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Changes in Swedish spruce forests since 1986 from a reindeer husbandry perspective

- Changes in field layer, age distribution and relative stocking level

Svenska granskogens förändring sedan 1986 ur ett renskötselperspektiv - Förändringar i fältskikt, åldersfördelning och slutenhet

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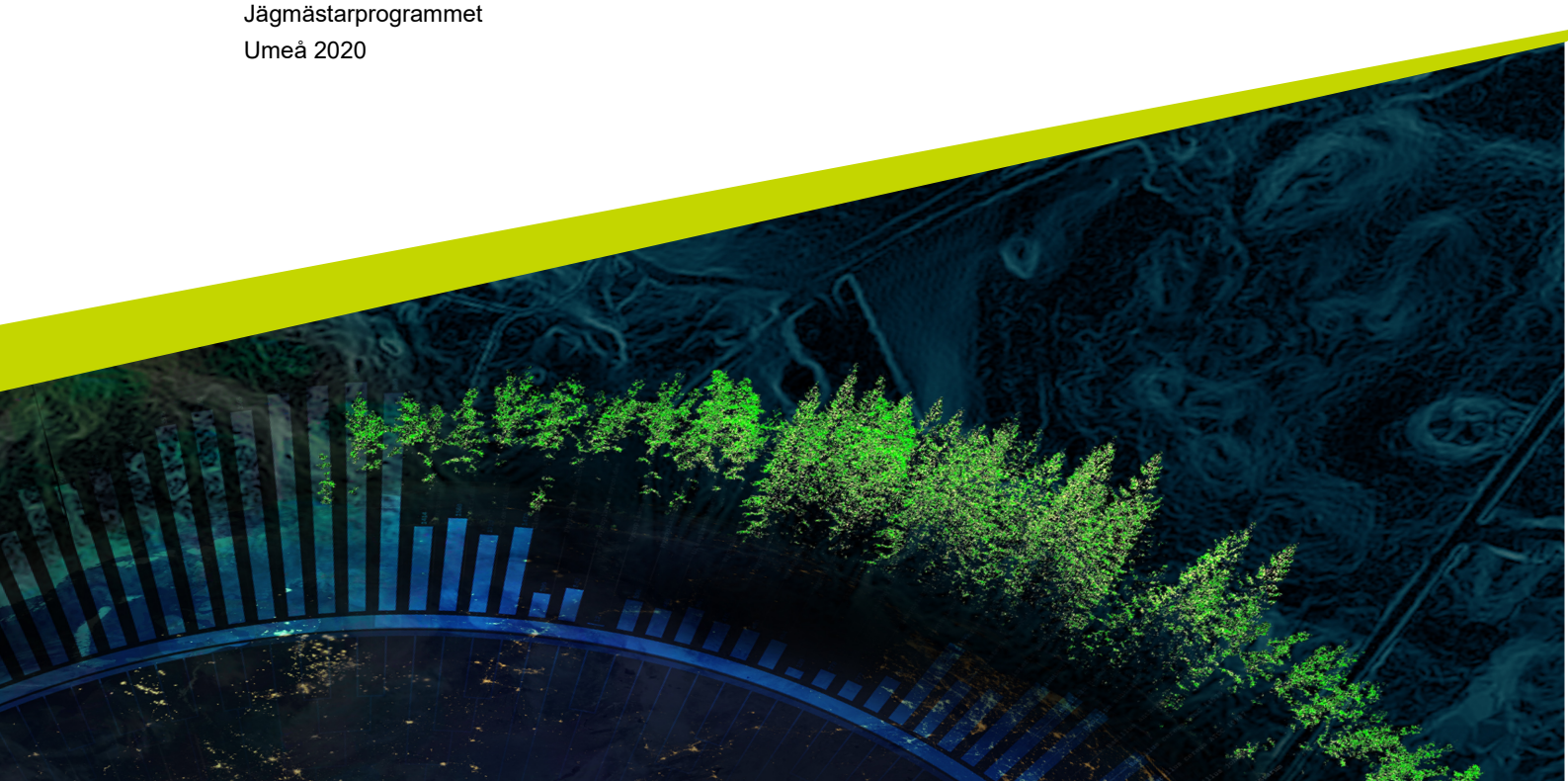

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Abstract

Loss of important reindeer habitats is an increasing concern in Sweden. The focus for loss of habitats has mainly been pine (*Pinus sylvestris L.*) forests and lichens. However, reindeer diets also consist of other food sources like sedges, grasses and herbs (often found in spruce forests) that will be discussed in this study. There has been a decline of spruce (*Picea spp.)* forests within the reindeer husbandry area and the importance of those habitats for reindeers has been neglected through planning in favour of lichen rich pine stands. The aim of this study is to describe the change of spruce forests within the reindeer husbandry area with focus on changes over time in field layer, age distribution and relative stocking level. As well as performing a statistical analysis on the relationship between field-layer and relative stocking level or age distribution. This study is centred around two main questions: What explains the results and how does it affect the reindeer? The results from this study has shown a change in age distribution, relative stocking level and a large total area decrease of spruce forests within the reindeer husbandry area since 1986. The results also show a significant association between herbs/grass and relative stocking level through statistical tests. There is also a significant relationship between grass and forest age.

Keywords: field layer, reindeer, Sweden, spruce forests

Sammanfattning:

Förlust av viktiga habitat för renar är ett ökande problem i Sverige. Fokus har främst varit förlusten av tallskog (*Pinus sylvestris L.*) och lavar. Renens diet består emellertid också av andra betesresurser som starr, gräs och örter som kommer att diskuteras i denna studie. Granskogarna (*Picea spp.*) har minskat inom renskötselområdet och dessa livsmiljöers betydelse för renar har försummats i planering till förmån för lavrika marker. Syftet med denna studie är att beskriva förändringen hos granskogar inom renskötselområdet med fokus på fältskikt, åldersdistribution och slutenhet. Samt utföra en statistisk analys av förhållandet mellan fältskikt och densitet- eller åldersfördelning. Studien bygger på två huvudsakliga frågeställningar: Vad förklarar resultaten och hur påverkar det renarna? Resultaten från denna studie har visat en förändring i åldersfördelning, densitet och en stor total arealförlust av granskogar inom renskötselområdet sedan 1986. Resultaten visar också ett signifikant samband mellan örter/gräs och densitet genom statistiska tester. Det finns också en betydande relation mellan förekomsten gräs och skogsålder.

Nyckelord: fältskikt, renen, Sverige, granskogar

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1. INTRODUCTION

1.1. Background

Ever since the 1950s clear cutting has been the most common forest management method in northern Sweden. This is due to the system being easy to understand and plan since it follows the common/similar pattern of gardening/agriculture from sowing to growth and finally harvest (Albrektsson *et al* 2012) or supposedly mimics stand-replacing forest fires. Clear cutting has its obvious financial benefits but followed by negative consequences for biodiversity and reindeer husbandry. Reindeer husbandry is essential for Sami culture and has been for over 400 years (Josefsson *et al.* 2010). In the north of Sweden commercial forestry and reindeer husbandry use the same forestland. Approximately half of Sweden's productive forest lands are within the reindeer husbandry area (Sandström *et al.* 2016; Carlsson & Boström 2014).

The negative consequences of forestry for reindeer husbandry causes difficulties in forest planning and some form of sustainable trade-off between the two industries is essential. Therefore § 20 (SFS 2010:930 Skogsvårdslagstiftningen) in Swedish forestry act was created in 2010 to facilitate communication and the planning process between the industries. This law states that before harvesting takes place in the year-round grazing areas of reindeer husbandry, the affected reindeer herders must be offered a consultation. The government or authority that the government decides may issue regulations on such consultation. The consultations are meetings between forest companies and the reindeer herders. This is an opportunity for reindeer herders and forest companies to discuss future forest actions, if they should be conducted and when. However, numerous studies in recent years show a change in vegetation due to effects of modern forest management (Kuuluvainen 2002; Strengbom *et al.* 2004; Uotila & Kouki 2005; Shorohova *et al.* 2009; Kivinen *et al.* 2010; Bäcklund *et al.* 2015). Removal of trees through clear cutting cause reindeer to lose sun protection and furthermore it decreases the abundance of arboreal lichen, an important food source (Mallory & Boyce 2018). However, reindeer diet consists of more than just lichens. Vascular plants like sedges, grasses and herbs is also a main part of reindeer diets, especially during the summer months (Käyhkö & Horstkotte 2017; Mallory & Boyce 2018; Bergerud 1972).

In the early summer months, it is very important for reindeer to regain their nutritional balance after a long winter (Käyhkö & Horstkotte 2017). During warm summers reindeer depend highly on dense spruce forests to protect them from sun and bloodsucking insects (Carlsson & Boström 2014; Helle 1982; Hagemoen & Reimers 2002). High summer temperatures cause the reindeer a lot of distress since they lack the ability to sweat (Kolloen 2015; Helle 1982). Thus, maintaining spruceforests within the reindeer summer husbandry area is crucial for the survival of reindeer. The plantation of foreign tree species such as lodgepole pine (*Pinus contorta)* also threatens the life of the reindeer making the area to conduct reindeer husbandry smaller. This effect is due to dense impassable lodgepole pine forests without edible vegetation (Carlsson & Boström 2014). Logging mainly affects the winter grazing lands for mountain reindeer whereas it has an all year-round effect on forest reindeer who spend all year within the forest (Eriksson 1976).

The most important food source for reindeer during winter is lichen (Kivinen *et al.* 2010). Today there are challenges when assessing the importance of a forest since there is no method for calculating the economic value of the lichen which means that the economic value of the grazing cannot be calculated for reindeer husbandry. Furthermore, the impact of forest management and its effect on the reindeer grazing vegetation cannot be calculated (Sandström, Esselin *et al.* 2006). Even if there is not a current system for assessing value of the biomass of lichens, attempts to assess the changes in lichen cover have been made. According to *The Swedish national forest inventory,* ground lichen has decreased with 70 percent the last 50 years (Skogsstyrelsen 2019). There has also been a decrease in arboreal lichen (Skogsstyrelsen 2019).

Even though lichen has been the main focus for studies of changes in ground vegetation in the boreal forests the focus is evolving to include other ground vegetation such as sedges, grasses and herbs. A previous study conducted in Finland (Tonteri *et al.* 2016) indicated that the total understorey plant cover had decreased with 10% while the total stand volume increased with 26% in the south and 16% in the north from 1985 to 2006. The decrease in vegetation cover was mainly lichens in the north and vascular plants in the south. It was thought to be an effect of forest management (Tonteri *et al.* 2016).

Changes in the forest that are potential threats to the reindeer husbandry has also been noticed in consultation meetings between forest companies and the reindeer herders (Centrala samrådsgruppen skogsbruk/rennäring sammanträdesprotokoll 2018). During the consultations, the impact of forestry on the reindeer husbandry is discussed extensively. Negative impacts include harvesting of important forest stands, planting of lodgepole pine and the disappearance of important food sources. During consultation, it has been noted that forests set aside to remain for the reindeer husbandry have been sold by forest companies to new owners who have subsequently harvested the land. During warmer summers, spruce forests have been of utmost importance to provide the reindeer with protection from the sun so that they do not suffer from overheating (Mallory & Boyce 2018). This requires a cluster of spruce forests in the pasture area so that reindeer can move

between them. The two most important parts of a reindeer husbandry forest are protection (against sun as well as insects) and food (Centrala samrådsgruppen skogsbruk/rennäring sammanträdesprotokoll 2018).

According to some reindeer herders, the focus for consultations has mostly been to preserve the lichen rich forests and therefore the importance of old spruce forests for summer grazing has been neglected (Sandström, Esselin *et al.* 2006). This report was aimed to describe the changes in relative stocking level, age distribution and field-layer (herbs, sedges and grass) in spruce forests within the reindeer husbandry area since 1985. Furthermore, an analysis of the connection between the field-layer and relative stocking level or age was made. The study was conducted with the help of recorded data from *The Swedish national forest inventory*.

1.2. Historical land use and forest structure

Historically the forest structure has mainly been determined by natural disturbances and climate (Josefsson *et al.* 2010). Topography, hydrology and soil composition are also factors effecting forest structure (Josefsson *et al.* 2010). Anthropogenic impact can change forest structure by clearcutting, favouring certain tree species and/or lowering the age of trees (Josefsson *et al.* 2010). A study conducted by Josefsson *et al* (2010) on historic sami settlements in the north of Sweden has shown the local forest had a considerably lower age and a five times higher abundance of birch than the surrounding forest. However, the changes are only local within and around the settlements (Josefsson *et al.* 2010). Preindustrial anthropogenic land use may have had a positive impact on ecosystems of the forest land by grazing, felling trees, the use of fire, or a combination of such disturbances (Josefsson *et al.* 2010).

The use of forest land in Sweden has been going on for a long time (KSLA 2015). Initially it was mostly used for hunting grounds, wood for fuel and building materials (KSLA 2015). The forest was also used for the production of coal, tar and potash (KSLA 2015). In the 13th century mining became a large consumer of wood until the end of the 19th century (KSLA 2015). Mining was concentrated to the north parts of Sweden (KSLA 2015). The wood was used as fuel during ore extraction while charcoal was used for melting and processing (KSLA 2015). In the south parts of Sweden wood materials was used in the production of iron and steel, shipbuilding, glassmaking, other industrial activities as well as domestic use (KSLA 2015). In the mid of the 19th century the demand for sawn logs increased and 50 years later materials for the manufacture of paper and pulp (KSLA 2015). The intense exploitation of the forest during this period led to a depleted forest which caused the government to pass the first forestry act in 1903, which implies an obligation to rejuvenate after harvesting (KSLA 2015). During the rapid exploitation phase the proportion of pine forest decreased while the proportion of spruce forests increased (Linder & Östlund 1998). However, through silvicultural measures driven by trend the proportion of pine forests increased after the 1920s

(Linder & Östlund 1998). The proportion of deciduous trees has also seen a rise and fall during the 20th century. First a rise from pioneer tree species being favoured after clear-cuts and a fall through the use of herbicides during the 1960-1970s (Linder & Östlund 1998). Today, most deciduous trees are young and grow in stands that was clear-cut 10-20 years ago (Axelsson & Östlund 2001).

Modern forestry have changed the structure of forests by creating unnaturally dense monocultures (Linder & Östlund 1998; Axelsson & Östlund 2001). Since the 20th century clear cutting has replaced fire as the most important factor that influences forest structure (Axelsson & Östlund 2001). The structure of forests in Sweden is driven by the demand of the industry which is regulated by the legislation of forestry. As mentioned above the first forest act was passed in 1903. In 1905 a forestry authority was established, university-level forest education started in 1915 and the Swedish National Forest Inventory was established in 1923 (KSLA 2015). The legislation of forestry has been revised many times since 1903 (KSLA 2015). Today ecological values and the preservation of biodiversity is becoming more important due to the lack of natural disturbances as a consequence of forest management structure (KSLA 2015). Modern forestry is focused on preserving areas with high biodiversity (KSLA 2015). The disappearance of natural forests and their ecological niches threaten the species associated with old forest structures (Axelsson & Östlund 2001).

The impacts of modern forestry have affected most forest regions around the world (Boucher *et al.* 2009). Natural disturbances have been replaced by modern forestry practises and can be considered a major component of a new disturbance regime (Boucher *et al.* 2009). Modern forestry has reduced forest ages, diminished the abundance of dead wood, favoured pioneer species and homogenized the landscape structure and composition (Boucher *et al.* 2009).

1.3. Extreme weather events and the need for reindeer suited habitats

The early summer months of May and June are important for reindeer. This is the time when the calves are born and the reindeer have to regain their nutritional balance after the long winter (Käyhkö & Horstkotte 2017; Mallory & Boyce 2018). They graze on birch (Betula), willow (Salix spp.) and new vegetation around creeks and mires (Käyhkö & Horstkotte 2017). Spring diet can consist of up to 50% of sedges (Bergerud 1972). Sedges keep being 10% of the diet all throughout summer and fall until falling to 7% by winter (Bergerud 1972). At the end of June to the beginning of august the reindeer graze freely on a wide range of herbs and grasses to prepare for winter (Käyhkö & Horstkotte 2017).

A tough winter followed by a warm summer is devastating for reindeer. As seen in Lapland during the 1970s calves and adult reindeer in poor condition died in the heat and by insects (Helle 1982). A tough winter for reindeer is when a shell of ice covers the lichen and other important food sources, preventing grazing

(Helle 1982, Hansen *et al.* 2010). In coniferous forests, winters with a lot of snowfall do not form hard snow on the snow surface that can bear the weight of a reindeer until early spring (Helle 1982). This prevents reindeer from moving around in search of food (Helle 1982). Reindeer try to minimize energy loss during winter by avoiding habitats with deep and hard snow when digging for food (Hansen *et al.* 2010). Lichen covered with a layer of ice is detrimental for reindeer since warming up the food to body temperature can mean higher energy loss than gained (Helle 1982). Lichens can also mold when snow falls on them before the ground is frozen. When a reindeer must search large areas for food their condition can deteriorate even before mid-winter (Helle 1982).

Hot summers are problematic for reindeer since they do not have the ability to sweat, therefore all excess heat must evaporate through their mouths (Kolloen 2015; Helle 1982). Hot summers also increase the abundance of blood sucking insects such as gnats, midges, horseflies, and parasites (Helle 1982; Hagemoen & Reimers 2002). The high season for bloodsucking insects starts in June and July and can be very stressful for the reindeer (Helle 1982).

In a study (Hagemoen & Reimers 2002) of reindeer behaviour in response to insects, reindeer was observed avoiding direct sunlight since the intensity of Oestrid fly harassment decreased in the shades. Under severe harassment reindeer seek wind exposed hilltops or other open spaces where the heat and insects are less prominent (Hagemoen & Reimers 2002; Mallory & Boyce 2018). On less windy day's reindeer can run around for hours or whole days seeking refuge, preventing them from feeding (Hagemoen & Reimers 2002). They can also seek dry, shady forest slopes and they depend on dense spruce forests to protect them from heat and insects (Carlsson & Boström 2014).

1.4. Effects of Modern management on reindeer habitats

In the boreal forest's disturbance such as forest fires has been a major driver that effects forest succession (Kuuluvainen, 2002, Kivinen 2010). The natural succession time for boreal forests can be up to 700 years (Shorohova *et al*. 2009). However, modern forest management has pushed the rotation time down to 100 years (Hedwall *et al*. 2019; Petersson *et al*. 2019). This along with an increase of spruce has become an important driver of change in understorey vegetation structure and diversity. Differences in ground vegetation patterns can be linked to tree species, forest stand age and differences in canopy cover (Widenfalk & Weslien 2009). For stands of spruce, grass cover decreases as canopy cover increases (Widenfalk & Weslien 2009; Bäcklund *et al*. 2015).

Spruce forests offer increased shading that creates unique conditions for the field layer (Petersson *et al*. 2019). Changes in light exposure effects the growth of the field layer (Widenfalk & Weslien 2009; Petersson *et al*. 2019). Thus, the main event changing light exposure in modern boreal forests is forest management through thinning and clearcutting (Hedwall *et al*. 2013).

Natural disturbances such as forest fires and windthrow can also change light exposure but modern management tries to minimize the risk of natural disturbances because it means a loss in revenue. Higher relative stocking level reduces the risk of storm-fellings and also provides benefits in producing more twig-free timber for the industry. Thus, creating evenaged, evensized monocultures that influences the abundance-relationships between light demanding and shade tolerant species (Hedwall *et al*. 2019). Early pre commercial thinning in young stands can increase species richness by offering more light to the field layer (Widenfalk & Weslien 2009). However, it cannot compensate for the loss of such species and habitats lost through clear-cuts of old mature forests (Widenfalk & Weslien 2009).

The majority of boreal forest species have found ways to adapt to temporal and spatial changes in the landscape (Kuuluvainen 2002). This prevents extinction through stabilizing the forest over long time periods and large areas.
Modern management disrupt the natural disturbances of forests by preventing self-thinning and the accumulation of dead wood. Studies on different forest management treatments have shown that the less intensive treatments that are more similar to unmanaged forest are the best choice for maintaining understorey vegetation (Tonteri *et al*. 2016; Vanha-Majamaa *et al*. 2017). However, there have not been many studies carried out on the successional patterns of understorey vegetation in unmanaged or managed forests (Uotila & Kouki 2005).

1.5. Old spruce forests

An essential food source for reindeer that requires old undisturbed forests, mostly spruce forests is arboreal lichen (Borchert 2001). The best arboreal is found in spruce forests around 120 to 210 years old (Borchert 2001).

Regulations such as FSC have improved the forest management methods in Sweden. Large forests companies and the state have certified their lands. However, 50% of the forest lands in Sweden is owned by private landowners whereas many reject the FSC certification (FSC 2018).

1.6. The aim of the study

The aim of the study was to i) describe how spruce forests within the reindeer husbandry area of Sweden have changed over time with regards to field layer, stand age distribution and relative stocking level from a reindeer husbandry perspective,, and ii) perform a statistical test of the relationship between field-layer and relative stocking level or age distribution. The study was focused on three groups of the field layer: sedges, herbs and grass.

2. MATERIAL AND METHOD

2.1. Introduction

Ever since 1923 The Swedish national forest inventory has had a commission to describe the state and changes of Sweden´s forests. Every year The Swedish national forest inventory conducts an inventory on circa 11 000 sample plots all over Sweden by collecting data on a large range of variables (Riksskogstaxeringen 2020). The inventory is based on temporary and permanent sample plots with a radius of 7 or 10 meters. When the data has been collected it goes through tests and quality controls and then stored in a database located at SLU (Swedish university of agricultural sciences) in Umeå. This information is the basis for growth estimations of Swedish forests. For further information on how the tests were conducted see Fridman *et al* (2014) and The Swedish national forest inventory´s webpage (The Swedish National Forest Inventory | Externwebben). The results in this study are restricted to spruce forests of municipalities situated within the reindeer husbandry area see (Fig 1, appendix A). Spruce forests are indicated as forests containing at least 65% spruce (Nilsson *et al.* 2019). This study was conducted in Umeå during March and April of 2020.

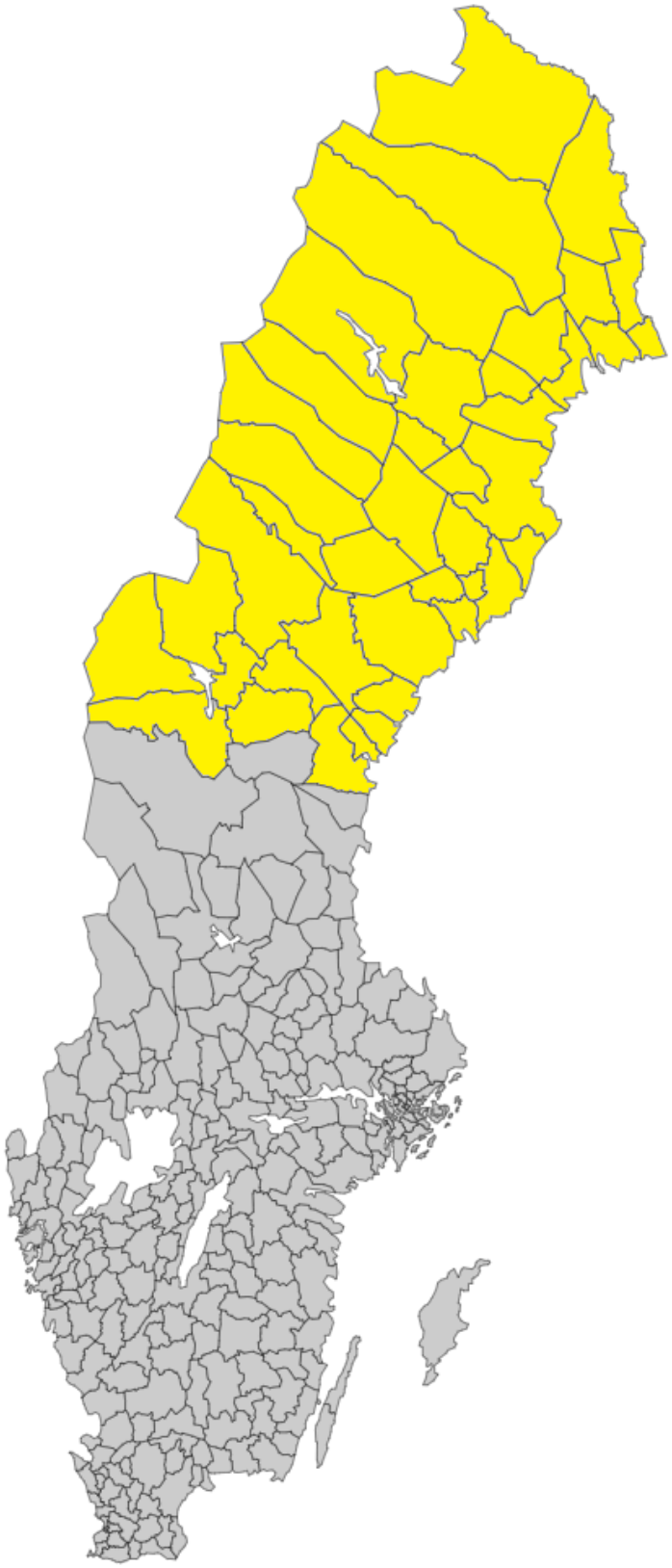


Figure 1: Municipalities included in the study marked as yellow.

2.2. Data collection

Data of stand age distribution, field-layer (vascular plants that are less than 0.5 m in height) and relative stocking level was derived from The Swedish national forest inventory´s database *kuben*. Kuben was downloaded in Microsoft Excel (version 2019) in the form of pivot tables where the search was limited to spruce forests within the reindeer husbandry area. A spatial demarcation was made to include only municipalities located within the reindeer husbandry area (appendix A). The data was then examined over a time horizon (from 1986 to 2016). The results were represented as average values over five years in 1000s of hectares.

The age of a stand is recorded as total age. Total age of a tree is the number of years that have elapsed from the time that the seed has germinated up to the year before the estimate. The total age is calculated as breast height increased with the number of years that are normally expected to take place to see a freely grown plant at the site in question to reach breast height. In The Swedish national forest inventory´s field instructions (The Swedish National Forest Inventory | Externwebben) there is a table which is used as a guideline for conifers.

Field-layer is recorded for each species as coverage percentage of a sample plot.

Relative stocking level is an index that describes the relative growth capacity of a stand compared to the ideal production at the site. The relative stocking level is a measure of relative density compared to an ideal stand density that make use of the growth capacity of the site. For stands up to seven meters of average height it is based on site index, average tree height and number of main stems per hectare, and for taller stands it is based on site index, average height and basal area. Stand density index is indicated in tenths of 0.1 and up, where the density is 1.0 represents full use of growth capacity. More fertile sites need higher number of stems/basal area to reach the same relative stocking level. The assessment is made on the main tree species. In the assessment, seed trees, undergrowth trees and dead trees are ignored.

2.3. Data processing

2.3.1. Changes in total area, relative stocking level and age distribution

To display changes in age distribution and total area the values derived from Kuben was converted into a bar diagram in Microsoft excel (2019). Changes in relative stocking level was made the same way but instead of using a bar diagram displaying the results in percentages.

2.3.2. Statistical analysis

To be able to compare the changes of spruce forests over a timeframe of 30 years the values had to be converted into percentages of total area. This was made in Microsoft excel (2019) by dividing the values with total area for each variable and creating tables (appendix C, appendix D) to display the results for further processing.

Age was used as categorical data with intervals of 20 years (see appendix D) and the percentage (rounded to 10th of %) of either grass or herbs as nominal data for one analysis. For the other analysis relative stocking level was used as categorical data with intervals of 0,2 and the percentage (rounded to 10th of %) of either grass or herbs was used as nominal data

The next step was to import the data into the statistical analysis software SPSS. The percentages of Grasses and herbs where studied separately towards either relative stocking level or age distribution through Chi-square tests. Since the data was insufficient for the normal Chi-square test a variation of the test called fisher´s exact test for smaller samples was used. If the Chi-square test determined the variables where dependent on each other (significance value less than 5%) the strength of the association was noted through Cramer's V. When the statistical analyses had been made the results were turned into a scatterplot for each test. age distribution

3. RESULTS

3.1. Age distribution

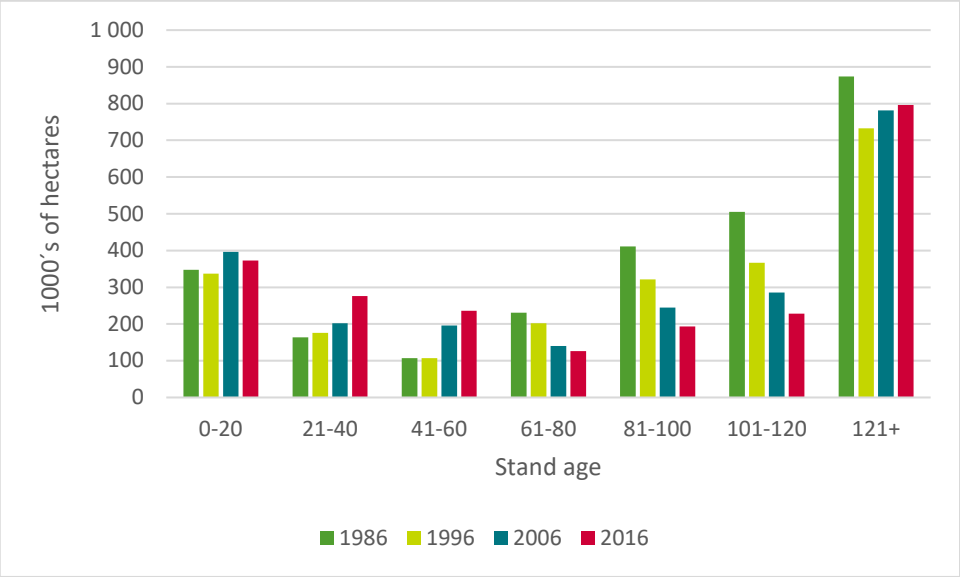


Figure 2: Age distribution of spruce forests within the reindeer husbandry area from 1986 to 2016 in 1000´s of hectares. Source: The Swedish national forest inventory.

There is a trend of increasing younger stands 21-60 years and a decrease of stands 60 to 120 years (Fig 2). Spruce forests older than 121 has increased since 1996. The total hectares of spruce forests has gone from 2 641 000 hectares since 1986 to 2 227 000 hectares by 2016 (Fig 2).

3.2. Relative stocking level of spruce forests

There has been a significant increase from circa 10% year 1986 to circa 50% year 2016 of spruce forests between 0-20 years with a relative stocking level of 1(Fig 3). There has been an increase of spruce forests of 21-40 years with a relative stocking level of 1 since 1986 to 2016 of circa 20% (Fig 4). Spruce forest over 40 years show minor changes in relative stocking level since 1986 (appendix B).

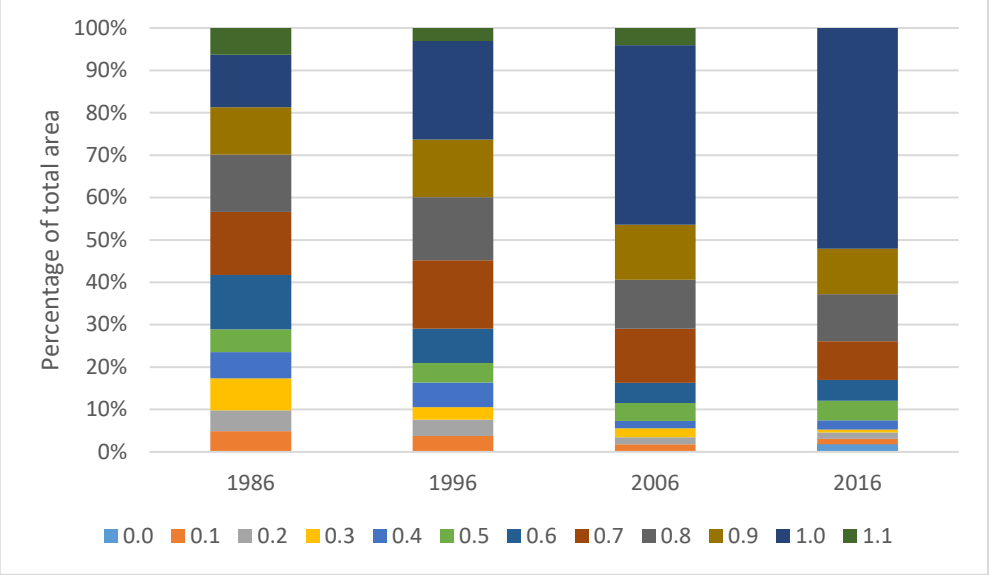


Figure 3: Relative stocking level distribution in percentage of total area of Spruce forests within the reindeer husbandry area aged between 0-20 years from 1986 to 2016. Source: The Swedish national forest inventory

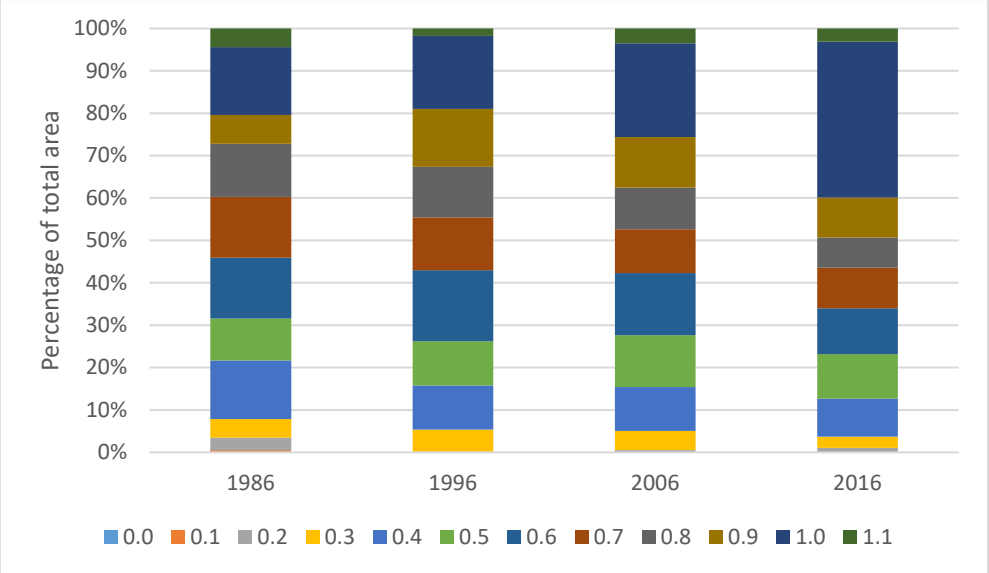


Figure 4: Relative stocking level distribution in percentage of total area of Spruce forests within the reindeer husbandry area aged between 21-40 years from 1986 to 2016. Source: The Swedish national forest inventory

3.3. Relative stocking level and Field-layer distribution

The field-layer and relative stocking level was stable from 1986 to 2016 with a few exceptions (appendix C). The area of spruce forests with a relative stocking level of 1 has doubled since 1996 and the average value of herbs in forests with a relative stocking level of 1 has decreased with circa 20% the last 20 years (appendix C). There has been a 30% decrease of herbs within spruce forests with relative stocking level 0,1 from 1996 to 2006 and an increase of 35% from 2006 to 2016 (appendix C). There is a larger proportion of herbs in spruce forests with a relative stocking level over 0,5 and forests with a relative stocking level of 0,1 (appendix C). The field-layer in forests with a relative stocking level between 0,2 and 0,5 has similar values except an increase in grass in less dense stands (appendix C). There is a larger proportion of grass in stands with a relative stocking level between 0 and 0,3 as well as 1 (appendix C). Sedges is the highest percentage in low densities but still only about 10% (appendix C).

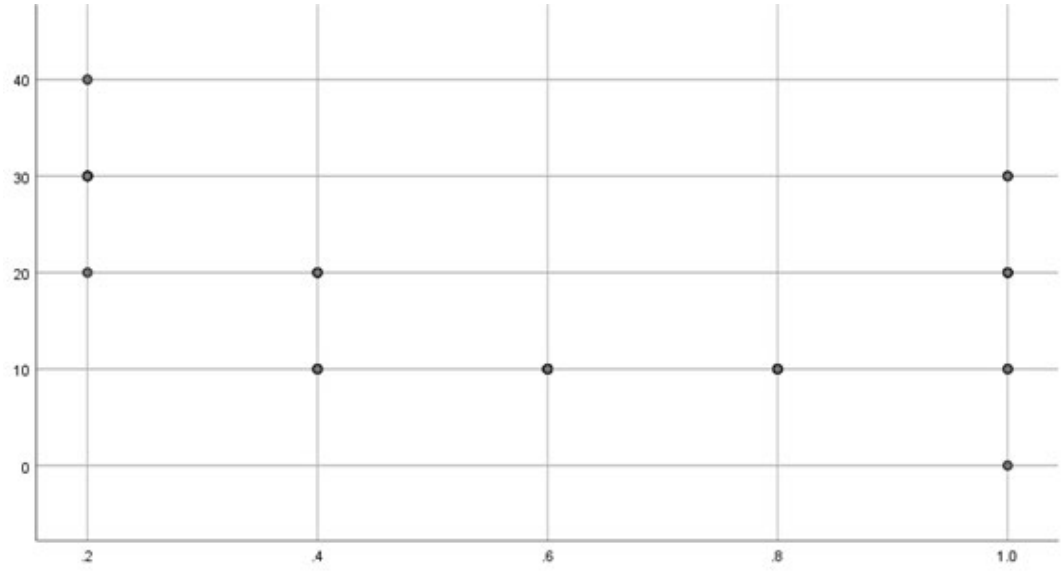


Figure 5: Scatter plot of the correlation between percentage of total hectares with grass (y-axis) and the relative stocking level of spruce forests (x-axis) within the reindeer husbandry area.

Fisher´s exact test indicated a significance value of less than 0.001 (Fig 5). Thus, this value was under 0.05 the null hypothesis could be rejected. Therefore, there was a positive association between percentage of total hectares with grass and the relative stocking level of spruce forests within the reindeer husbandry area (Fig 5). Cramer's V indicated a strong association between the variables of 0,512.

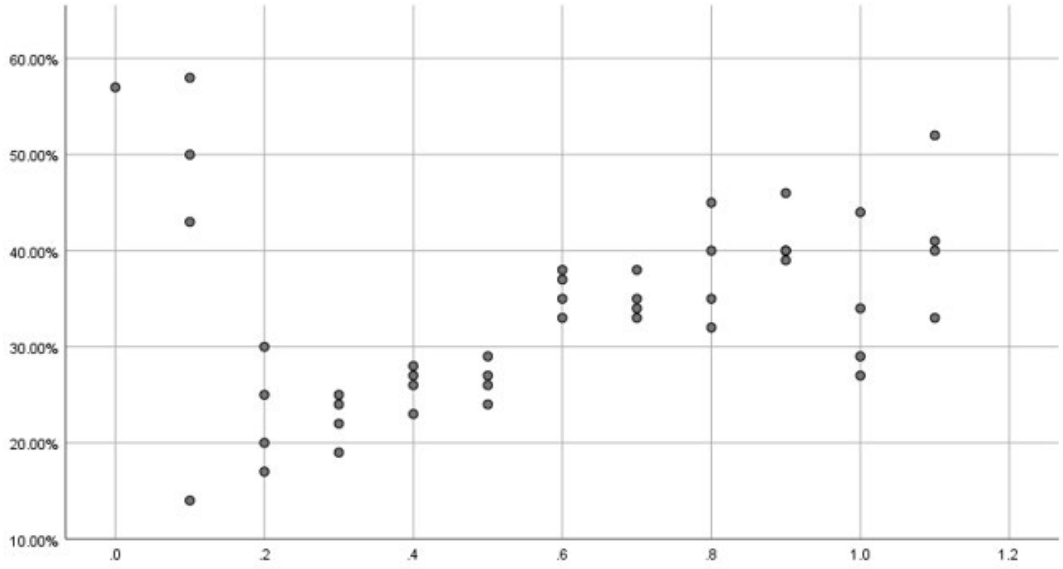


Figure 6: Scatter plot of the correlation between percentage of total hectares with herbs (y-axis) and the relative stocking level of spruce forests (x-axis) within the reindeer husbandry area.

Fisher´s exact test indicated a significance value of 0,041 (Fig 6). Thus, this value was under 0.05 the null hypothesis could be rejected. Therefore, there was an association between percentage of total hectares with herbs and the relative stocking level of spruce forests within the reindeer husbandry area (Fig 6). Cramer's V indicated a strong association between the variables of 0,417.

3.4. Age and Field-layer distribution

There has been a 1/3 decrease of the total area of spruce forests between 101-120 years and a decrease of the average value of herbs with circa 15% since 1996 (appendix D). The proportion of herbs in forests between 0-20 have decreased with circa 10% from 1996 to 2006 (appendix D). The proportion of grass is higher in spruce forests between 0-20 years (appendix D). The largest proportion of grass is found in forests between 0 and 40 years (appendix D). Sedges is 20% in forests between 21-40 years, by far the highest percentage of sedges in any other age class (appendix D). Fisher´s exact test indicated a significance value of 0,002 (Fig 7). Thus, this value was under 0.05 the null hypothesis could be rejected. Therefore, there was an association between percentage of total hectares with grass and the age of spruce forests within the reindeer husbandry area (Fig 7). Cramer's V indicated a strong association between the variables of 0,647.

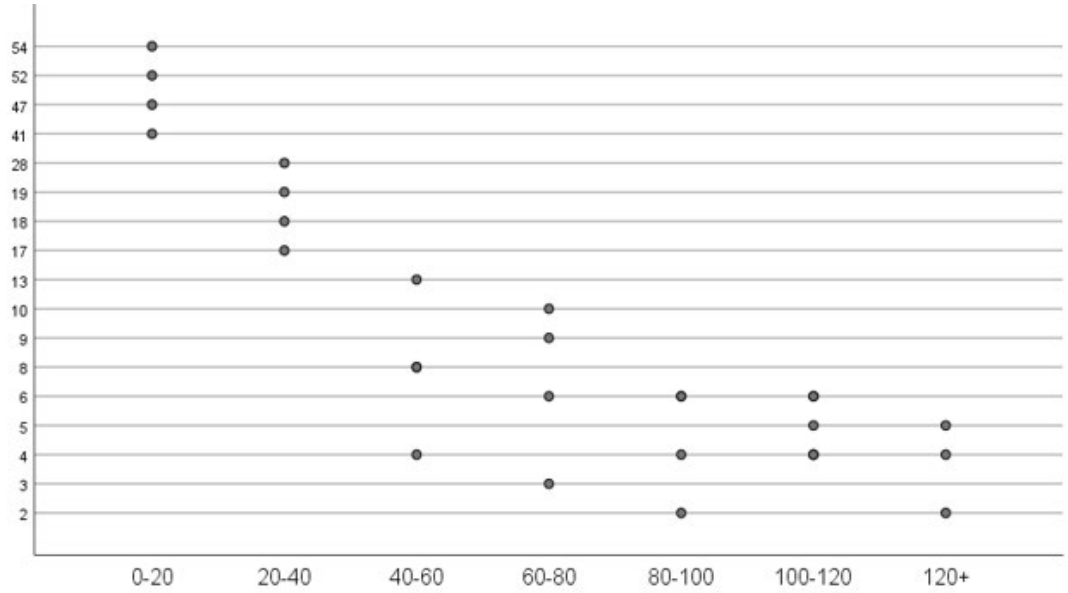


Figure 7: Scatter plot of the correlation between percentage of total hectares with grass (y-axis) and the age of spruce forests (x-axis) within the reindeer husbandry area.

Fisher´s exact test indicated a significance value of 0,98 (Fig 8). Thus, this value was over 0.05 the null hypothesis could not be rejected. Therefore, there was no association between percentage of total hectares with herbs and the age of spruce forests within the reindeer husbandry area (Fig 8).

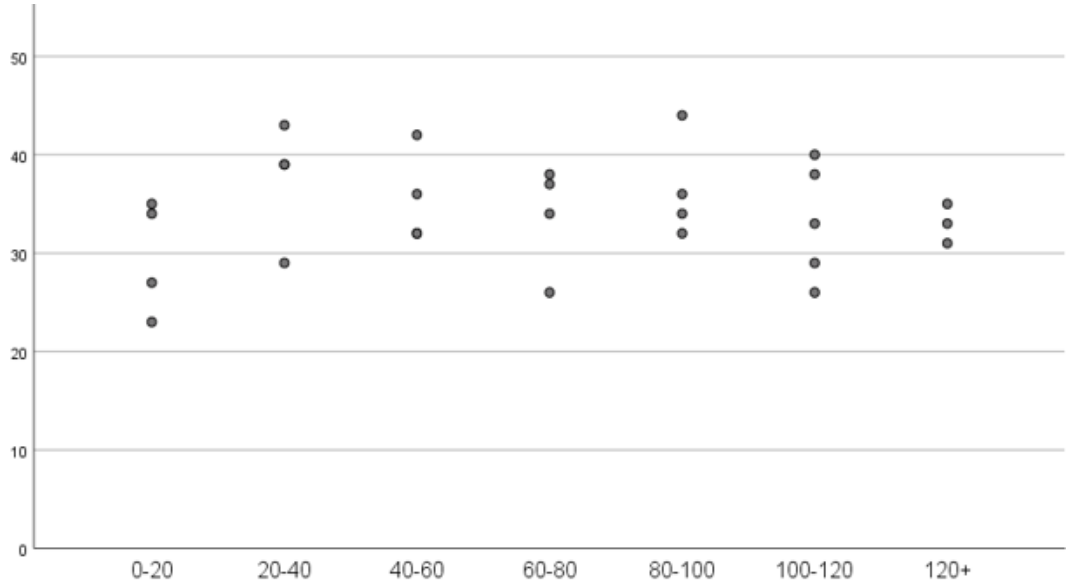


Figure 8: Scatter plot of the correlation between percentage of total hectares with herbs (y-axis) and the age of spruce forests (x-axis) within the reindeer husbandry area.

4. DISCUSSION

4.1. Changes in spruce forests within the reindeer husbandry area of Sweden

There has been a total decrease of 414 000 hectares of spruce forests within the reindeer husbandry area since 1986 (Fig 2). The age distribution has shifted with an increase of younger forests 21- 60 years and a decrease of older forests 60 to 120 years. According to Figure 1, spruce forests older than 120 years increased in 1996 to 2016, after an initial reduction in 1986 to 1996. The increase of forests older than 120 years might be a result of FSC certification and/or the protection of old forests for nature conservation. The total area of forests with a relative stocking level of 1 has doubled since 1996 (appendix C). There has been a significant increase of spruce forests between 0-40 years with a relative stocking level of 1 (Fig 3, Fig 4). Spruce forests over 40 years show minor changes in relative stocking level since 1986 (appendix B).

There are more sedges in low densities than high densities but still only about 10% (appendix C). There is a strong relationship between herbs/grasses and relative stocking level of spruce forests within the reindeer husbandry area (Fig 5, Fig 6). The proportion of herbs increases as relative stocking level increases (Fig 6). The proportion of grass decreases as relative stocking level increases with the exception of relative stocking level 1 (Fig 5).

The increased proportion of grass in relative stocking level 1 may be caused by a larger proportion of trees between 0-40 years whereas grass is in higher proportion in younger stands (appendix D). There is a strong relationship between the proportion of grass and forest age (Fig 7) The highest percentage of grass was found in spruce forests between 0-20 years (appendix D).

The total area of forests with relative stocking level 1 has doubled since 1996 and herbs have simultaneously decreased with 20% (appendix C). There is a larger proportion of herbs in spruce forests with a relative stocking level over 0,5 and spruce forests with relative stocking level 0,1 (appendix C). No relationship was found between herbs and age of spruce forests within the reindeer husbandry area (Fig 8). However, the proportion of herbs has decreased with 10% in spruce stands aged 101-120 since 1996. This may be due to 139 000 hectares decrease of

spruce forests between age 101- 120 since 1996 (appendix D). Through loss of stands with a high proportion of herbs the average could have been pushed down.

4.2. Method discussion and future studies

In this study spatial boundaries that reflects the entire reindeer husbandry area would have been desirable. In the future, it would be good if such boundaries were included in The Swedish national forest inventory´s database to facilitate further studies.

The results of the correlation between field-layer and relative stocking level (Fig 5, Fig 6) obtained from this study is not surprising. Previous studies explained earlier in this report (see section 2.2.) strengthen those results. Furthermore, the reason for the changes in forest structure that supports the results of this study is explained in section 2.1. Therefore, the results of this study are not surprising and is supported by previous studies.

An increase of grass in younger and less dense stands may be explained by an increase in clear-cuts (appendix C, appendix D). After final harvesting, it is common to see an increase in grass (Uotila & Kouki 2005). Stands with relative stocking level 1 has doubled since 1996 with the majority of the new area being stands between 0-40 years (appendix C). The high proportion of grass seen in these areas likely remained from the low densities following a clear-cut (Fig 3, Fig 4, appendix C, appendix D). Although the proportion of grass is increasing with younger more dense stands, the old spruce forests that offers habitats for arboreal lichen are decreasing (see section 2.3., Fig 2). It would have been interesting to investigate what has happened to the spruce forests that have disappeared within the reindeer husbandry area. Perhaps it has been planted with another tree species.

It would also be interesting to do a study on the spatial relationship of spruce forests within the reindeer husbandry area and complement with age distribution, field layer and relative stocking level since reindeer need to be able to move between habitats. It could offer additional knowledge for the trade-off planning process of commercial forestry and reindeer husbandry. Planning reindeer husbandry and commercial forestry is hard (Sandström, Moen *et al.* 2006). Furthermore impacts of climate change adds additional pressure to the reindeer herding industry (Furberg *et al.* 2011). Decision makers on national level, regional as well as local levels, need to have an increased understanding into the various pressures affecting reindeer husbandry to be able to make substantiated decisions (Furberg *et al.* 2011). Maintaining essential habitats for reindeer is just as important as secure connectivity of those habitats in the landscape so the reindeer can roam between them (Kivinen *et al.* 2010). The challenges of the future will be to combine production forest, maintain biodiversity and reindeer husbandry through landscape planning.

4.3. Relative stocking level and forest age impact reindeer habitats

There have been no significant differences in proportion of sedges in spruce forests within the reindeer husbandry area since 1986 except an increase of sedges with 10% in stands with relative stocking level 0,1 (appendix C). However, one must not forget that the total area of spruce forests within the reindeer husbandry area has decreased by 414 000 hectares since 1986 (Fig 2). There could also be a difficulty in assessing the proportion of sedges due to a lack of data (appendix C, appendix D). No Chi-square test was performed on sedges in this study due to a lack of data.

Grass cover decreases as relative stocking level increases (Fig 6) ultimately giving the same effect of increased shading as a closed canopy cover (see section 2.3.). Even though spruce forests have decreased in recent years (Fig 2) the remaining spruce forests have become increasingly dense (appendix C). Relative stocking level of spruce forests are strongly correlated to field-layer (Fig 5, Fig 6) and the relative stocking level distribution of spruce forests in Sweden is changing (appendix B). Therefore, the field-layer of spruce forests within the reindeer husbandry area is expected to change due to the effects of modern forest management. Mainly through a larger proportion of younger and denser forests. However, the effects on different species in the field-layer will differentiate. As seen from the results of this study grasses are affected by age and relative stocking level but herbs only by relative stocking level (Fig 5-8). More studies need to be conducted to further understand the effects of modern management on reindeer husbandry.

Within the reindeer husbandry area there has been an increase of stands between 0-20 with relative stocking level 1 and simultaneously a 10% decrease of herbs since 1996 (appendix C). The results suggest that forests of high densities do not necessarily mean low proportions of herbs. On the contrary forests with a relative stocking level over 0,5 has a higher proportion of herbs (appendix C, appendix D, Fig 6). In contrast to herbs, grasses are highest in abundance in stands with low densities (Fig 5). However, there has been a 10% increase of grass in forests with a relative stocking level of 1 since 1986 (appendix C, appendix D). This may be an effect of an increased proportion of younger stands with relative stocking level 1, since grass is more abundant in younger stands (appendix D, Fig 3-4). After a clear-cut the successional pattern usually starts with grass dominating in the open forest and later herbs in the older denser forests (appendix C, appendix D.

There is no research on how old and/or dense spruce forests need to be to offer reindeer protection. However, since dense lodgepole pine stands have been marked impassable (Carlsson & Boström 2014) it suggests that to be suitable for

reindeer the stands should be neither to open nor to dense. Denser and younger stands may be detrimental to reindeer, but it cannot be answered with this study alone. However, since the spruce forests have decreased by 414 000 hectares within the reindeer husbandry area since 1986 (Fig 2). Further decline of spruce forests combined with tougher winters and warmer summers could be deadly for reindeer (see section 2.2.). Furthermore, a decrease of spruce forests means a decrease in reindeer food sources found in those habitats.

The age distribution of spruce forests within the reindeer husbandry area has shifted (Fig 2). There is an increase of younger forests under 60 years and a decrease of older forests over 60 years (Fig 2). This is an effect of modern forestry where one wants to exploit stand production capacity through shorter rotation times and not to let the forest get too old and ruined.

Since reindeer do not eat coniferous saplings or seedlings, they are not a risk to the production of spruce forests but since these forests' harbours arboreal lichen and other food sources they should still be considered as important reindeer habitats.

4.4. Conclusion

Spruce forests within the reindeer husbandry area of Sweden has decreased since 1986. This have negative consequences for the reindeer through loss of protection against heat and insects, especially during hot summers. The decrease of spruce forests also means less food sources for the reindeer. The age distribution of spruce forests has shifted with an increase in forests younger between 20-60 years and a decrease of forests between 60 -120 years. The proportion of grasses in spruce forests within the reindeer husbandry area has a strong correlation with relative stocking level and forest age. The proportion of herbs has a strong correlation to relative stocking level and no correlation to forest age. Modern forestry has made the spruce forests younger and denser, which is accompanied by changes in field-layer.

5. REFERENCES

Albrektson,A,. Elfving, B., Lundqvist, L., Valinger, E & Skogsstyrelsen. (2012). Skogsskötsel grunder och samband, Skogsskötselserien nr 1. Page 17. Jönköping. Skogsstyrelsens förlag.
https://www.skogsstyrelsen.se/globalassets/mer-om-skog/skogsskotselserien/skogsskotsel-serien-1-skogsskotselns-grunder-och-samband.pdf

Axelsson, A.-L. & Östlund, L. (2001). Retrospective gap analysis in a Swedish boreal forest landscape using historical data. *Forest Ecology and Management*, vol. 147 (2–3), pp. 109–122

Bergerud, A.T. (1972). Food Habits of Newfoundland Caribou. The Journal of Wildlife Management, vol. 36 (3), p. 913

Borchert, N. (2001). Land is Life: Traditional Sámi Reindeer Grazing Threatened in Northern Sweden. Available at:
http://www.oloft.com/pressfolder.htm

Boucher, Y., Arseneault, D. & Sirois, L. (2009). Logging history (1820–2000) of a heavily exploited southern boreal forest landscape: Insights from sunken logs and forestry maps. *Forest Ecology and Management*, vol. 258 (7), pp. 1359–1368

Bäcklund, S., Jönsson, M., Strengbom, J. & Thor, G. (2015). Composition of functional groups of ground vegetation differ between planted stands of non-native Pinus contorta and native Pinus sylvestris and Picea abies in northern Sweden. Silva Fennica, vol. 49 (2). DOI: https://doi.org/10.14214/sf.1321

Carlsson, L & Boström, M. (2014). Skog och Ren. Tryckeribolaget AB
https://www.skogsstyrelsen.se/globalassets/mer-om-skog/rennaring/skog-och-ren-2014.pdf

Centrala samrådsgruppen skogsbruk/rennäring. (2018). Sammanträdesprotokoll. Boden.

Eriksson, O. (1976). Silvicultural Practices and Reindeer Grazing in Northern. Ecological Bulletins, No. 21, Man and the Boreal Forest (1976), pp. 107-120

Fridman, J., Holm, S., Nilsson, M., Nilsson, P., Ringvall, A. & Ståhl, G. (2014). Adapting National Forest Inventories to changing requirements – the case of the Swedish National Forest Inventory at the turn of the 20th century. *Silva Fennica*, vol. 48 (3). DOI: https://doi.org/10.14214/sf.1095

FSC (2018). FSC-certifierad produktiv skogsareal, hektar per län år 2006, 2009, 2011, 2013 och 2017. Available at: https://se.fsc.org/preview.fsc-certifierad-areal-per-ln-2017.a-1078.pdf [2020-06-16]

Furberg, M., Evengård, B. & Nilsson, M. (2011). Facing the limit of resilience: perceptions of climate change among reindeer herding Sami in Sweden. Global Health Action, vol. 4 (1), p. 8417

Hagemoen, R.I.M. & Reimers, E. (2002). Reindeer summer activity pattern in relation to weather and insect harassment. Journal of Animal Ecology, vol. 71 (5), pp. 883–892

Hansen, B.B., Aanes, R. & Sæther, B.-E. (2010). Feeding-crater selection by high-arctic reindeer facing ice-blocked pastures. Canadian Journal of Zoology, vol. 88 (2), pp. 170–177

Hedwall, P.-O., Brunet, J., Nordin, A. & Bergh, J. (2013). Changes in the abundance of keystone forest floor species in response to changes of forest structure. (Halvorsen, R., ed.) Journal of Vegetation Science, vol. 24 (2), pp. 296–306

Hedwall, P. -O., Holmström, E., Lindbladh, M. & Felton, A. (2019). Concealed by darkness: How stand density can override the biodiversity benefits of mixed forests. *Ecosphere*, vol. 10 (8). DOI: https://doi.org/10.1002/ecs2.2835

Helle, T. & Säntti, V. (1982). Vinterkatastrofer inom ren-skötseln i Finland: Förluster och deras förebyggande [Winter-catastrophes in the reindeer husbandry of Finland: Losses and their prevention]. Rangifer2(1): 2-8.

Josefsson, T., Gunnarson, B., Liedgren, L., Bergman, I. & Östlund, L. (2010). Historical human influence on forest composition and structure in boreal Fennoscandia. *Canadian Journal of Forest Research*, vol. 40 (5), pp. 872–884

Kivinen, S., Moen, J., Berg, A. & Eriksson, Å. (2010). Effects of Modern Forest Management on Winter Grazing Resources for Reindeer in Sweden. *AMBIO*, vol. 39 (4), pp. 269–278

Kolloen, M.R. (2015). Effects of weather on summer and winter activity level of the high arctic ungulate Svalbard reindeer (Rangifer tarandus platyrhynchus). 54, Norwegian University of Life Sciences, Ås. Available at: https://nmbu.brage.unit.no/nmbu-xmlui/handle/11250/294198 [2020-04-11]

Kuuluvainen, T. (2002). Natural variability of forests as a reference for restoring and managing biological diversity in boreal Fennoscandia. Silva Fennica, vol. 36 (1). DOI: https://doi.org/10.14214/sf.552

Käyhkö, J. & Horstkotte, T. (2017). Jukka Käyhkö och Tim Horstkotte (Red.) – Den globala förändringens inverkan på rennäringen på norra Fennoskandiens tundra. p. 39

Linder, P. & Östlund, L. (1998). Structural changes in three mid-boreal Swedish forest landscapes, 1885–1996. Biological Conservation, vol. 85 (1–2), pp. 9–19

Mallory, C.D. & Boyce, M.S. (2018). Observed and predicted effects of climate change on Arctic caribou and reindeer. Environmental Reviews, vol. 26 (1), pp. 13–25

Nilsson, P. Roberge, C. Fridman, J. & Wulff, S. (2019). Skogsdata 2019: Aktuella uppgifter om de svenska skogarna från SLU Riksskogstaxeringen. Available at: https://www.slu.se/globalassets/ew/org/centrb/rt/dokument/skogsdata/skogsdata_2019_webb.pdf [2020-04-30]

Petersson, L., Holmström, E., Lindbladh, M. & Felton, A. (2019). Tree species impact on understory vegetation: Vascular plant communities of Scots pine and Norway spruce managed stands in northern Europe. Forest Ecology and Management, vol. 448, pp. 330–345

Riksskogstaxeringen (2020). *Om inventeringen*. Available at: https://www.slu.se/centrumbildningar-och-projekt/riksskogstaxeringen/om-riksskogstaxeringen1/om-inventeringen/ [2020-06-16]

Sandström, C., Carlsson-Kanyama, A., Lindahl, K.B., Sonnek, K.M., Mossing, A., Nordin, A., Nordström, E.-M. & Räty, R. (2016). Understanding consistencies and gaps between desired forest futures: An analysis of visions from stakeholder groups in Sweden. Ambio, vol. 45 (S2), pp. 100–108

Sandström, C., Moen, J., Widmark, C. & Danell, Ö. (2006). Progressing toward co-management through collaborative learning: forestry and reindeer husbandry in dialogue. International Journal of Biodiversity Science & Management, vol. 2 (4), pp. 326–333

Sandström, C., Widmark, C., Moen, J., Danell, Ö & Esselin, A. (2006). Skogen som gemensam resurs: Vägledning för effektivare samråd mellan ren- och skogsnäring. (FjällMistrarapport Rapport nr: 23. ISSN 1652-3822 juni 2006). Umeå.

SFS 2010:930 Skogsvårdslagstiftningen. Stockholm: Näringsdepartementet

Shorohova, E., Kuuluvainen, T., Kangur, A. & Jõgiste, K. (2009). Natural stand structures, disturbance regimes and successional dynamics in the Eurasian boreal forests: a review with special reference to Russian studies. *Annals of Forest Science*, vol. 66 (2), pp. 201–201

Skogsstyrelsen. (2019). Skogsbruk och rennäring. Available: https://www.skogsstyrelsen.se/mer-om-skog/skogsbruk-och-rennaring/ [2020-03-03]

Strengbom, J., Näsholm, T. & Ericson, L. (2004). Light, not nitrogen, limits growth of the grass Deschampsia flexuosa in boreal forests. vol. 82, p. 6

Svensk skogsbruksstandard. Available at: https://se.fsc.org/se-se/standarder/svensk-skogsbruksstandard [2020-04-13]

The Royal Swedish Academy of Agriculture and Forestry (KSLA). (2015). *Forests and Forestry in Sweden*.

The Swedish National Forest Inventory | Externwebben. Available at: https://www.slu.se/nfi [2020-04-13]

Tonteri, T., Salemaa, M., Rautio, P., Hallikainen, V., Korpela, L. & Merilä, P. (2016). Forest management regulates temporal change in the cover of boreal plant species. Forest Ecology and Management, vol. 381, pp. 115–124

Uotila, A. & Kouki, J. (2005). Understorey vegetation in spruce-dominated forests in eastern Finland and Russian Karelia: Successional patterns after anthropogenic and natural disturbances. *Forest Ecology and Management*, vol. 215 (1–3), pp. 113–137

Vanha-Majamaa, I., Shorohova, E., Kushnevskaya, H. & Jalonen, J. (2017). Resilience of understory vegetation after variable retention felling in boreal Norway spruce forests – A ten-year perspective. *Forest Ecology and Management*, vol. 393, pp. 12–28

Widenfalk, O. & Weslien, J. (2009). Plant species richness in managed boreal forests—Effects of stand succession and thinning. Forest Ecology and Management, vol. 257 (5), pp. 1386–1394

Appendix

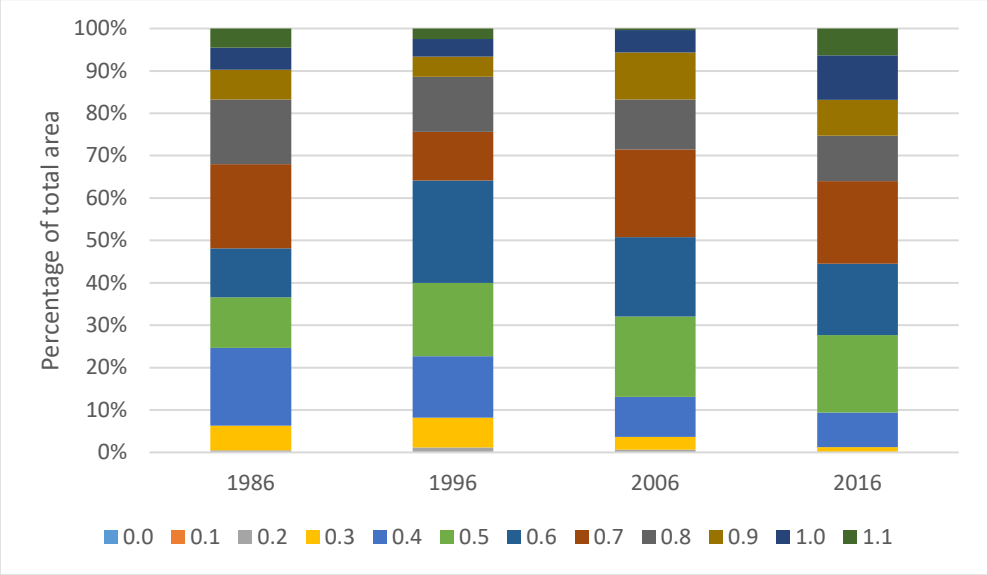
Appendix A:

Municipalities included in the study (sorted alphabetically):

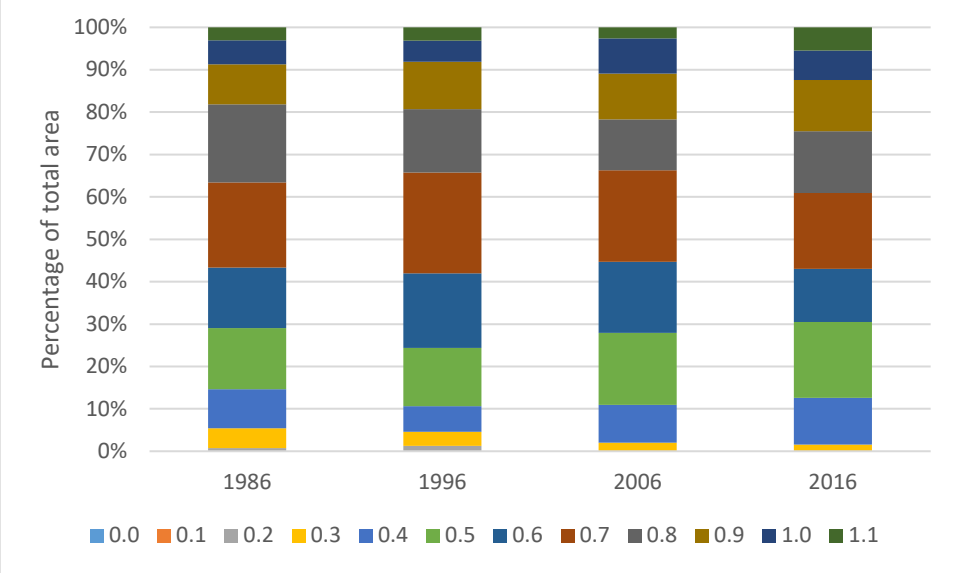
Arjeplog
Arvidsjaur
Berg
Bjurholm
Boden
Bräcke
Dorotea
Gällivare
Haparanda
Härnösand
Jokkmokk
Kalix
Kiruna
Kramfors
Krokom
Luleå
Lycksele
Malå
Nordmaling
Norsjö
Pajala
Piteå
Ragunda
Robertsfors
Skellefteå
Sollefteå
Sorsele
Storuman
Strömsund
Sundsvall
Timrå
Umeå
Vilhelmina
Vindeln
Vännäs
Åre
Åsele
Älvsbyn
Örnsköldsvik
Östersund
Överkalix
Övertorneå

Appendix B

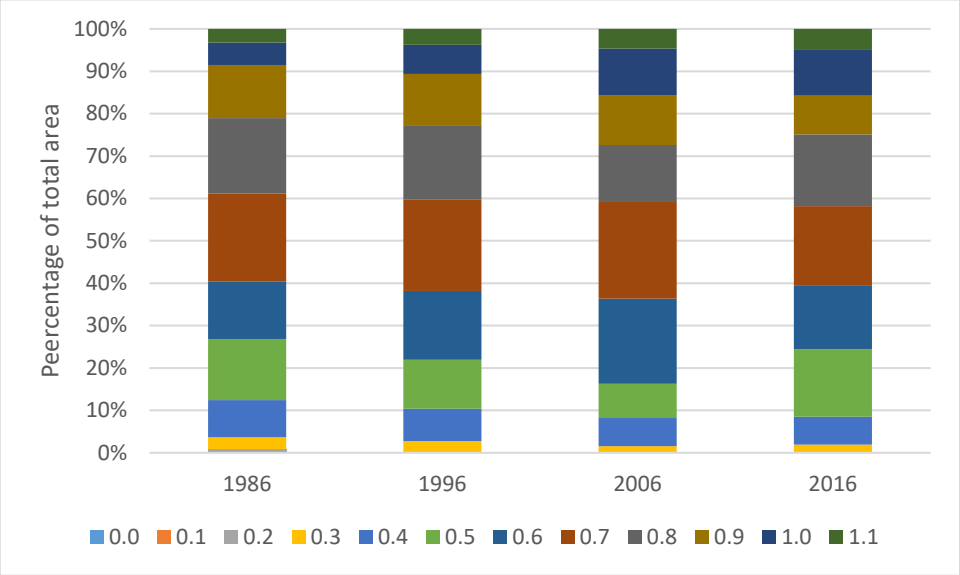
Relative stocking level distribution of spruce forests within the reindeer husbandry area sorted by age



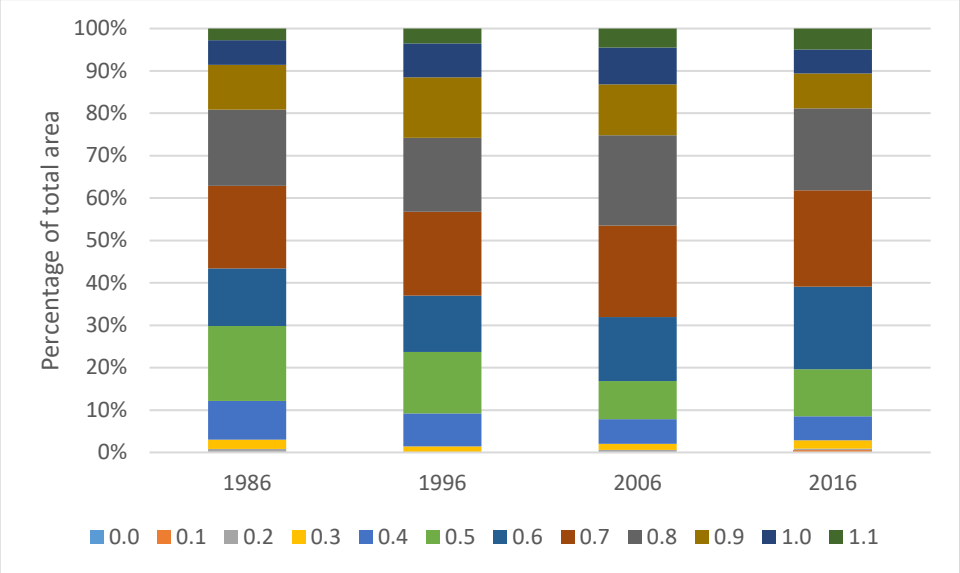
Relative stocking level distribution in percentage of total area of Spruce forests within the reindeer husbandry area aged between 41-60 years from 1986 to 2016. Source: The Swedish national forest inventory



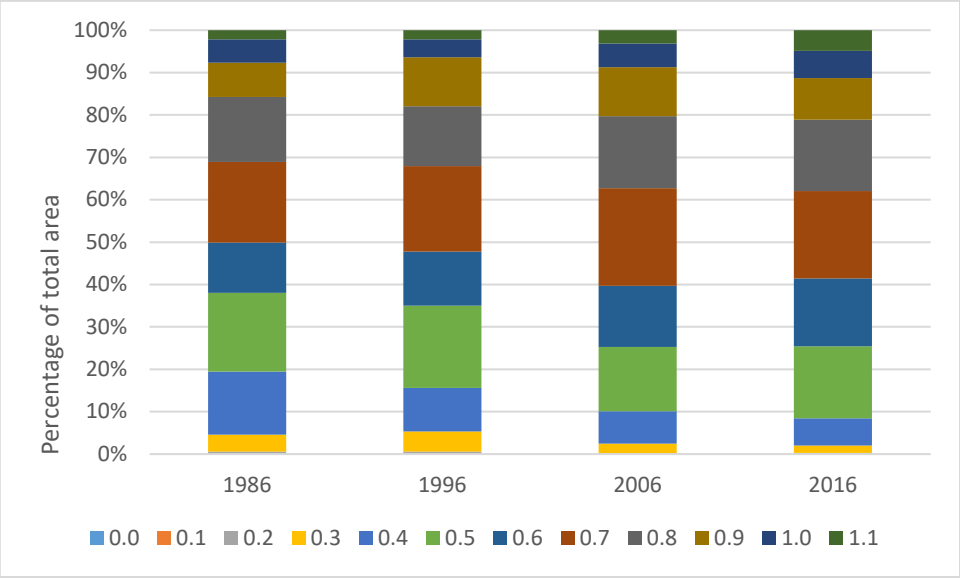
Relative stocking level distribution in percentage of total area of Spruce forests within the reindeer husbandry area aged between 61-80 years from 1986 to 2016. Source: The Swedish national forest inventory



Relative stocking level distribution in percentage of total area of Spruce forests within the reindeer husbandry area aged between 81-100 years from 1986 to 2016. Source: The Swedish national forest inventory



Relative stocking level distribution in percentage of total area of Spruce forests within the reindeer husbandry area aged between 101-120 years from 1986 to 2016. Source: The Swedish national forest inventory



Relative stocking level distribution in percentage of total area of Spruce forests within the reindeer husbandry area by the age of +121 years from 1986 to 2016. Source: The Swedish national forest inventory

Appendix C

Field-layer distribution within the reindeer husbandry area (sorted by relative stocking level)

Field-layer distribution (percentage of total area) since 1986 of spruce forests within the reindeer husbandry area of Sweden (sorted by relative stocking level). Empty cells indicate a lack of data. Source: The Swedish national forest inventory.

	1986	1996	2006	2016
Relative stocking level: 0				
Herbs				57%
Grass				29%
Sedges				
Total area (1000s of hectares)				7
Relative stocking level: 0,1				
Herbs	58%	43%	14%	50%
Grass	26%	29%	43%	33%
Sedges	5%			17%
Total area (1000s of hectares)	19	14	7	6
Relative stocking level: 0,2				
Herbs	20%	30%	17%	25%
Grass	23%	30%	25%	25%
Sedges	3%			8%
Total area (1000s of hectares)	35	20	12	12
Relative stocking level: 0,3				
Herbs	25%	24%	19%	22%
Grass	19%	8%	23%	16%
Sedges	3%		2%	
Total area (1000s of hectares)	109	83	52	37
Relative stocking level: 0,4				
Herbs	26%	27%	28%	23%
Grass	13%	10%	12%	15%
Sedges	2%	1%	1%	3%
Total area (1000s of hectares)	297	194	151	143
Relative stocking level: 0,5				
Herbs	27%	24%	29%	26%
Grass	11%	7%	9%	9%
Sedges	2%	2%	2%	1%
Total area (1000s of hectares)	391	312	266	303

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	1986	1996	2006	2016
Relative stocking level: 0,6				
Herbs	33%	38%	37%	35%
Grass	11%	10%	9%	11%
Sedges	1%	0%		0%
Total area (1000s of hectares)	342	313	314	305
Relative stocking level: 0,7				
Herbs	34%	38%	33%	35%
Grass	11%	9%	12%	10%
Sedges	1%	2%	1%	1%
Total area (1000s of hectares)	492	426	440	381
Relative stocking level: 0,8				
Herbs	40%	45%	35%	32%
Grass	9%	11%	11%	13%
Sedges	2%	1%	0%	0%
Total area (1000s of hectares)	424	339	331	315
Relative stocking level: 0,9				
Herbs	40%	46%	39%	40%
Grass	12%	11%	15%	16%
Sedges	2%	1%	0%	0%
Total area (1000s of hectares)	255	274	266	216
Relative stocking level: 1				
Herbs	34%	44%	29%	27%
Grass	17%	24%	30%	30%
Sedges	3%	1%	2%	4%
Total area (1000s of hectares)	187	205	329	414
Relative stocking level: 1,1				
Herbs	41%	52%	33%	40%
Grass	15%	8%	16%	3%
Sedges	1%		4%	1%
Total area (1000s of hectares)	87	63	76	90

Appendix D

Field-layer distribution within the reindeer husbandry area sorted by age

Field-layer distribution (percentage of total area since 1986 of spruce forests within the reindeer husbandry area of Sweden (sorted by age). Empty cells indicate a lack of data. Source: The Swedish national forest inventory.

	1986	1996	2006	2016
0-20 years				
Herbs	34%	35%	27%	23%
Grass	41%	47%	52%	54%
Sedges	4%	3%	2%	4%
Total area (1000s of hectares)	348	337	396	372
21-40 years				
Herbs	29%	43%	39%	39%
Grass	28%	17%	18%	19%
Sedges	7%	2%	2%	1%
Total area (1000s of hectares)	163	176	202	276
41-60 years				
Herbs	32%	36%	32%	42%
Grass	4%	8%	13%	8%
Sedges	6%	2%	1%	1%
Total area (1000s of hectares)	108	107	196	236
61-80 years				
Herbs	34%	38%	26%	37%
Grass	9%	3%	6%	10%
Sedges	1%	0%		1%
Total area (1000s of hectares)	231	202	140	126
81-100 years				
Herbs	36%	44%	34%	32%
Grass	6%	4%	2%	6%
Sedges	1%	1%	0%	
Total area (1000s of hectares)	411	322	245	193
101-120 years				
Herbs	38%	40%	33%	26%
Grass	5%	4%	6%	4%
Sedges	1%		1%	0%
Total area (1000s of hectares)	506	367	286	228
+120 years				
Herbs	29%	33%	35%	31%
Grass	6%	2%	4%	5%
Sedges	1%	1%	1%	1%
Total area (1000s of hectares)	874	732	781	796