving areas. On the other hand, due to forestry roads search for reindeer and arrangement for supplementary winter feeding may be easier (Huusko, 2008; Berg, 2010; Hallikainen et al., 2010; Kivinen, 2015; Järvenpää, 2018) (**Table 3**).

Some forestry measures may have positive impacts on reindeer husbandry. Thinning results in increased light and decreased moisture conditions, which improve growth of lichens and other forage plants (Gauslaa et al., 2009; Hallikainen et al., 2010; Akujärvi et al., 2014; Kumpula et al., 2014). Increased visibility makes herding work easier, and grazing conditions of reindeer are improved. In

addition, new reindeer forage plants, such as wavy-hair-grass will appear to the regeneration sites for short-term (Kumpula, 2003; Kivinen et al., 2010) (**Table 3).**

Table 3. The impacts of forestry measures on reindeer husbandry and recommendations for preventing or reducing the damage. Table includes references from both scientific and professional literature.

Forestry measure	Impacts		Recommendations to prevent or reduce damage	Reference
	pasture	**herding work**		16
Regeneration fellings				
Clear cutting	Trees rich in epiphytic lichens disappear, ground lichens and other forage plants deteriorate, decrease or disappear, fragmentation of pasture land, changes in snow conditions	Usability of pasture deteriorates due to changing snow and wind conditions, logging residue and tall stumps; difficult to dig, move and gather herds	trees not logged; longer rotation times; planning the size and location of the sites so that wind conditions would change as little as possible; logging and harvesting during snow, harvest of logging residue from the most lichen-rich sites	Norokorpi, 1982; Anonymous, 1984; Kupiainen and Nieminen, 1985; Näsi, 1992;Pohtila, 2002; Kumpula, 2003;Kumpula et al., 2003; 2004; 2014; 2019 Ottosson-Löfvenius et al., 2003; Huusko, 2008; Roturier and Roué, 2009; Berg, 2010; Hallikainen et al., 2010; Kivinen et al., 2010; 2012; Jaakkola et al., 2013; Horskotte and Roturier, 2013; Kivinen & Kumpula, 2014; Kivinen, 2015; Järvenpää, 2018;
Cover tree, seed tree, shelter tree and strip cuttings	see above	Usability of pasture deteriorates	see above	see above
Site preparation				
Soil preparation				
Screefing, scalping	Ground lichens and other forage plants deteriorate, decrease or disappear	Usability of pastures deteriorate	Lichen-rich places not treated	Anonymous, 1984; Huusko, 2008; Berg, 2010; Hallikainen et al., 2010; Kivinen et al., 2012; Järvenpää, 2018
Harrowing	see above	Usability of pastures deteriorate; difficult to gather and move herds	Avoidance of harrowing; as light method used as possible	Norokorpi, 1982; Anonymous, 1984; Eriksson and Raunistola, 1990; 1993; Huusko, 2008; Berg, 2010; Kivinen et al., 2012
Mounding	Forage plants may increase	Difficult to gather and move herds	Reversible mounding preferred	Huusko, 2008; Järvenpää, 2018
Reversible mounding	see above			Huusko, 2008; Järvenpää, 2018
Ditching combined with mounding	see above	Difficult to gather and move herds; increased damage to calves	Reversible mounding preferred	Huusko, 2008; Järvenpää, 2018
Adjustable ploughing	Some forage plants may increase	Difficult to gather and move herds	Avoidance of ploughing; as light method used as possible	Norokorpi, 1982; Anonymous, 1984; Autto, 1987; Eriksson and Raunistola, 1990, 1991;Huusko, 2008; Berg, 2010; Kivinen et al. 2010; Järvenpää, 2018
Restoration of ditches	Forage plants disappear under ditches, some of them may increase	Difficult to gather and move herds; increased damage to calves particularly close to the calving areas	Incline and building routes over ditches to make moving of calves easier	Anonymous, 1984; Huusko, 2008; Berg, 2010; Järvenpää, 2018
Controlled burning	Lichens disappear, forage plants increase in a long run	Burning logging residue facilitates digging and moving of reindeer; gathering and moving herds	Avoidance of controlled burning in lichen rich forests; burning in more productive sites	Anonymous, 1984; Huusko, 2008; Berg, 2010; Kivinen et al, 2010; Järvenpää, 2018
Construction of forestry roads	Lichens and other forage plants disappear in the sphere of road influence	Reindeer move to undesirable regions, increased disturbances close to calving areas, may attract reindeer thieves and hunters;	Avoidance of construction roads through important reindeer pasture areas	Anonymous, 1984; Pohtila, 2002;Huusko, 2008; Berg, 2010: Hallikainen et al., 2010; Kivinen, 2015; Järvenpää, 2018

		Easier for herders to search for reindeer and organize supplementary feeding		
Fertilizing	Species composition and abundancy of vegetation may change, lichens may decrease	Reindeer may avoid fertilized regions. Risk of poisoning	Avoidance of fertilizing in lichen-rich forest stands	Eriksson and Raunistola, 1993; Olsson and Kellner, 2006; Huusko, 2008; Berg, 2010; Kivinen et al., 2010
Intermediate fellings				
Cutting of hold-overs	Trees rich in epiphytic lichens disappear	Usability of pastures deteriorate	Harvest during snow season, harvest of logging residue from the most lichen-rich sites	Huusko, 2008; Järvenpää, 2018
First thinning	Lichen growth improves	Usability of pastures improved, visibility improved, easier to gather and move herds; difficulties in herding work due to logging residue	Thinning strong and early enough, during snowy season particularly close to round up fences, harvest of logging residue from the most lichen-rich sites	Kumpula et al., 2004; Huusko, 2008; Berg, 2010; Hallikainen et al., 2010; Järvenpää, 2018
Thinning	Trees rich in epiphytic lichens disappear, lichen growth improves	see above	see above	Huusko, 2008; Berg 2010; Hallikainen et al., 2010

1 Anonymous 1984, 2 Autto 1987, 3 Berg 2010, 4 Eriksson and Raunistola 1990, 5 Eriksson and Raunistola 1993, 6 Hallikainen et al. 2010, 7 Horskotte and Roturier 2013, 8 Huusko 2008, 9 Jaakkola et al. 2013, 10 Järvenpää 2018, 11 Kivinen 2015, 12 Kivinen et al. 2010, 13 Kivinen et al. 2012, 14 Kivinen & Kumpula 2014, 15 Kumpula 2003, 16 Kumpula et al 2004, 17 Kumpula et al. 2014, 18 Kumpula et al. 2019, 19 Kupiainen and Nieminen 1985, 20 Norokorpi 1982, 21 Näsi 1992, 22 Olsson and Kellner 2006, 23 Ottosson-Löfvenius et al. 2003, 24 Pohtila 2002, 25 Roturier and Roué 2009.

3.3. Impacts of reindeer husbandry on boreal forest and forestry

Reindeer have multiple effects on boreal forest by selective grazing, trampling and fertilizing. Reindeer change the composition, structure and abundancy of vegetation, and they usually accelerate below-ground processes such as decomposition of dead organic material and nutrient cycling. Studies have shown that the impacts of reindeer on boreal forest are greatly dependent on the site type, reindeer density and the season in question (Väre et al., 1996; Stark et al., 2000; 2003; Olofsson et al., 2010; Köster et al., 2013; 2015; Akujärvi et al., 2014; Santalahti et al., 2018). As reindeer is highly adapted to utilize lichens, its winter grazing is targeted to the nutrient-poor lichen-rich habitats: xeric, sub-xeric and barren forests. Winter grazing of reindeer decreases mostly the amount of terricolous lichens and epiphytic lichens (Väre et al., 1995; 1996; Stark et al., 2000; 2003; denHerder et al., 2003; Köster et al., 2013; 2015; Akujärvi et al., 2014; Kumpula et al., 2015; 2019). The changes in the composition of understorey vegetation of lichen-rich forests may include either an increase, e.g. in the abundancy of *Stereocaulon sp*. lichens at the expense of *Cladonia sp*. lichens or an increase in the abundance of

bryophytes at the expense of lichens (Väre et al., 1995; 1996; den Herder et al., 2003). At the same time, the biomass of vascular plants, including dwarf shrubs may be either decreased, unaffected or even increased due to grazing (Stark et al., 2000; Susiluoto et al., 2008; Olofsson et al., 2010; Köster et al., 2015). In winter, snow cover protects vegetation and grazing is targeted only to that part of vegetation where reindeer have been digging. Winter grazing does not thus affect vegetation as strongly as summer grazing (Kumpula et al., 2011). During summer, reindeer diet can consist of hundreds of different plant species, mostly sedges, shrubs, herbs and some deciduous tree species. The biomass of summer forage plants can greatly decrease due grazing, but their regeneration is often effective (Warenberg et al.,1997; Norberg et al., 2001; Turunen et al., 2009).

In Finland, lichens have decreased in the winter pastures of the RMA for the whole 1900s', and especially after 1970s' (Kumpula et al., 2014). Greatly decreased proportion of lichens can be explained by other land use, particularly forestry, high reindeer densities (Kumpula et al., 2013; 2019), and increased competition of lichens with other faster growing species, such as shrubs, due to climate change (Turunen et al., 2009). The impact of reindeer husbandry on lichen pastures depends not only on reindeer densities, but also on herding practices. For example, a lack of pasture rotation exposes lichen-rich winter pastures to summer time trampling by reindeer. A full seasonal pasture rotation may be difficult to organize in a number of HDs, however, due to the lack of seasonal pastures or other land use (Kumpula et al., 2009; 2011; 2013; 2014; 2019).

The detrimental impacts of reindeer grazing and trampling on regeneration (Suominen and Olofsson, 2000; Koster et al., 2013; 2015) or seedling stands (Pohtila, 1983; Helle, 1987; Moilanen and Helle, 1987; Helle and Moilanen, 1993; Roturier and Bergsten, 2006) of the forests have been discussed in both scientific and professional literature. Reindeer digging lichens through the snow can cause direct damage or indirect frost damage to seedlings in winter pastures (Moilanen and Helle, 1987; Roturier and Bergsten, 2006). In addition, herding work, such as moving reindeer herds through the seedling stands e.g. to the round up sites and supplementary winter feeding of reindeer in the seedling stands can damage seedlings due to trampling of reindeer and peeling of their antlers (Alaruikka, 1952; Moilanen and Helle, 1987). Damage to seedlings can also be caused by hares where reindeer are given supplementary feeds, since hares eat not only hay meant for reindeer but also seedlings close to the feeding places (Mäkitalo et al., 1998).

Reindeer grazing can be also useful for regeneration of pine. Emergence of seedlings can become easier when reindeer makes lichen cover thinner and prepare soil. In habitats where lichen cover is scarce soil temperature and moisture conditions can be more favourable for seedling and tree growth than under the lichen cover, which isolates heat (Alaruikka, 1952; Helle and Nöjd, 1992; Roturier and Bergsten, 2006; Fauria et al., 2008). Recruitment of pine seedlings may also benefit from reindeer grazing of lichens, because lichens excrete allelopathic extracts (Brown and Mikola, 1974), which inhibit the development of mycorrhiza in pine seedlings.

Reindeer grazing limits the growth of birches in summer pastures, because birch leaves are an important part of the summer diet of reindeer (Warenberg et al., 1997; Norberg et al., 2001). When reindeer use birch leaves as forage, it may delay growth and delay or inhibit natural regeneration of birch (Hyppönen, 1998; Kubin and Savilampi, 1998; Mäkitalo et al., 1998; Jalkanen, 2001). The situation can be complicated in regions where regeneration is difficult, and naturally regenerated birch could be a valuable addition in commercial pine seedling stands (Lust et al., 2001). On the other hand, the impact of reindeer summer grazing on birch can be favourable in regions where sprouting of birch hampers the development of cultured pines. In these sites reindeer grazing can reduce the need of clearing the seedling stands (Helle and Lyykorpi, 1987; Härkönen, 1988).

3.4. Recent perspectives of practitioners

We report the results from the survey by presenting the practitioners' perspectives firstly on the impacts of conventional forestry measures used during the past decades on reindeer husbandry, secondly, on the impacts of forestry measures enabled by the recently reformed Forest Act (1093/1996) with its amendments (567/2014) on reindeer husbandry, and thirdly, on the relations between the livelihoods.

3.4.1. Impacts of conventional forestry measures

The practitioners estimated that from the conventional **regeneration felling** methods, clear-cutting has the most unfavorable impact on reindeer husbandry (see **Table 3** for the impacts), whereas seed tree felling (50 -100 pines ha^{-1} are left as mother/seed trees) has the least unfavorable impact on it (**Table 4**). Practitioners in reindeer husbandry reported that instead of clear cutting, new practices enabled by the reformed Forest Act (1093/1996; amendments up to 567/2014 included) should be favoured, e.g. continuous-cover silviculture, small-scale clear-cutting, selection cuttings with no gaps and upper-layer thinning and natural regeneration (**Table 4**). The practitioners considered it important to conduct regeneration fellings during a thick snow cover to facilitate reindeer winter feeding with epiphytic lichens of the logged trees, to cut trees into low stumps and to harvest logging residues from the most lichen-richest sites.

The practitioners considered that almost all **soil preparation** methods, particularly adjustable plowing, are damaging to reindeer husbandry (see **Table 3** for the impacts). Only controlled burning was regarded somewhat favourable. In their opinion, soil preparation should be as light as possible, and that it should not cause barriers for moving and transportation of herds (**Table 4**). Therefore, in addition to building routes across the soil treatment site for the herds, one should take into account the direction of soil treatment. The practitioners also pointed out that barren and sub-xeric heath forests,

as well as sites which already have a natural seedling stand or are expected to get it should remain unprepared. Practitioners in forestry notified that there is a need to develop a new soil preparation method for sorted, less stony and barren soils; an intermediate method between unpreparation and the lightest soil preparation method available at present. Controlled burning was seen a good method from the point of views of both forestry and reindeer husbandry and its use should be increased.

All practitioner groups estimated that natural **regeneration** is a more favourable method to reindeer husbandy than cultivation by sowing or planting (**Table 4).** Natural regeneration and as light soil preparation methods as possible should be used to prevent detrimental impacts on reindeer husbandry. It was also reported that selection of the regeneration method is a target-specific consideration, as there is no single model to be used. It was also emphasized that reindeer husbandry should be taken into account not only in state forests, but through voluntary consultations also in private and jointly owned forests.

The practitioners regarded the impact of all presented **thinning** methods somewhat favourable for reindeer husbandry, the first thinning being the most favourable (**Table 4**). They reported that tending seedling stands should be made more effective both in private and state forests, because dense seedling stands prevent growth of lichens due to lack of light, and deteriorate visibility and prevent moving, which makes gathering herds difficult. The routes of reindeer and all-terrain-vehicles (ATVs) should be taken into account particularly close to the round-up sites. Thinning should be conducted early enough and during appropriate season (e.g. during frozen soil before deep snow) based on the consultations with the HDs. Thinnings should not be conducted during deep snow, because remaining tall stumps make moving complicated, and a risk for accidents of herders is increased. Herders also recommended to harvest logging residue from the most lichen-rich sites.

Practitioners in reindeer husbandry estimated that **construction of forestry roads** through important pasture areas is unfavorable for reindeer husbandry (**Table 4)**, because the roads increase traffic, which is detrimental particularly during calving and round ups. Roads can also make access of hunters and reindeer thieves easier to the herds. On the other hand forestry roads can be utilized in reindeer husbandry for monitoring and gathering reindeer and for organizing supplementary winter feeding for the herds.

Practitioners in reindeer husbandry reported more often than those in forestry that **restoration ditching** is detrimental for reindeer husbandry (**Table 4).** Reindeer herders reported that ditches make moving of reindeer and herders difficult. The ditches should have gentle edges/banks to make moving easier. Routes for moving should be added, so that animals could get out from the ditches and ATVs and snowmobiles could drive across them. One informant estimated that the number of ditches has decreased significantly, even into one-third on state land during the past ten years. It was also suggested that mires with poor tree stands should be restored/reconstructed, so that the amount of important summer forage plants such as buckbean (*Menyanthes trifoliate*) would increase.

3.4.2. Impacts of the forestry measures enabled by the reformed Forest Act

The reformed Forest Act (1093/1996) with its amendments (567/2014) enables new ways of carrying out forestry activities with less detailed regulation. The amendments to the Forest Act increase the freedom of choice of forest owners in managing their forest property, improve the profitability of forestry and operating conditions of wood-producing industry, and enhance the biodiversity of forests (MAF, 2018). In the reformed act, age and diameter limits in regeneration are removed, and a more diverse tree species selection is allowed. Under the former act, regeneration felling was not possible before the trees had reached sufficient size and maturity for use as logwood. The most important changes include allowing uneven-aged forest stands. To support the profitability of forestry, the new act facilitates upper-layer thinnings in which the largest trees are removed, whereas in the lower-layer thinnings the smallest or weakest trees are removed. Particularly the regulation related to the outstandingly important objects of the environment was specified. The act aims at responding to the needs of bioeconomy for increasing the loggings while at the same time the biological diversity of the forest is preserved and the legislation is clarified (Lähteenoja, 2018; MAF, 2018).

All practitioner groups reported in the survey that the fact that forest owner can determine the length of rotation period of the forest (limits of sturdiness and age were removed) (**Table 4**) is the most unfavorable change made in the forest law from the point of view of reindeer husbandry. Reindeer herders were afraid that this change would result in a temptation of forest owners to regenerate their forests too early, to conduct "*final fellings in young forests*" and speed up of soil preparation ("*soil surface would be continuously broken*").

Practitioners reported that by including outstandingly important objects of the environment to the law, allowing small-scale clearcutting (< 0,3 ha) and intermediate felling of forest of uneven age structure and equalizing natural regeneration and cultivation are favourable for reindeer husbandry (**Table 4**). They notified that equalizing natural regeneration and cultivation is expected to lead to an increase in natural regeneration.

The survey included a question of which method would be the best practice for felling young forests. Seventy-nine percent of all respondents estimated lower-layer thinning, and 21% upper-layer thinning as the best practice method in tending the seedling stands (**Table 4**). All practitioners in forestry supported lower-layer thinning. It was reasoned firstly by the fact that when the smallest trees are removed, the remaining trees grow much faster. Secondly, in lower-layer thinning more trunks can be removed from the site, and less dense forest is easier for moving. It also improves visibility and recovery of lichens. Those who preferred upper-layer thinning, notified that it improves availability of light, keeps the site continuously forested and soil surface unbroken. The method was also supported since the large dominating trees could provide plenty of epiphytic lichens for reindeer when logged

(**Table 4**). Some reindeer herders informed that selection of the thinning method is case-specific. Also a mixture of the both thinning methods could be used: first thinnings as lower-layer thinnings and loosening thinning at least partly as upper-layer thinning. In accordance to a mixed form e.g. small-scale clear-cutting would be a good method.

The practitioners were also asked whether they preferred conventional clear-cutting or keeping regeneration area continuously forested. Sixty-one percent of all practitioners preferred a regeneration method in which the site is kept continuously forested and 39% preferred conventional clear-cutting) (**Table 4).** Almost all practitioners in reindeer husbandry (93%) were against clear-cutting and in favour of continuous forestation, because it makes natural tree stand survival possible, and there is no need for soil preparation and planting of seedlings.

Practitioners were for and against the different regeneration methods enabled by the reformed Foresty Act (**Table 4).** Some preferred small-scale clear-cuttings with groups of retention trees, and some seed-tree cuttings. Ninety-three percent of practitioners in reindeer husbandry preferred keeping sites continuously forested, because it results in fewer disturbances in the region. Keeping site continuously forested was also supported not only due to good timber production and income, but also due to more effective carbon sequestration through improved growth of forest stands and smaller soil surface area to be prepared.

3.4.3. Relations between forestry and reindeer husbandry

Practitioners reported that the development during the past ten years regarding forestry measures has been somewhat unfavorable for reindeer husbandry (**Table 4).** Practitioners in reindeer husbandry had clearly more negative views to these developments than those in forestry. Negative views to forestry methods were related to too high logging amounts, logging of old-growth trees, moving machines too close to the reindeer fences, undone thinnings and logging residues left on the site. Practitioners in forestry, in turn reported that there is a need to gain better knowledge about the truly significant regions for reindeer husbandry.

The development regarding co-operation between practitioners in forestry and reindeer husbandry was seen favourable (**Table 4).** Practitioners were in general satisfied with the Co-operation Agreement between Reindeer Herders' Association and Metsähallitus (2013). A number of reindeer herders informed that in state forests the development has been good due to consultation procedure between Metsähallitus and reindeer husbandry. No such development can be seen in private and jointly-owned forests,however, due to a lacking legal obligation for having consulting negotiations between the livelihoods. A corresponding, but voluntary procedure of consultations between private forests; and reindeer husbandry was therefore required. Information flow from Metsähallitus to HDs

could be made even more effective not only by having more meetings, phone calls and electronic mail, but also by using compatible data systems and real time geographic information.

The planned bioeconomy investments were estimated to have somewhat positive impacts on the operational environment of reindeer husbandry (**Table 4)**. As discussed earlier, reindeer husbandry would benefit from thinnings because growth of lichens and visibility are improved due to less dense forests. Reindeer herders were unanimously afraid that if the investments are realized, the demand of raw materials increase and after thinnings have been conducted, old-growth forests, which are critically important winter pastures of reindeer, will be exposed to fellings. New bioeconomy investments would benefit reindeer husbandry only if the forest enterprises acquired raw material only from thinnings and old-growth forests were not logged. Practitioners in forestry stressed that bioeconomy investments will be based on undone thinnings, and believed that all would benefit from the bioeconomy investments, which would also bring employment to the region.

Table 4. Mean values calculated from the estimations given by the practitioners to the questions presented in the survey. Estimations were given on a scale 1-5. (1=unfavorable/negative impact, 5=favorable/positive impact).The numbers in each question refer to the numbers in the survey (**Appendix D**.). Values below three are bolded.

	Reindeer husbandry	Forestry	Reindeer husbandry forestry	All
4. What is the impact of different forestry measures on grazing, reproduction (rut, ca moving and behaviour of reindeer during insect harassment period?				
4.1. Regeneration fellings:				
4.1.1 Clear cutting[1] avohakkuu	**2,42**	3,34	**2,81**	**2,86**
4.1.2 Nurse crop cuttings[2] verhopuuhakkuu	**2,71**	3,54	**2,93**	3,06
4.1.3 Seed tree cutting[3] siemenpuuhakkuu	3,08	3,34	3,3	3,24
4.1.4 Shelterwood felling[4] suojuspuuhakkuu	3,18	3,5	**2,83**	3,17
4.1.5 Strip felling[5] kaistalehakkuu	**2,41**	3,25	3,28	**2,98**
4.2. Thinning (timing, logging residue)				
4.2.1 Cutting of hold-overs[6] ylispuuhakkuu	3,23	3,46	3,54	3,41
4.2.2 First thinning[7] ensiharvennus	3,79	4,27	4,1	4,05
4.2.3 Loosening fellings[8] väljennyshakkuu	3,85	4	3,9	3,92
4.3. Soil treatment				
4.3.1 Screefing /scalping[9] laikutus	**2,62**	3,18	**2,83**	**2,88**
4.3.2 Harrowing[10] äestys	**2,19**	**2,92**	**2,37**	**2,49**
4.3.3 Mounding combined with screefing[11] laikkumätästys	**2,14**	3,02	**2,67**	**2,61**
4.3.4 Mounding combined with making small grooves for water flow[12] naveromätästy	**2,16**	**2,61**	**2,47**	**2,41**
4.3.5 Adjustable plowing[13] säätöauraus	**1,71**	**2,33**	**2,37**	**2,14**
4.3.6 Controlled burning[14] kulotus	3,79	3,66	3,4	3,62
4.4. Regeneration practice				
4.4.1 Natural regeneration	3,66	3,76	3,63	3,68
4.4.2 Cultivation (planting, sowing)	**2,15**	3,29	3,13	**2,86**
4.5. *Restoration of ditches*	**1,74**	**2,8**	**2,27**	**2,27**

4.6. Construction of roads	**2,85**	3,85	3,5	3,4
4.7. Tending of seedling stands	3,56	4,19	3,87	3,87
5. What kind of felling practice would be the best practice as a whole for felling youn forests?				
Lower-layer thinning[15]	57 %	100 %	80 %	79 %
Upper-layer thinning[16]	43 %	0 %	20 %	21 %
6. What kind of felling practice would be the best regeneration practice as a whole?				
Keeping the area forested	93 %	30 %	60 %	61 %
Conventional clear cutting with its regeneration methods	7 %	70 %	40 %	39 %
8. How amended Forest Act and silviculture based on renewed recommendations wi impact forest regeneration from the point of view of reindeer husbandry?				
8.1. Limits of sturdiness and age were removed. Forest owner determines rotation period	**2,14**	3,11	**2,67**	**2,64**
8.2. Method for conducting intermediate felling can be reasoned by the forest owner (uppe thinning)	3,77	3,63	3,4	3,6
8.3. Small-scale clearcutting (< 0,3 ha) and intermediate felling of forest of uneven age structure are allowed	4,15	4,5	4,6	4,42
8.4. Natural regeneration and cultivation are equal.	3,71	4,38	4,6	4,23
8.5. Regulation of tree species selection was loosened – not bound to habitat	3,64	4,14	4	3,93
8.6. Outstandingly important objects of the environment were added	4,45	4,43	5	4,63
9. How do you estimate the impacts of the planned bioeconomy investments on the operational environment of reindeer husbandry?				
9.1. Kaicel	3,42	3,83	3,67	3,64
9.2. Kaidi	3,38	4	3,8	3,73
9.3. Boreal Bioref	3,57	4,33	3,8	3,9
11. What has been the development like during the past ten years?				
Regarding forestry measures	3,21	4,4	3,8	**2,47**
Regarding co-operation between practitioners in forestry and reindeer husbandry	3,57	4,2	3,8	3,86

[1]All trees, except retention trees, are cut from the site.
[2]A method used particularly on regeneration sites of Norway spruce, in which deciduous trees are left covering seedling stands to prevent them from the impacts of frost.
[3]A method for regenerating barren heath forests, in which 50 -100 Scots pines/ha are left as mother/seed trees.
[4]A method for regenerating Norway spruce, in which shelterwood is left covering spruce seedlings, which prevents abundant growth of grass and sprout by shadowing and evens out temperature variation and protects seedlings both from intensive solar radiation and frost.
[5]Conifer forest is regenerated naturally with the help of edging forest. The width of a strip to be cut in the forest is about 25m from the edging forest.
[6]Taller than dominating trees, shading trees are removed, e.g. seed/mother trees.
[7]Young, growing trees are thinned to increase space to grow for the trees left in the forest.
[8]Thinning form of trees (>16cm, >25yrs) the purpose of which is the same as in first thinning.
[9]A soil preparation method for barren heath forests, in which soil surface is broken lightly to improve emergence of seedlings.
[10]A soil preparation method used in barren soils, in which mineral soil is exposed by making ca 60cm wide, uniform or intermittent parallel lines, spaced every ca-5m.
[11]Mounding is a suitable soil preparation method for fine, weakly permeable mineral soils and most peat soils. Mounds are made, on which seedlings are planted. Mounding combined with screefing and reversible mounding are the most common mounding methods.
[12]A soil preparation method for wet/moist mineral soils and peat soils in locations which require drying. It is used when basic drainage is in order, but surface waters can cause problems.
[13]Adjustable plowing is conducted by using a plough drawn by a tractor, which can be used for adjusting the depth and width of plowing track. It is used as a soil preparation method nowadays only rarely.
[14]Controlled burning is suitable for regeneration of Norway spruce dominated forests on moraine soils of sub-xeric and mesic heath forests. Areas of controlled burning are prepared by harrowing or screefing and regenerated in general by sowing with Scots pine. Controlled burning results in a release of nutrients for the use of trees and soil becomes less acidic.
[15]Mostly small diameter trees left under the dominating trees are removed.
[16]Mostly taller than the dominating trees are removed.

4. Discussion

4.1. Relations between forestry and reindeer husbandry

Both scientific and practitioners' knowledge agreed that the historical relations between the livelihoods have been complicated within the Finnish RMA. Archival sources in forestry revealed unfavorable impacts of reindeer husbandry on regeneration of commercial forests already in the beginning of 20th century, but after reindeer husbandry was regulated, sanctioned and territorialized in a new way (Nyyssönen, 2004) the number of such writings was decreased. Archival sources, particularly the annual management reports of the HDs, described significant negative impacts of forestry on reindeer husbandry, which have accumulated since the 1950s due to the intensification of forestry after the Second World War until the present. The unfavorable impacts of forestry on reindeer husbandry have been mostly caused by clear-cutting and ploughing, which have aggravated the prerequisites of reindeer husbandry by many ways. Similar developments and disputes have been experienced also in neighboring regions such as Sweden and Norway, but also in North America (Whitney, 1994; Östlund et al., 1997; Widmark, 2006; 2009; Berg, 2010). During past years, also improvements have taken place: for example, Metsähallitus has totally given up adjustable ploughing as a soil preparation method within the RMA, and it is used nowadays only on thick humus soils of private forests in eastern part of the region (Finnish Forest Centre, 2019).

The present survey indicated that reconciliation of reindeer husbandry and state forestry has improved during the past decades. Metsähallitus applies more interactive and participatory planning for prevention and governance of conflicts between the livelihoods than earlier. The respondents were rather satisfied with the present consultation procedure between Metsähallitus and HDs (Co-operation Agreement between Reindeer Herders' Association and Metsähallitus, 2013). The consultation procedure used in Finland is comparable to that in Sweden, with the exception that in Sweden the regulations are defined in the Forestry Act, they are organized by Skogstyrelsen (2017) and besides state-owned forests, also the owners of private forests are consulted if the size of forest holding is over 500 hectares or the size of the planned regeneration site is over 20 hectares (Sandström et al., 2006; Widmark, 2006; 2009; Berg et al., 2008; Huusko, 2008; Berg, 2010).

Reindeer herders were well aware that private and jointly-owned forestry in Finland do not have a legal oblicgation to take into account the needs of reindeer husbandry in a similar way as state forestry has to do. Private forestry is important in the southern RMA, as 45% of forest land outside the area specially intended for reindeer husbandry is owned by private owners, e.g. municipalities, church and companies (**Fig. 1, Table 1)**. Open conflicts are not so easily formed between reindeer husbandry and private forestry, however, because the threshold for criticizing state forestry may be lower than for private forests due to collective characteristics of national heritage (Jokinen, 2014). In addition, many reindeer herders are engaged in private forestry for important extra income received

from cuttings or forestry work. Reindeer herders may also own forests located in another HD, which means that the cuttings are not targeted to the pastures of their own HD (Jokinen, 2014). The practitioners who responded to the survey required or hoped for a voluntary consultation procedure between reindeer husbandry and private forestry.

PEFC-certification provides that forestry measures in state forests within the RMA are reconciliated with reindeer husbandry through the local co-operation so that the requirements for practicing reindeer husbandry are secured (PEFC Finland Standard, 2014). PEFC also provides that in Sapmi, land and resources are managed so that the preconditions for practicing traditional Sami livelihoods and culture are secured. Approximately 85% of the forests in Finland are certified with PEFC. The criteria of PEFC certification do not however apply to private forests within the RMA. Part of the Finnish forest enterprises and jointly-owned forests follow FSC certification, whose criteria apply also to private forests (FSC standard for Finland 2010). According to the principles of FSC certification the prerequisites of reindeer husbandry have to be taken into account regardless of the forest owner. However, less than 10% of forests have been certified with FSC in Finland. Nowadays forest enterprises often require that the timber they buy is from forest owner who follows the criteria of the FSC certification system. This would improve the prerequisites of reindeer herding in private forests (Järvenpää, 2018).

4.2. Forestry measures adapted to reindeer husbandry

Reindeer husbandry has had to adapt to the requirements of forestry for decades, not completely however, since forestry has taken reindeer husbandry into account locally, e.g. by cutting or allowing herders to cut trees rich in lichens to feed reindeer when snow conditions have been difficult for digging. For the past twenty years, both scientific and practitioners' knowledge about the effects of conventional forestry measures on reindeer husbandry has accumulated (Huusko, 2008; Kivinen et al., 2010; Järvenpää, 2018). The practitioners reported that the forestry measures adapted to reindeer husbandry, which aim at minimizing the disturbance to reindeer husbandry **(Table 3, Table 4)** (Järvenpää, 2018) should be applied more often. Unfavorable impacts experienced by reindeer husbandry could be reduced significantly by planning, targeting and timing of loggings and other forestry measures appropriately for reindeer husbandry. In practice, this would mean that important areas exhibiting epiphytic lichens would be saved and the most essential loggings would be carried out in late winter, logging in summer would be avoided on good lichen pastures and as light soil preparation methods as possible would be used, for example.

The practitioners found logging residue left on site problematic, because it prevents moving and digging of lichens by reindeer, and they thus proposed harvest of logging residue in lichen-rich pastures critical for reindeer, but not in all pastures due to high expenses. Harvesting logging residue improves growth of ground lichens in clear-cuts by reducing ground shading by logging residue and

increases access of reindeer to food resources (Ranius et al., 2018). Potential benefits may be offset, however, by additional soil distrurbance and damage to lichen communities associated with the process of logging residue extraction (Kaarakka et al., 2018). In addition, extraction of logging residue can pose risks for future biomass production due to associated loss of nutrients, for example (Kivinen et al., 2010; Palviainen et al., 2010; Ranius et al., 2018). In case fertilizing impact of the logging residue is fundamentally important for the forest, it should be found out if the logging residue could be harvested immediately after needle shedding, when the amount of nutrients leached away would be smaller.

When developing forestry measures adapted to reindeer husbandry, it would be worthwhile also to study if lichens could be re-established after forestry by artificial distribution of lichen fragments (Lidén et al., 2005). Roturier et al. (2007) studied methods to improve the recovery of ground lichens after soil disturbance, and found that artificial dispersal of lichen thalli on an appropriate substrate could be a successful strategy for promoting lichen recovery. Main problems concern the colonization of young stands and the length of rotation time based on the age, volume, and productivity of the stand. The dispersal capacity of epiphytic lichens is restricted since the number of thallus fragments, which are the most important dispersal mechanism, decline sharply as a function of the distance from the forest edge (Helle, 2005). This means that the colonization of young stands covering large areas is a time-consuming and costly process. To ensure the long-term maintenance of epiphytic lichens, a continuous cover forestry and prolonged rotation are thus recommended (Stevenson and Coxson, 2004; Jaakkola et al., 2006).

Practitioners regarded the new possibilities enabled by the reformed Forest Act (1093/1996; amendments up to 567/2014 included) both positive and negative for reindeer husbandry. Reindeer herders reported that continuous-cover silviculture, small-scale clear-cutting, selection cuttings with no gaps and upper-layer thinning could facilitate reindeer herding. Over 90% of practitioners in reindeer husbandry informed that "*keeping the area forested* "would be the best regeneration practice. The practitioners responded negatively to some of the amendments of the reformed Forest Act, e.g. the fact that the limits of sturdiness and age of logged trees were removed, and that the forest owner could determine the length of the rotation period. This could most probably mean that the forest in question would never reach a stage/phase of old-growth forest rich in lichens and important winter pasture for reindeer. It could also lead to the fact that the soil surface would constantly be broken and the lichens and other reindeer forage plants would never recover.

The scenarios of Korosuo et al. (2014) for northern Sweden indicate, that the current trend of a decrease in lichen area will continue if existing forestry practice prevails, but implementing continuous cover forestry as a management alternative and carrying out pre-commercial thinning could halt the decrease in reindeer pasture area and even lead to a future increase in pasture area, with losses of approximately 5% in the net present value of forestry. Another study showed that forest

management which is adapted to reindeer husbandry leads to an increased standing volume and larger carbon sequestration in the forest as well as improved conditions for reindeer grazing, but also to a reduced potential for felling, employment, and revenue for the forest companies (Berg et al., 2016; Horskotte et al., 2016). Reconciliation of state forestry and reindeer husbandry has economic consequences also for Metsähallitus in Finland, because legal consideration of reindeer husbandry and other societal obligations decrease income from Metsähallitus to the State and profitability of forestry (Rytkönen et al., 2013; Järvenpää, 2018). On the other hand, multiple use of forests including e.g. recreation, gathering, hunting and tourism would greatly benefit from reconciliation of state forestry and reindeer husbandry.

4.3. Conclusions and future views

Including both scientific and practitioners knowledge into the present research broadened the scope and set the scene for a more holistic insight to the interaction of forestry and reindeer husbandry in different times than before. Combining information from different knowledge systems helps to better understand and prevent land use disputes not only between forestry and reindeer husbandry, but also between other livelihoods using the same land. The number of practitioners in reindeer husbandry and forestry participating in the present survey was relatively small (n=29), however, and thus the results should not be generalized for the whole RMA in Finland. However, many important points about the current situation of the reconciliation of reindeer husbandry and forestry came to the fore. First of all, it is viable to gradually improve the commercial forests within the RMA as reindeer pastures by changing and developing forestry measures adapted to reindeer husbandry. Long-term implications of the forestry measures enabled by the recently reformed Forest Act (1093/1996) with its amendments (567/2014) on both forestry and reindeer husbandry within the RMA should be studied more in detail. Flow of information between forestry, reindeer husbandry and other land users could still be improved. Development of the consultation procedure for private forestry and jointly-owned forests and reindeer husbandry would be useful particularly for forest owners at least in Saami Home area, because in future forest companies may buy timber only from those forest owners whose forestry has been reconcilated with reindeer husbandry. Some further steps have been lately taken, since a reindeer herding GIS-database, which includes information related to reindeer husbandy and pastures, has been developed (Oinonen et al., 2014), and will be utilized in planning and reconciliation of reindeer husbandy, forestry and other land use.

Both climate change and silvicultural measures have changed the prerequisites of timber production in the boreal forests of northern Finland. Longer and warmer growing seasons (Ruosteenoja, et al., 2016a;b;c) have increased the growth and volume of tree stands (Salminen,

2015; Korhonen et al., 2017; LUKE, 2018). Most probably also different risks for both forest growth and forestry will increase in future. For example, damage caused by the pests (e.g. nun moth; *Lymantria monacha* L., spruce bark beetle; *Ips typographus* L.) (Neuvonen and Viiri, 2018; Neuvonen et al., 2018) as well as those caused by storms and forest fires are expected to increase. In addition, more commonly occurring milder winters with less frozen soils will increase difficulties in timber harvesting (Kellomäki et al., 2010). Some of these threats may be smaller in the northern part of the boreal forest zone compared to southern part of it, however.

Increased forest growth may lead to shorter rotation times and denser forests. It has been estimated that the logging possibilities in northern Finland will double until 2050 when compared to the situation in 1990. The focus of Finnish forestry may be changing from southern to northern Finland in future. Harvesting trees in earlier weakly utilized regions may increase due to growing demand of woody biomass for planned bioeconomy investments, e.g. for bioenergy (biofuel, woodchips) (Kalliokoski, 2015; Laplands Arctic Bioeconomy Development Programme, 2018-2025). The practitioners' perspective for the planned bioeconomy investments was in general positive, but particularly reindeer herders were afraid of losing the last old-growth forests, which are critical winter pastures of reindeer. Diminishing lichen pasture resources further increase the expenses of reindeer husbandry at the same time when its profitability remains weak. More effective utilization of forests may increase the risk for further conflicts between forestry and reindeer husbandry (Pettersson et al., 2017). It is important to recognize this fact when multiple use of forests is planned further in Finland; it is decisive how political decision-making and governance of natural resources are willing to develop and guide the multiple use of state forests within the RMA.

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Appendix A.

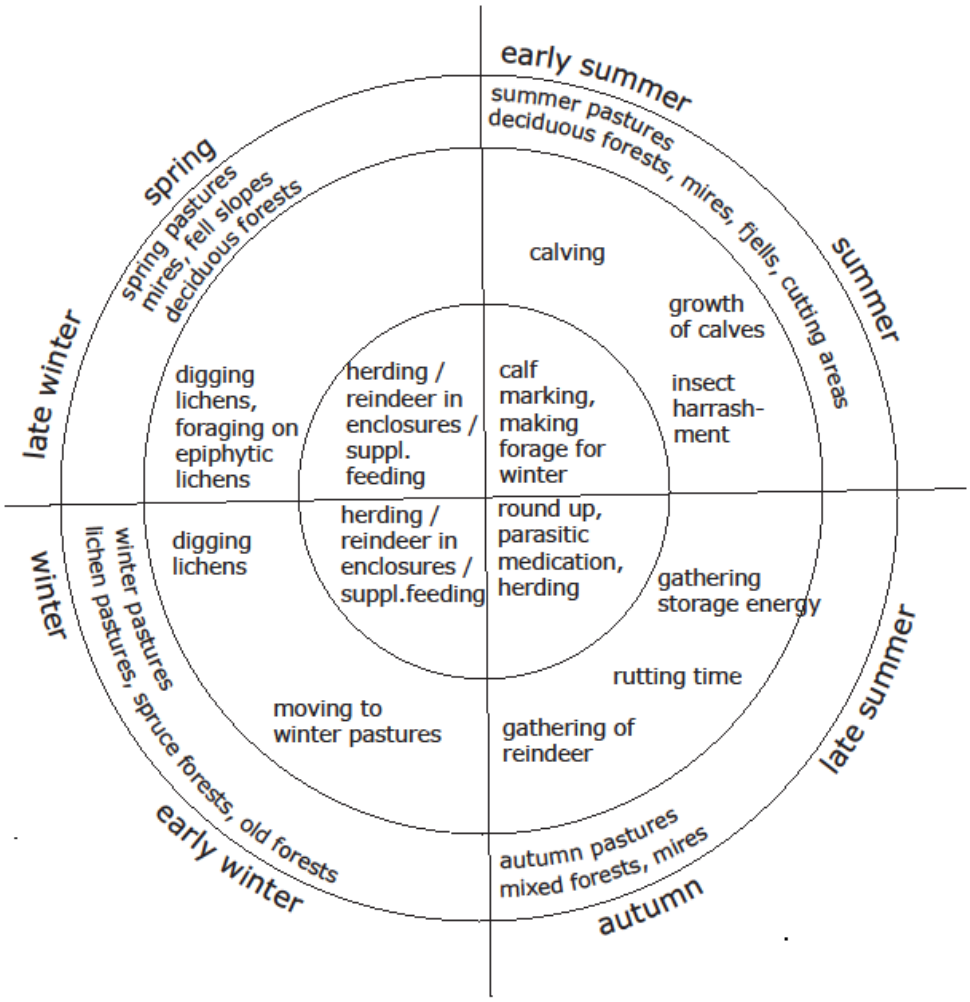

Fig. A.1. Seasonal cycle of reindeer and reindeer herding.

Reindeer herding year starts in the beginning of May with calving. The calving areas include edges of mires, slopes of hills and fells and deciduous forests. After calving herders ear-mark the calves usually from Midsummer onwards or immediately after calving when it takes place within the enclosure. Hay-making for supplementary winter feeding is part of herders' summer activities. In summer reindeer prefer grazing in deciduous forests, open mires, fjells and cutting areas. Reindeer diet can consist of 200–300 plant species, mainly herbs, sedges, shrubs and leaves of different trees (Warenberg et al. 1997). As a consequence of insect harassment and heat reindeer gather into large herds and move to the open and windy habitats (Helle 2015).

In autumn reindeer grazes in mixed forests and on mires, when it prefers grasses in addition to mushrooms. During rut reindeer are often gathered on open habitats or heaths with few trees. In late autumn the proportion of lichens and shrubs is increased in the diet of reindeer. In autumn herders gather and move herds to the round up sites. Rut makes work easier since male reindeer attract female reindeer gathered around them. In the round up, reindeer left alive are separated from reindeer to be slaughtered, and calves which were not marked in summer will get their ear-marks. Reindeer left alive get medicine against parasites. After round up reindeer are herded to the winter pastures and they are given supplementary forage particularly during difficult snow conditions. Protecting reindeer from predators by herding, search of reindeer killed by predator, repair of fences and driving

reindeer away from the settlements and agricultural fields are also parts of herder's annual duties (Helle, 2015; Turunen et al., 2016; Jaakkola et al., 2018).

Boreal forests are vital for reindeer especially in winter time, when they graze in xeric or barren heath forests, spruce forests and old forests. When digging lichens beneath the snow cover becomes difficult due to hard or thick snow cover in January-March, reindeer start foraging epiphytic lichens if possible. In late winter the availability of epiphytic lichens growing in old forests is extremely important for reindeer (Jaakkola et al. 2006; Helle, 2005; 2015). Old mature, over 140 year-old pine and spruce forests of xeric, sub-xeric and mesic types are the best pastures of epiphytic lichens for reindeer herding.

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Appendix B.

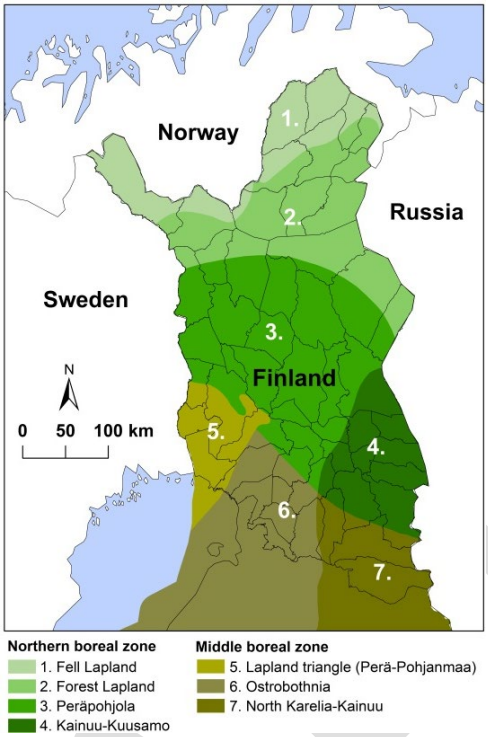

Fig. B.1. Forest vegetation zones in Finland (SYKE 2018).

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Appendix C.

List of articles about the relations between forestry and reindeer husbandry appeared in professional journals.

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Appendix D.

Survey for practitioners in reindeer husbandry, forestry and both livelihoods.

1. Municipality/reindeer herding district of the informant.

2. Location of the informant within the regional division of Metsähallitus, Metsätalous Oy

3. I am a forest owner: yes/no. If you responded yes, have you conducted/get done forestry measures or loggings during the past 15 years? Yes/no.

4. Impact of different forestry measures on grazing, reproduction (rut, calving), moving and behaviour of reindeer during insect harassment period. Estimate the impact on a scale 1-5 according to your opinion. Five means that the activity has a favorable impact. Correspondingly one means, that the activity has an unfavorable impact. Ics (I cannot say) means that you are not able to evaluate the impact.

4.1. Regeneration fellings
4.1.1 Clear cutting (all trees, except retention trees, are logged from the site). Estimate on a scale 1-5, Ics: (1=unfavorable impact, 5=favorable impact, Ics=I cannot say).

4.1.2 Nurse crop cuttings (a method used particularly on regeneration sites of Norway spruce, in which deciduous trees are left covering seedling stands to prevent them from the impacts of frost). Estimate on a scale 1-5, Ics: (1=unfavorable impact, 5=favorable impact, Ics: I cannot say).

4.1.3 Seed tree cutting (a method for regenerating barren heath forests, in which 50 -100 Scots pines/ha are left as seed/mother trees). Estimate on a scale 1-5, Ics: (1=unfavorable impact, 5=favorable impact, Ics=I cannot say).

4.1.4 Shelterwood felling (a method for regenerating Norway spruce, in which shelterwood is left covering spruce seedlings, which prevents abundant growth of grass and sprout by shadowing and evens out temperature variation and protects seedlings both from intensive solar radiation and frost). Estimate on a scale 1-5, Ics: (1=unfavorable impact, 5=favorable impact, Ics=I cannot say).

4.1.5 Strip felling (conifer forest is regenerated naturally with the help of edging forest. The width of a strip to be cut in the forest is about 25m from the edging forest). Estimate on a scale 1-5, Ics: (1=unfavorable impact, 5=favorable impact, Ics=I cannot say). Which regeneration felling methods would facilitate reindeer herding work?

4.2. Thinning (timing, logging residue)
4.2.1 Cutting of hold-overs (taller than dominating trees, shading trees are removed, e.g. seed/mother trees). Estimate on a scale 1-5, Ics: (1=unfavorable impact, 5=favorable impact, Ics=I cannot say).

4.2.2 First thinning (young, growing trees are thinned to increase space to grow for the trees left in the forest). Estimate on a scale 1-5, Ics: (1=unfavorable impact, 5=favorable impact, Ics=I cannot say).

4.2.3 Loosening felling (thinning of trees (grown >16cm, >25yrs), the same purpose as that of first thinning). Estimate on a scale 1-5, Ics: (1=unfavorable impact, 5=favorable impact, Ics=I cannot say). Which thinning methods would facilitate reindeer herding work?

43. Soil treatment

4.3.1 Screefing/scalping (a soil preparation method for barren heath forests, in which soil surface is broken lightly to improve emergence of seedlings). Estimate on a scale 1-5, Ics: (1=unfavorable impact, 5=favorable impact, Ics=I cannot say).

4.3.2 Harrowing (a soil preparation method used on barren soils, in which mineral soil is exposed by making ca 60cm wide, uniform or intermittent parallel lines, spaced every 4-5m). Estimate on a scale 1-5, Ics: (1=unfavorable impact, 5=favorable impact, Ics=I cannot say).

4.3.3 Mounding combined with screefing (a soil preparation method for fine, weakly water-permeable mineral soils and most peat soils. Mounds are made and seedlings planted on them. Mounding combined with screefing and reversible mounding are the most common mounding methods). Estimate on a scale 1-5, Ics: (1=unfavorable impact, 5=favorable impact, Ics=I cannot say).

4.3.4 Mounding combined with making small grooves for water flow (a soil preparation method for wet/moist mineral soils and peat soils, which require drying. It is used when basic drying is in order, but surface waters can cause problems). Estimate on a scale 1-5, Ics: (1=unfavorable impact, 5=favorable impact, Ics=I cannot say).

4.3.5 Adjustable plowing (adjustable plowing is conducted by using a plough drawn by a tractor, which can be used for adjusting the depth and width of plowing track. It is used as a soil preparation method nowadays only rarely, mostly in private forests for xxx, fine, thick- xxx soils). Estimate on a scale 1-5, Ics: (1=unfavorable impact, 5=favorable impact, Ics=I cannot say).

4.3.6 Controlled burning (controlled burning is suitable for regeneration of Norway spruce dominated forests on moraine soils of sub-xeric and mesic heath forests. Areas of controlled burning are prepared by harrowing or screefing and regenerated in general by sowing with Scots pine. Controlled burning results in a release of nutrients for the use of trees, soil becomes less acidic). Estimate on a scale 1-5, Ics: (1=unfavorable impact, 5=favorable impact, Ics=I cannot say). How soil treatment methods should be changed/developed to facilitate reindeer herding work?

4.4. Regeneration practice

4.4.1 Natural regeneration.
Estimate on a scale 1-5, Ics: (1=unfavorable impact, 5=favorable impact, Ics=I cannot say).

4.4.2 Cultivation (planting, sowing).
Estimate on a scale 1-5, Ics: (1=unfavorable impact, 5=favorable impact, Ics=I cannot say). How forest regeneration methods should be developed to facilitate reindeer herding work?

4.5. Restoration of ditches.

Estimate on a scale 1-5, Ics: (1=unfavorable impact, 5=favorable impact, Ics=I cannot say). How practices for ditching should be changed to facilitate reindeer herding work?

4.6. Construction of roads

Estimate on a scale 1-5, Ics: (1=unfavorable impact, 5=favorable impact, Ics=I cannot say). How practices for construction of roads should be changed to facilitate reindeer herding work?

4.7. Tending of seedling stands.

Estimate on a scale 1-5, Ics: (1=unfavorable impact, 5=favorable impact, Ics=I cannot say). How practices for tending of seedling stands should be changed to facilitate reindeer herding work?

5. What kind of felling practice would be the best practice as a whole for felling young forests in your opinion? Lower-layer thinning (mostly small diameter trees left under the dominating trees are removed)/Upper-layer thinning (mostly taller than the dominating trees are removed). Explanations:

6. What kind of felling practice would be the best regeneration practice as a whole in your opinion?
Continuous-cover forestry/Conventional clear cutting with its traditional regeneration methods. Explanation:

7. What would be the best means for securing flow of information between practitioners in reindeer herding and forestry? Proposals for improvement:

8. How amended Forest Act (1093/1996; amendments up to 567/2014 included) and silviculture based on renewed recommendations will impact forest regeneration from the point of view of reindeer husbandry? Estimate on a scale 1-5, Ics: (1=unfavorable impact, 5=favorable impact, Eos=I cannot say).
8.1. Limits of sturdiness and age were removed. Forest owner determines rotation period.
8.2. Method for conducting intermediate felling can be reasoned by the forest owner (upper-layer thinning)
8.3. Small-scale clearcutting (<0,3 ha) and intermediate felling of forest of different age structure is allowed.
8.4. Natural regeneration and cultivation are equal.
8.5. Regulation of tree species selection was loosened – not bound to habitat.
8.6. Outstandingly important objects of the environment were added.

9. How do you estimate the impacts of the planned bioeconomy investments on the operational environment of reindeer husbandry? Estimate on a scale 1-5, Ics: (1=unfavorable impact, 5=favorable impact, Eos=I cannot say)
9.1. Kaicel/Paltamo
raw material: pulpwood and saw woodchips. 2,5 Mm3/y/ in total, sale district within a 100 km radius from Paltamo/ investment decision in the end of 2018. Production would start in 2021/product: pulp, textile fibre and other processed products
9.2. Kaidi/Kemi
raw material: wood based biomass (energy wood, logging residue, saw dust sahanpuru, bark) 2,8 Mm3/y/ sale district within a 200 km radius from Kemi/ investment decision during 2017 / product: bio fuels (diesel 75%/ gasoline 25%)
9.3. Boreal Bioref/Kemijärvi
raw material: thinned trees 2,3 Mm3/y. and woodchips/ sale district: most probably northeastern Finland, Lapland / investment decision during 2017/ product: according to demand: pulp, sugers, tall oil and turpentine oil, bioenergy, materials for soil enrichment
Other comments:

10. What is your profession?
Practitioner in reindeer husbandry/Practitioner in forestry/Practitioner in both reindeer husbandry and forestry
10.1. If you are a practitioner in reindeer husbandry or practitioner in both reindeer husbandy and forestry, what is the main winter herding practice? Free grazing/Enclosure/Supplementary feeding
Other comments:

11. What has been the development like during the past ten years?
Estimate on a scale 1-5, Ics: (1= into unfavorable direction, 5=into favorable direction, Ics=I cannot say) regarding forestry methods/regarding co-operation between practitioners in forestry and reindeer husbandry

12. Do you have other proposals, by which reindeer could be taken better than presently into account in planning and conducting forestry measures?