ECOLOGICAL IMPACTS OF REINDEER HERDING
IN OULANKA NATIONAL PARK

Diplomarbeit
vorgelegt von

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Semi-domesticated reindeer in Oulanka National Park feeding on arboreal lichen in wintertime.

ERKLÄRUNG:

„Hiermit erkläre ich, dass ich diese Arbeit selbstständig angefertigt habe und dass alle Stellen, die dem Wortlaut oder dem Sinn nach anderen Werken entnommen sind, durch Angabe der Quellen als Entlehnung kenntlich gemacht worden sind.“

Konstanz, 15.06.2005

Helgard Fischer
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1 INTRODUCTION

1.1 PAN Parks

Reindeer husbandry - its economic viability, its ecological consequences, its relationship with forestry and tourism, its social and ethnic importance as a traditional livelihood – has been the subject of much research in Finland. International nature protection organizations have recently begun to take an interest as well. Reindeer herders who protest against the destruction of old-growth forests that are needed as pasture areas have found allies in the international organization Greenpeace. On the other hand, herders and nature conservationists do not always agree what nature protection should entail and whether semi-domestic reindeer (*Rangifer tarandus tarandus* L.) should be part of the wilderness or not. Oulanka National Park, situated in Eastern Finland just below the Arctic Circle, drew admonishment from the PAN (Protected Area Network) Parks Foundation during the process to be verified as a PAN Park due to alleged overgrazing by semi-domestic reindeer.

PAN Parks Foundation is a non-profit organization that was started in 1999 as a joined project of the nature conservation organisation World Wide Fund for Nature (WWF) and a Dutch leisure company, Molecaten Group (Bengeldorp Gastelaars 2002). The foundation endeavours to synergize nature conservation and tourism on a European scale (PAN 1 2005). It aims to promote wilderness management in protected areas in Europe, to facilitate sustainable tourism development in and around these protected areas, and to increase knowledge of and pride in Europe's nature (PAN 2 2005). In order to achieve these goals, PAN Parks Foundation promotes networking between nature conservation organisations, national parks, tourism businesses, local communities, and other interest groups on a local, national, and international level. Protection of European nature is to be encouraged by placing economic value on it (PAN 1 2005). The concept of wilderness stands at the centre of the foundation's mission. It defines wilderness as

large area of land, (at least 10,000 hectares) which, together with its native plant and animal communities and the ecosystems of which they are a part, is in an essentially natural state. PAN Parks wilderness areas are that lands that have been least modified by man, they represent the most intact and an undisturbed expanse of Europe's remaining natural landscapes. (PAN 3 2005, emphasis mine.)

During the verification process, the visiting Verification Team found the grazing pressure of reindeer on ground lichens to be beyond the carrying capacity of the park. While reindeer herding was recognized as an important economic activity and local
livelihood, the Verification Report (Zinke 2002) concluded that the present situation must change and that reindeer should be excluded from certain areas of the park by fencing. As a Minor Corrective Action Requirement, an independent study was to be conducted until 2005 that should indicate the winter carrying capacity for reindeer in Oulanka. The study results would then have to be implemented between 2005 and 2010 to make sure that the impact of reindeer will be below the carrying capacity of the national park (ibid). A preliminary study of 2002 concluded that reindeer do not have negative impact on the development of the vegetation and do not exceed the winter carrying capacity (Miller 2003). In the 2003 verification report, the verifiers continue to stand by their initial position but accept that the resolution of this issue will be a long-term process (ibid).

1.2 Reindeer winter grazing and different food plants

Most models concerning winter grazing, carrying capacity and maximization of meat production only look at abundance of reindeer lichens as food that guarantees survival and productivity of reindeer herds (e.g. Skogland 1986, Moxness 1998). However, many studies show that reindeer can and do use alternatives to reindeer lichens where available (e.g. Helle & Saastamoinen 1979, Helle 1981, Jaakkola et al. 2005), as in the multi-pasture grazing system which prevails in the whole southern part of the Finnish reindeer management area (cf. Mattila 1981). In Alakitka, the herding association that includes part of Oulanka National Park, winter feeding can be divided into two periods. In early winter, as long as the snow is soft and shallow, reindeer feed on Cladonia lichens and grasses and sedges, particularly hair grass (Deschampsia flexuosa) (Figure 1). In mid- and late winter, reindeer that are not kept in corrals feed on arboreal lichens, especially Alectorionia and Bryoria species (Helle 1981).

Figure 1. Abundant growth of hair grass.

Once the ground is snow covered, reindeer have to dig to reach ground lichens, grasses and sedges. To find abundant lichen sites and to avoid futile energy investments they make trial holes for smelling tests. Reindeer can adequately judge lichen abundance by smell even at a snow depth of 91 cm, though snow thickness of
more than 65 cm generally triggers movement to areas with shallower snow (Helle 1984). In difficult snow conditions, reindeer are more selective when choosing digging sites, use a higher proportion of the biomass per feeding hole (ibid), and also eat other ground vegetation like mosses and dwarf shrubs (Helle & Saastamoinen 1979).

In dry Scots pine forests, the climax vegetation state in the absence of grazing is dominated by *Cladonia stellaris* (Suominen & Olofsson 2000). Its competitiveness is based on its compact structure and dense branching that prevents other species from growing through it (Helle & Aspi 1983). *C. stellaris* also produces allelopathic extracts that inhibit growth of pine mycorrhizae and are thought to inhibit the growth of dwarf shrubs (Suominen & Olofsson 2000). Dwarf shrub height and abundance increases under moderate grazing pressure (Helle & Aspi 1983) as *C. stellaris* does not tolerate grazing well. While other lichens break off easily above the base and can regenerate quickly, *C. stellaris* is broken off entirely. This phenomenon can be demonstrated by hand (ibid). Thick reindeer lichen carpets have substantial effects on many physical features at ground level and in the soil. They inhibit deep freezing of the soil and prevent rising of temperature in daytime and lowering at night. Grazing decreases soil moisture and increases rainwater-runoff. For these reasons, reindeer lichens and consequently reindeer have been called important ecosystem engineers (Suominen & Olofsson 2000)

Silvicultural practices like clear-felling, prescribed burning and ploughing of reforestation areas are often considered harmful to winter ranges. While it has been demonstrated that clear-felling reduces the amount of reindeer lichens on dry and subdry sites (Eriksson 1976 cited in Helle et al. 1983, Helle & Saastamoinen 1983), many studies show that the detrimental effects of regeneration fellings are felt for only a short time (Helle & Saastamoinen 1979, Helle et al. 1983, Helle et al. 1990). Microclimate in clear-felling areas is similar to those in thinned old-growth forests (Helle et al. 1983) and lichen biomass is only reduced for a few years, mostly because of cutting residuals (Helle et al. 1990). However, reindeer do not like to graze in clearings or dense young growth forests for several reasons. Litter and cutting residuals obstruct digging, snow is likely packed harder because of strong wind gusts and visibility of predators in dense young growth forests is low (ibid). Helle, Aspi and Kilpelä (1990) show in their study that in the Kuusamo region, the number of faecal groups increases with the stand age and is negatively correlated with lichen height and cutting residuals.

Composition of faecal groups proves that grasses and sedges play an important role as reindeer winter food (Helle & Saastamoinen 1979). Forest regeneration on rich-to-
subdry mineral soils frequently brings abundance of *Deschampsia flexuosa*. In Kuusamo, the maximum yield is achieved 5-10 years after clear felling (Helle 1975). Because the snow surface hardens more easily in clear-felled areas, use of hair grass is normally restricted to sites with more than 200 kg of grass per hectare (Helle & Saastamoinen 1979).

When deep or hard snow prevents access to ground vegetation, reindeer turn to arboreal lichens as winter food (Figure 2). Before effective supplemental feeding, semi-domestic reindeer used to feed on arboreal lichens 3-4 months per year (Helle & Saastamoinen 1979). Nevertheless, arboreal lichens have often been neglected in inventories of reindeer winter pastures (Jaakkola et al. 2005). Biomass of pendulous lichens was drastically reduced in the 20th century due to pollution, especially emission of sulphurdioxid (Kuusinen et al. 1990). However, with the decline of emissions in the 1980s, the conditions for the remaining lichen populations improved and habitat loss due to silvicultural practices has become the biggest problem (Jaakkola et al. 2005). Generally, abundance of arboreal lichens in young and managed forests is smaller than in old-growth unmanaged forests (Mattila & Helle 1978, Dettki & Esseen 1998). Mattila and Helle (1978) and Mattila (1981, 1988, 1998) show in inventories of the whole reindeer herding area that about 60 % of the forest area does not have any arboreal lichens due to the young stand age. There are mainly two reasons causing that problem: the insufficient colonisation of young stands and too short length of forestry rotation time (Jaakkola et al. 2005). Forestry rotation time in Kuusamo is only about 120 years but biomass of arboreal lichens increases until 200 years (250 years in spruce). Additionally, the colonization of large-size clear-cuttings takes a long time because the dispersal mechanism is distance-dependent. Thallus fragments are not carried far and are only spread to a distance of maximally 150 meters from the forest edge (ibid). Dettki and Esseen (1998) conclude that short rotation times and restricted dispersal capacity lead to a situation where even the oldest forest classes in managed areas have only about 5 % of the arboreal lichen biomass of virgin forest of the same age.
Jaakkola, Helle, Soppela, Kuitunen and Yrjönen (2005) find that arboreal lichen biomass is mainly correlated to tree species composition and cubic volume. It is also correlated with the density of the forest but density is not a useful biomass predictor because very young stands are usually dense without lichen load. Biomass in Oulanka on spruce is 9-13 times higher than on Scots pine and birch due to denser branchiation in spruce (ibid). Halonen et al. (1991) explain the difference between species by referring to highly dissimilar microclimates on trunks of pine and spruce. Spruce trunks remain moist much longer than pine trunks. Bark properties such as pH, nutrient status, tannins, resins, hardness, porosity and water relations are important for composition of arboreal lichen stands (ibid). Hyvärinen, Halonen and Kauppi (1992) observe that stand age is important for biomass because it leads to changes in the structure of the tree canopy, microclimate and properties of the bark. According to Bostedt, Parks and Boman (2003), spruce trees must be older than 100 years to support high arboreal lichen biomasses.

Reindeer can feed on arboreal lichens that hang up to two meters high (Helle 1975). When considering arboreal lichens as winter food, it is therefore important to know the proportion of lichens growing below two meters. According to McCune (1993) the epiphytes migrate upwards in trees through time, but below the height of two meters reindeer feeding also has impact on the biomass. According to Helle (1982) the lichen biomass on trees in grazed areas is about 50 percent compared to ungrazed areas. In Oulanka, the biomass of arboreal lichens below two meters was 7 kg*ha⁻¹ on fresh sites, 2 kg*ha⁻¹ on subdry sites and 1 kg*ha⁻¹ on dry sites, which amounts to 6-7 % of the total biomass (Jaakkola 2005). In addition, lichens from higher up are blown off the tree and can be eaten from the snow surface. On dry Scots pine forest sites, the litter fall has been measured as being between 10 and 22 kg*ha⁻¹ (Sulkava & Helle 1975, Kuusinen & Jukola-Sulonen 1987). Ultimately, for arboreal lichens to be maintained over time, the growth rates of the lichens must exceed the amount of the litter fall (Stevenson & Coxson 2004). Growth rates of arboreal lichens lie between 6 and 20 % (Jaakkola 2005).
2 Aim

It is the aim of this thesis to examine the ecological impacts of reindeer herding in Oulanka National Park. The first part of the study deals with the ground vegetation structure in reindeer lichen-rich Scots pine forests in the national park and the change in lichen biomass there from 1971 to the present. The second part of the paper looks at grazing pressure in relation to vegetation. Oulanka is only part of Alakitka reindeer herding association. The different forest structures inside and outside the park influence the availability of reindeer food plants like arboreal lichens, reindeer lichens and hair grass. Different site types are expected to show unequal grazing pressure. Finally, it is necessary to determine the importance of the national park for the herding association. Therefore, the abundance of the different food plants and their distribution inside and outside the park will be investigated. To answer the questions of carrying capacity and over-grazing in Oulanka, an attempt at a meaningful interpretation of the terms will conclude the paper.
3 MATERIAL AND METHODS

3.1 Study Area

3.1.1 Oulanka National Park

Oulanka National Park is situated 800 km north of Helsinki just below the Arctic Circle (66°24’N, 29°12’E) and bounded on the eastern side by the Russian national park Paanajärvi. It was established in 1956 and expanded in 1982 and 1989 to its present size of 277.2 km² (Metsähallitus 2005). The area belongs to the coniferous forest belt (Helle 1981). The park contains spruce forests, pine forests, open peat land (aapamires) that are important to the preservation of animal life, and diverse river habitats including Oulanka river that is characterised by deep gorges, waterfalls and rapids. The vegetation of the Oulankajoki river valley has more southerly affinities than that of its surroundings and is much more luxuriant. It includes a number of rarities, notably some eastern and northern species living at the extreme edge of their range (Metsähallitus 2005). Oulanka is used for nature tourism and reindeer farming. The ground is normally snow covered from the end of October to the end of May and the mean temperature is 0°C (Helle et al. 1983). The altitude is between 135 and 500 m above sea level (PAN 2002). Located inside the park is the university of Oulu research station. The old, southern half of the park with an area of 139.6 km² is part of Alakitka reindeer herding association (Figure 3).

Figure 3: Alakitka reindeer herding association. The grey area indicates Oulanka National Park. The insert shows Alakitka’s location in Finland.
Alakitka has a total area of 1180.6 km². The forested area that constitutes suitable pasture grounds covers 834.8 km². The non-pasture areas are open bogs, streets and houses, fields, and rivers and streams. 13% of the total pasture area is located in the national park (Table 1).

Table 1. Pastures and other areas and site type distribution in Alakitka reindeer herding association and Oulanka National Park (NP).

<table>
<thead>
<tr>
<th>Area Inside Oulanka NP [km²]</th>
<th>Area Outside NP [km²]</th>
<th>Alakitka RHA Total Area [km²]</th>
</tr>
</thead>
<tbody>
<tr>
<td>non-pasture areas</td>
<td>30.9</td>
<td>315.0</td>
</tr>
<tr>
<td>total pasture areas</td>
<td>108.7</td>
<td>726.0</td>
</tr>
<tr>
<td>dry</td>
<td>5.7</td>
<td>5.8</td>
</tr>
<tr>
<td>subdry</td>
<td>72.2</td>
<td>275.2</td>
</tr>
<tr>
<td>fresh</td>
<td>30.8</td>
<td>445.0</td>
</tr>
<tr>
<td>total area [km²]</td>
<td>139.6</td>
<td>1041.0</td>
</tr>
</tbody>
</table>

In the course of the Finnish multi-source national forest inventory, the old part of Oulanka National Park was classified according to three site types: dry, subdry and fresh (Mattila 1998). Outside the park, forest structure has been mapped through a satellite image-aided survey (Nivala 2005). Since no site type classifications exist for these areas, 124 random sample sites were used to calculate the percentage and area for each site type. Table 1 shows the total area of site types inside and outside the park. The much larger areas of subdry and fresh sites outside the park are noticeable (Figure 4). Altogether, only 2% of pasture lands are dry sites, 41% are subdry and 57% are fresh.

Figure 4: Pasture areas [ha] differentiated by site types inside and outside Oulanka National Park.
3.1.2 Age structure

Tree age at all sample sites was determined by coring one or several representative trees per site at breast height with an increment borer. In Oulanka National Park, age measurements at 109 random sample sites by Ukkola (2005) and Soppela (2000) result in the age structure shown in Figure 5. The average tree age is 146 years (Std. deviation 55.8) with a minimum of 50 and a maximum of 250 years. Even though Soppela’s measurements were done in 1999, they can be still used because forest structure does not change quickly inside the park.

![Figure 5: Tree age distribution in Oulanka National Park 2004.](image)

On dry Scots pine forest sites, the age structure is different because forest fires play an important role in regeneration for pine forests (Kuuluvainen et al. 2002). The remnants of a forest fire in the 1930s are still visible at some sites on the northern site of Oulanka river. In these places, some large old pine trees (today older than 200 years) survived the fire due to their thick, heat-insulating bark (ibid). They are interspersed between younger pines that have grown back after the fire. The average age is 157.4 (Std. deviation 73.2, range 50 to 250). Figure 6 shows three distinct age classes on dry sites in the park with average age 65, 170 and older than 200.
Logging in Alakitka did for the most part not start until the 1950s. Therefore, the age structure of the forest until then is comparable to the one in Oulanka National Park today. Figure 7 shows the forest age structure of Kuusamo province which includes Alakitka herding association. Average age in 1953 was 150.7 (Std. deviation 60.5). The youngest stand was 18 years, the oldest trees were 350 years old.

Figure 7: Age structure in Kuusamo province 1953 (Finnish National Forest Inventory III).

Based on measurements by Ukkola (2005) on 124 random sample sites, the age structure in 2004 in Alakitka is characterized by a high percentage of clearings,
seedling trees and young growth forest (Figure 8). Mean tree age is 64.3 (Std. deviation 45.4, range 0-200). The trees are harvested at maximally 160 years.

![Figure 8: Age structure in Alakitka (excluding the national park) in 2004.](image)

### 3.1.3 Volume structure

The calculation of the cubic volume of a forest depends on its growth stage. For areas with seedling trees and young trees up to 6 meters height, the Smalian-Amgwerdin formula $v = 0.4 \times d^2 \times h$ is used, where $v$ is cubic volume, $d$ is stem diameter at breast height and $h$ is tree height (Häggman 1997). For young growth and older forest, cubic volume is calculated based on dominant tree species, tree height and basal area, i.e. the cross section area of the tree stems in a stand (Nyyssönen 1955).

Cubic volume is positively correlated with age (two-tailed Pearson, $r=0.708$, $p<0.001$).

Inside the national park (Figure 9), the mean cubic volume is $109.7 \text{ m}^3\text{ha}^{-1}$ (Std. deviation 40.2, range 17-212).
Figure 9: Cubic volume distribution in Oulanka National Park (Soppela 2000).

Outside the national park (Figure 10), the mean cubic volume is 65.8 m³ha⁻¹ (Std. deviation 52.9, range 0 to 180).

Figure 10: Cubic volume distribution in Alakitka (excluding the national park) in 2004.

### 3.2 Reindeer herding in Alakitka

Reindeer herding is limited to the northern part of Finland. Unlike in Norway and Sweden, the right to reindeer herding is not restricted to the Saami people. The reindeer herding area is divided into 56 reindeer herding cooperatives, the paliskunta, each with its own administration. The reindeer of a cooperation form in principle a single stock
which is herded and managed by all reindeer owners together (Suominen & Olofsson, 2000). The reindeer are prevented from crossing into other districts by fences.

Alakitka Reindeer Herding Association currently has approximately 1500 reindeer in wintertime and 2300 in summer (Ukkola 2005) (Figure 11). While the numbers have remained relatively constant in the last century, herding techniques have changed considerably in adaptation to changing pasture conditions.

Reindeer herders in Alakitka today keep 80-95% of the reindeer in enclosures in wintertime. The separation of herds in autumn starts in late September. The majority of reindeer are collected in November. Those not kept in corrals receive supplemental hay feeding in winter and feed on hair grass, reindeer lichens and arboreal lichens. If the snow conditions are good, the corralled reindeer are set free in April or else kept until after calving in May-June (Helle & Saastamoinen 1979, Säkkinen 2004).

3.3 Fieldwork

Fieldwork in Oulanka National Park was conducted in June and July 2004. Inside and adjacent to the park one subdry site and 21 dry Scots pine forest sites were surveyed.
The areas outside the park borders were included to get a picture of Scots pine forest vegetation at different stages of forest development. The sites were chosen with the help of a forest inventory map that showed tree species composition. At each site, we took the GPS coordinates and inventoried 15 plots spaced approximately 100 meters apart.

Fieldwork in the whole of Alakitka reindeer herding association was carried out at the same time by Juha Ukkola from Rovaniemi Polytechnic University (Ukkola 2005). 200 places were randomly selected with the ArcGis 8.3 mapping software programme (Nivala 2004) on the condition that each sample site had to be at least 600 meters from other sample sites and after excluding infrastructure, water areas and open bogs with a cubic volume of less than 20 m³. In the end, 146 sites were suitable for survey: 6 subdry and 10 fresh sites inside the park and 1 dry, 47 subdry and 76 fresh sites outside the park.

3.3.1 Survey of forest characteristics

On dry Scots pine forest sites, the forest characteristics were measured for each of the 15 plots. The basal area was estimated with a relascope, a slotted gauge that is used to count trees that appear bigger than the notch when kept at a constant distance from the eye (Bitterlich 1948). Average tree height was estimated using a 4 m long fishing rod as standard. Tree age and cubic volume were calculated as described above. Arboreal lichens were classified as 0 (none), 1 (little), 2 (moderate), 3 (abundant) (Mattila 1981). The numbers of pine seedlings and of reindeer pellet groups were counted in a circle with a radius of 4 meters. Summer and winter pellet groups were counted separately based upon the fact that summer pellets stick together in one lump whereas winter pellets are small and separate. Numbers of pine seedlings and pellet groups were then calculated as N*ha⁻¹.

Ukkola measured age, height, cubic volume and tree composition (Pinus sylvestris, Picea abies, Betula spp.) of the forest for each site. He also ascertained site type, development class (Table 2) and arboreal lichen class, counted summer and winter pellet groups and conducted 10 measurements per site of reindeer lichen cover, lichen length (Figure 12) and Deschampsia flexuosa cover percentage.

Figure 12. Assessment of reindeer lichens.
Table 2: Forest development classes and their average cubic volumes [m$^3$ ha$^{-1}$] in the Kuusamo region (Tomppo et al., 1998).

<table>
<thead>
<tr>
<th></th>
<th>Clearing</th>
<th>0.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Stand of seed-trees</td>
<td>21.9</td>
</tr>
<tr>
<td>3</td>
<td>Young seedling stand</td>
<td>3.4</td>
</tr>
<tr>
<td>4</td>
<td>Young growth forest</td>
<td>11.3</td>
</tr>
<tr>
<td>5</td>
<td>Young or middle aged stand</td>
<td>52.1</td>
</tr>
<tr>
<td>6</td>
<td>Mature stand</td>
<td>123.9</td>
</tr>
<tr>
<td>7</td>
<td>Regeneration mature stand</td>
<td>161.9</td>
</tr>
<tr>
<td>8</td>
<td>Shelterwood stand</td>
<td>52.2</td>
</tr>
<tr>
<td>9</td>
<td>Under-productive</td>
<td>99.3</td>
</tr>
</tbody>
</table>

3.3.2 Survey of reindeer lichens and other ground vegetation on dry Scots pine forest sites

A square with 0.5 m side length was used to estimate the percentages of reindeer lichens (*Cladonia stellaris*, *Cladonia* spp.) and moss ground cover and of dwarf shrubs *Vaccinium vitis-idaea*, *Vaccinium myrtillus*, *Vaccinium uliginosum*, *Ledum palustre*, *Calluna* spp. and *Empetrum* spp. The average length of live reindeer lichen thalli in the square was measured. Reindeer lichen biomass was calculated using Eero Mattila’s conversion formula (Mattila 1988):

\[
\text{Lichen biomass [kg*ha$^{-1}$]} = 0.6288 * \text{lichen cover [%]} * \text{lichen thallus length [mm]}
\]

The relationships between lichen biomass and lichen cover/lichen length can be seen in Figure 13.

![Figure 13: Scattergraphs showing the relationship between lichen biomass and lichen cover/lichen length.](image-url)
3.4 Statistics

For the statistical analysis, SPSS 12.0.1 for Windows and WinStat for Microsoft Excel were used. Graphs were drawn in SPSS or Microsoft Excel.

3.4.1 Ground vegetation structure on dry Scots pine forest sites

In order to discover relationships between lichen cover/length/biomass, other vegetation, and forest characteristics, two-tailed Pearson correlation matrices were drawn up using the statistics programme SPSS 12.0.1 for windows. Correlation matrix tables were created for each of the 22 dry Scots pine forest sites to find correlations within one site based on 15 plot measurements. Additionally, a correlation matrix table to find correlations between sites was prepared using the mean values of the 15 plot measurements.

3.4.2 Reindeer lichens and forest characteristics

One-way analysis of variance (ANOVA) and post-hoc Bonferroni of the surveyed 162 sites in Alakitka inside and outside the park were used to find out if site type influences lichen abundance. Two-tailed Pearson correlations were utilized to study the effect of forest age and cubic volume. Pearson correlations between lichen cover and lichen length were calculated for each site type.

Total biomass inside and outside Oulanka National Park was estimated using the calculated mean values and the pasture areas for each site type.

3.4.3 Deschampsia flexuosa and forest characteristics

The square with 0.5 m side length was also used to estimate the cover percentage of hair grass (*Deschampsia flexuosa*). The mean value from 10/15 measured plots was used to calculate hair grass biomass with the formula (Mattila 1988):

\[
\text{Hair grass biomass [kg*ha}^{-1}\text{]} = 19.8 \times \text{hair grass cover [%]}
\]

In addition to the 162 sites surveyed in 2004, 20 sites surveyed in 1971 by Timo Helle (1975) were used to provide additional data for seedling stands on fresh sites. 38 sites lay inside the national park, 144 outside. By site type, there were 22 samples for dry sites, 54 for subdry and 106 for fresh sites.
One-way ANOVA and two-tailed Pearson-correlations were again used to find which forest characteristics (site type, forest age, cubic volume) influence hair grass abundance.

Total hair grass biomass was calculated using mean biomass values for 5-year intervals up to the forest age of 50 and 50-year intervals for older forests and corresponding pasture area percentages on subdry and fresh sites. Biomass for dry sites was based on the mean value for dry sites because age structure of dry sites was unknown outside the national park due to there being only one dry sample site.

### 3.4.4 Arboreal lichens and forest characteristics

Percentages of arboreal lichen classes inside and outside the national park were computed. The arboreal lichen classes 0 to 3 correspond to the biomasses shown in table 3 (Mattila 1981):

Table 3: Arboreal lichen biomass according to arboreal lichen class.

<table>
<thead>
<tr>
<th>Class</th>
<th>Biomass</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 (none)</td>
<td>4.75 kg*ha$^{-1}$</td>
</tr>
<tr>
<td>1 (little)</td>
<td>43.33 kg*ha$^{-1}$</td>
</tr>
<tr>
<td>2 (moderate)</td>
<td>132.76 kg*ha$^{-1}$</td>
</tr>
<tr>
<td>3 (abundant)</td>
<td>323.17 kg*ha$^{-1}$</td>
</tr>
</tbody>
</table>

One-way analysis of variance (ANOVA) and post-hoc Bonferroni of the surveyed sites in Alakitka inside and outside the park were used to find out if site type influences lichen abundance. Relationship of arboreal lichen biomass with age, cubic volume and proportion of different tree species was studied with two-tailed Pearson correlations.

In addition to Ukkola’s 146 random sample sites and the 22 non-random sites in dry Scots pine forests, 90 random sample sites from inside the national park surveyed by Soppela, Jaakkola and Helle in 1986 and 1999 (Soppela 2000) were used for statistical computations. Soppela, Jaakkola and Helle measured forest age, cubic volume and arboreal lichen biomass using a clump method where the observer compares (by branches) the existing clumps of lichen thalli that are attached to a 2-meter fishing rod to clumps of lichens of known dry weight (0.1, 0.2, 0.5, 1.0, 2.0, 5.0 and 10.0 g) (Jaakkola, 2005). Site type and development class were also ascertained.

To calculate total biomass of arboreal lichens, different methods had to be used for the national park and outside areas. Jaakkola (2001) has calculated arboreal lichen
biomasses for each site type in Oulanka National Park (Table 4) which could be employed in this study to estimate total biomass inside the park:

Table 4: Arboreal lichen biomass according to site type in Oulanka National Park.

<table>
<thead>
<tr>
<th>Type</th>
<th>Biomass (kg ha⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>dry</td>
<td>18.4</td>
</tr>
<tr>
<td>subdry</td>
<td>24.7</td>
</tr>
<tr>
<td>fresh</td>
<td>96.8</td>
</tr>
</tbody>
</table>

The values must not be used for pasture areas outside the park because of the different age structure there. Therefore, biomass was computed using the percentages of and biomass values of the counted arboreal lichen classes and the corresponding pasture areas.

3.4.5 Grazing pressure

Grazing pressure is expressed in winter pellet groups per hectare. To find out where grazing pressure is highest and what forest characteristics can be used to estimate it, Pearson correlations and ANOVA statistics were utilized.
4 Results

4.1 Dry Scots pine forests: Ground vegetation structure

The ground vegetation structure (table 5) on dry Scots pine sites is a multi-layered system with four main systematic and ecological components: mosses, lichens, dwarf shrubs and coniferous trees (seedlings of Scots pine) (cf Helle & Aspi 1983).

On all sites, only reindeer lichens able to withstand grazing pressure are present. *Cladonia stellaris* is almost absent with a maximum of 1 % cover percentage. The most abundant dwarf shrubs are *Vaccinium sp.* and *Empetrum nigrum*, though *Calluna vulgaris* dominates very dry plots. *Ledum palustre* is only found on plots bordering on subdry. The number of pine seedlings per hectare is very high, suggesting that regeneration is not impeded by grazing even though a few seedlings are visibly damaged by grazing.

Table 5: three-layered ground vegetation on dry Scots pine forest sites

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Min</th>
<th>Max</th>
<th>Std. Dev.</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>bottom layer</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moss (div. spec.)</td>
<td>43.94</td>
<td>0</td>
<td>100</td>
<td>41.80</td>
<td>328</td>
</tr>
<tr>
<td><em>Cladonia stellaris</em></td>
<td>0.02</td>
<td>0</td>
<td>1</td>
<td>0.13</td>
<td>330</td>
</tr>
<tr>
<td><strong>ground layer</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Cladonia spp.</em></td>
<td>28.10</td>
<td>0</td>
<td>90</td>
<td>21.77</td>
<td>330</td>
</tr>
<tr>
<td><em>Calluna vulgaris</em></td>
<td>4.06</td>
<td>0</td>
<td>60</td>
<td>8.93</td>
<td>330</td>
</tr>
<tr>
<td><em>Vaccinium vitis-idaea</em></td>
<td>9.65</td>
<td>0</td>
<td>50</td>
<td>8.76</td>
<td>330</td>
</tr>
<tr>
<td><em>Vaccinium myrtillus</em></td>
<td>2.94</td>
<td>0</td>
<td>55</td>
<td>7.87</td>
<td>330</td>
</tr>
<tr>
<td><em>Vaccinium uliginosum</em></td>
<td>0.69</td>
<td>0</td>
<td>80</td>
<td>4.99</td>
<td>330</td>
</tr>
<tr>
<td><em>Empetrum nigrum</em></td>
<td>8.72</td>
<td>0</td>
<td>70</td>
<td>13.90</td>
<td>330</td>
</tr>
<tr>
<td><em>Ledum palustre</em></td>
<td>0.38</td>
<td>0</td>
<td>30</td>
<td>2.31</td>
<td>330</td>
</tr>
<tr>
<td><strong>upper layer</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pine Seedlings</td>
<td>1776.49</td>
<td>0</td>
<td>16795</td>
<td>2725.97</td>
<td>330</td>
</tr>
</tbody>
</table>

*Cladonia* mean live thallus length is quite short at approximately 21 mm (St. dev. 11.4) with a maximum of 70 mm, indicating frequent grazing by semi-domesticated reindeer. Lichen biomass reaches a maximum of 880 kg*ha^{-1} with a mean of 342 kg*ha^{-1} (St. dev. 23.5) which is only 23 % and 14 % of the optimum values for lichen biomasses reported by Kärenlampi (1972) and Kumpula et al. (2000) at 1 500 kg*ha^{-1} and 2 400 kg*ha^{-1}, respectively.

Tables 6 shows vegetation structure correlations on 21 dry Scots pine forest sites. Table 7 presents the percentages of sample sites that show correlations within the 15 plots measured per site.
Table 6: Correlation matrix of the mean values of 21 sample sites of dry Scots pine forest.

<table>
<thead>
<tr>
<th></th>
<th>Lichen Length</th>
<th>Lichen Biomass</th>
<th>Moss Cover</th>
<th>Dwarfshrub</th>
<th>Tree Age</th>
<th>Cubic Volume</th>
<th>Winter Pellets</th>
<th>Pine Seedlings [ha⁻¹]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lichen Cover [%]</td>
<td>-0.763**</td>
<td>0.830**</td>
<td>-0.555**</td>
<td>-0.564**</td>
<td>x</td>
<td>x</td>
<td>0.486*</td>
<td>x</td>
</tr>
<tr>
<td>Lichen Length [mm]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lichen Biomass [kg·ha⁻¹]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moss Cover [%]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dwarfshrub [%]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tree Age [years]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cubic Volume [m³·ha⁻¹]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Winter Pellets [ha⁻¹]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* indicates a significance level of < 0.05
** indicates a significance level of < 0.001

Table 7: Percentages of individual sample sites that show correlations within their 15 measured plots.

<table>
<thead>
<tr>
<th></th>
<th>Lichen Length</th>
<th>Lichen Biomass</th>
<th>Moss Cover</th>
<th>Dwarfshrub</th>
<th>Tree Age</th>
<th>Cubic Volume</th>
<th>Winter Pellets</th>
<th>Pine Seedlings [ha⁻¹]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lichen Cover [%]</td>
<td>54.5%</td>
<td>95.2%</td>
<td>66.7%</td>
<td>19.0%</td>
<td>x</td>
<td>14.3%</td>
<td>9.5%</td>
<td>x</td>
</tr>
<tr>
<td>Lichen Length [mm]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lichen Biomass [kg·ha⁻¹]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moss Cover [%]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dwarfshrub [%]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tree Age [years]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cubic Volume [m³·ha⁻¹]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Winter Pellets [ha⁻¹]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

P/N indicates a case where there were positive and negative significant correlations in individual plots.
Reindeer lichen biomass (a function of lichen cover percentage and length) is positively correlated with lichen cover, a correlation also visible in 95% of individual sample sites, but not with thallus length. Lichen biomass shows no other correlations. Lichen cover percentage is negatively correlated with moss and dwarf shrub cover but positively with the number of winter pellet groups. Lichen length runs inversely to lichen cover and parallel to moss cover and dwarf shrub cover because reindeer graze less where lichen cover is low and moss and dwarf shrub grow abundantly. Additionally, all three are positively correlated with cubic volume. Dwarf shrub and moss cover increases with forest age. Pine seedlings are positively correlated with moss cover, forest age and cubic volume, pointing toward successful regeneration and an active role as microclimate controllers.

Looking at different dwarf shrub species (table 8), one can see that only *Calluna vulgaris* is negatively correlated with moss cover, thus behaving similarly to reindeer lichen. Cover of the other dwarf shrubs increases with moss cover (*Vaccinium vitis-idaea, Vaccinium myrtillus, Empetrum nigrum*), suggesting preference for moist sites, with lichen length (*E. nigrum, Ledum palustre*), indicating lower grazing pressure, and like moss with tree age (*Vaccinium myrtillus, E. nigrum*) and with cubic volume (*V. myrtillus, E. nigrum, L. palustre*). More coverage of *V. vitis-idaea* leads directly to less grazing, indicated by the negative correlation with winter pellet groups.

Table 8: Correlation matrix for different dwarf shrub species (mean values of 21 dry sites).

<table>
<thead>
<tr>
<th></th>
<th>Calluna vulgaris</th>
<th>Vaccinium vitis-idaea</th>
<th>Vaccinium myrtillus</th>
<th>Vaccinium uliginosum</th>
<th>Empetrum nigrum</th>
<th>Ledum palustre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moss</td>
<td>-0.576**</td>
<td>0.438*</td>
<td>0.521*</td>
<td>x</td>
<td>0.480*</td>
<td>x</td>
</tr>
<tr>
<td>Lichen cover</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Lichen length</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>0.563**</td>
<td>0.599**</td>
</tr>
<tr>
<td>Lichen volume</td>
<td>x</td>
<td>x</td>
<td>-0.557**</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Tree age</td>
<td>x</td>
<td>x</td>
<td>0.610**</td>
<td>x</td>
<td>0.491*</td>
<td>x</td>
</tr>
<tr>
<td>Cubic volume</td>
<td>-0.472*</td>
<td>x</td>
<td>0.484*</td>
<td>x</td>
<td>0.477*</td>
<td>0.462*</td>
</tr>
<tr>
<td>Winter pellets</td>
<td>x</td>
<td>-0.481*</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>

* indicates a significance level of < 0.05  
** indicates a significance level of < 0.001

*Calluna vulgaris* and reindeer lichens prefer dry and sunny growing conditions, provided in old-growth forests where the tree canopy is thin. All other dwarf shrubs and mosses fare better in dense, moist forests.
4.2 Grazing pressure by semi-domestic reindeer

4.2.1 Forest structure and reindeer winter food plants

4.2.1.1 Reindeer Lichen

As table 9 and figure 14 show, reindeer lichen biomass differs significantly for all site types (ANOVA, \( F = 458.7, \, \text{df} = 2, \, p < 0.001 \); post-hoc Bonferroni shows significance \( p < 0.001 \) for comparison between groups).

Table 9. Descriptives of reindeer lichen biomass on different site types.

<table>
<thead>
<tr>
<th>Site Type</th>
<th>mean lichen biomass [kg/ha]</th>
<th>Min</th>
<th>Max</th>
<th>Std. Dev.</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>dry</td>
<td>340.15</td>
<td>57.7</td>
<td>550.6</td>
<td>110.7</td>
<td>22</td>
</tr>
<tr>
<td>subdry</td>
<td>35.53</td>
<td>0</td>
<td>180.5</td>
<td>43.5</td>
<td>54</td>
</tr>
<tr>
<td>fresh</td>
<td>0.49</td>
<td>0</td>
<td>9.9</td>
<td>1.5</td>
<td>86</td>
</tr>
</tbody>
</table>

Figure 14: Mean reindeer lichen biomass on different site types.

Total reindeer lichen biomass was calculated from the mean biomass values and the pasture areas for each site type. Table 10 and figure 15 show that the total biomass is highest on subdry sites because of its high proportion of pasture areas in spite of low mean lichen biomass. On dry sites, the total biomasses inside and outside the national park are almost equal. Since only 2% of pasture areas are dry, total lichen biomass from dry sites is quite low compared to subdry sites.

Table 10: Total lichen biomass on different site types inside and outside the national park.
On fresh sites, competitors of reindeer lichens like mosses and dwarfshrubs dominate the ground vegetation. Reindeer lichens hardly occur: lichen cover is less than 1%.

![Figure 15: Total lichen biomass on different site types inside and outside the national park.](image)

The correlations between lichen cover and lichen length are negative only on dry sites (-0.747, p < 0.001) and positive on subdry and fresh sites (0.302 and 0.839, respectively, p < 0.05), indicating that grazing is restricted to dry sites in spite of the high total biomass on subdry sites. The mean lichen cover on subdry sites is only 1.8% (Std. Dev. 2.4) with a maximum of 9.2%, too low to trigger digging and grazing.

On dry and fresh sites, there is no correlation between lichen biomass and tree age or cubic volume. Only on subdry sites, significant correlations exist: 0.611 (p < 0.001) for cubic volume and 0.534 (p < 0.001) for age (Figure 16 and 17).

The growth conditions on subdry sites after clear-felling are better for mosses than for lichens: young seedling stands are dense and keep water from evaporating quickly. This results in very low lichen cover and biomass in young-growth subdry forests.
Figure 16: On subdry sites, the scattergraph shows a correlation between lichen biomass and cubic volume.

Figure 17: On subdry sites, the scattergraph shows a correlation between lichen biomass and age.
4.2.1.2 Hair Grass

As table 11 and figure 18 show, *Deschampsia flexuosa* biomass is significantly different for all site types (ANOVA, $F = 13.94$, df = 2, $p < 0.001$). Post-hoc Bonferroni shows highly significant differences ($p < 0.001$) for dry-fresh and subdry-fresh comparisons but not between dry and subdry sites.

Table 11. Descriptives of hair grass biomass on different site types.

<table>
<thead>
<tr>
<th>Site Type</th>
<th>mean hair grass biomass [kg ha$^{-1}$]</th>
<th>Min</th>
<th>Max</th>
<th>Std. Dev.</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>dry</td>
<td>6.6</td>
<td>0</td>
<td>117</td>
<td>25.4</td>
<td>22</td>
</tr>
<tr>
<td>subdry</td>
<td>40.93</td>
<td>0</td>
<td>194</td>
<td>49.1</td>
<td>53</td>
</tr>
<tr>
<td>fresh</td>
<td>187.19</td>
<td>0</td>
<td>960</td>
<td>232.9</td>
<td>107</td>
</tr>
</tbody>
</table>

Figure 18: Mean hair grass biomass on different site types.

Hair grass biomass depends not only on site type but also on the age of a forest (figure 19). On subdry sites, hair grass is significantly ($p < 0.05$) negatively correlated with tree age (-0.326) and cubic volume (-0.305). On fresh sites, the correlation is highly significant ($p < 0.001$) for tree age (-0.424) and cubic volume (-0.495). On dry sites, there are no significant correlations.
Highest mean biomass is reached 15 years after clear-felling on fresh sites (figure 20). On fresh sites, biomass is mostly higher than 200 kg ha\(^{-1}\) for 35 years. This translates to approximately 35 % of fresh pasture areas. On subdry sites, there is no such clear pattern. Hair grass biomass decreases rapidly after 35-45 years.

Table 12 and figure 21 demonstrate that hair grass biomass is negligible on dry sites and generally inside the national park due to the prevalence of old-growth forest there. Outside the national park the biomass of hair grass is higher than 7 million kg, making it an important component of reindeer winter food provisions.
Table 12: Total hair grass biomass on different site types inside and outside the national park.

<table>
<thead>
<tr>
<th>Site Type</th>
<th>inside Oulanka National Park [kg]</th>
<th>outside Oulanka National Park [kg]</th>
</tr>
</thead>
<tbody>
<tr>
<td>dry</td>
<td>2 157</td>
<td>3 894</td>
</tr>
<tr>
<td>subdry</td>
<td>157 317</td>
<td>1 165 584</td>
</tr>
<tr>
<td>fresh</td>
<td>312 612</td>
<td>6 788 388</td>
</tr>
</tbody>
</table>

Figure 21: Total hair grass biomass on different site types inside and outside the national park.

4.2.1.3 Arboreal Lichen

The percentages of arboreal lichen classes inside and outside the park differ strongly (figure 22, figure 23). Inside the park, classes 1 and 2 reach almost equal proportions of approximately 45 % each. Less than 5 % of forest areas have arboreal lichen class 3. The low percentage of the highest lichen class is most probably due to pollution since there are no forestry activities inside the park. Outside the park, over 30 % of the samples have no arboreal lichens and no areas are above class 1.

Figure 22: Distribution of arboreal lichen classes in Oulanka National Park (n = 94).
There is no clear relationship between arboreal lichen biomass and site type. Separate ANOVAs for sample sites inside the park and outside the park show no correlations between biomass and site type. An ANOVA analysis for all plots shows a significant difference ($F = 9.659$, dF = 2, $p < 0.001$) with dry plots reaching the highest mean biomass at 93.5 kg*ha$^{-1}$ and subdry the lowest with 28.5 kg*ha$^{-1}$. This conclusion is not valid, however, because the high value for dry sites is based only on old-growth forest sites inside the park whereas the values for subdry and fresh sites are for the most part from young growth forest outside the park.

Arboreal lichen biomass shows strong, positive correlation with cubic volume (0.317, $p < 0.001$), age (0.631, $p < 0.001$) and proportion of spruce (0.428, $p < 0.001$). The correlation with pine is negative (-0.328, $p < 0.001$).

Arboreal lichen biomass reaches its maximum at the age of 100 to 150 (Figure 24). Forests 150 years and older are less dense so that arboreal lichen biomass decreases again because of lack of substrate.

Figure 23: Distribution of arboreal lichen classes outside the national park ($n = 124$).

Figure 24: Arboreal lichen biomass at different growth stages.
Total arboreal lichen biomass is highest on fresh sites (figure 25) in spite of the high proportion of fresh young-growth forest outside the national park. The total biomass of dry sites is irrelevant in comparison to subdry and fresh sites because of low mean values for dry sites (Jaakkola 2001) and because only 2 % of pasture land is dry.

![Graph showing total arboreal lichen biomass on different site types inside and outside the national park.]

Figure 25: Total arboreal lichen biomass on different site types inside and outside the national park.

4.2.2 Grazing pressure on different site types

Grazing pressure as expressed by the number of winter pellet groups per hectare is strongly correlated with site type (ANOVA, $F = 68.51$, $df = 2$, $p < 0.001$), though post-hoc Bonferroni proves a significant difference ($p < 0.001$) only between dry and subdry and dry and fresh sites (table 13, figure 26). Grazing pressure is very high on dry sites where reindeer lichen cover and biomass are high (Pearson correlation 0.767 and 0.720, respectively, $p < 0.001$). There is no correlation to lichen length or to other food plants though, as mentioned above, on dry sites the number of faecal groups is negatively correlated with moss and *V. vitis-idaea*. Grazing pressure shows no correlation to forest age or cubic volume.

Table 13: Mean number of winter pellet groups per site type.

<table>
<thead>
<tr>
<th>Site Type</th>
<th>mean number of winter pellet groups [ha$^{-1}$]</th>
<th>Min</th>
<th>Max</th>
<th>Std. Dev.</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>dry</td>
<td>909.2</td>
<td>93.3</td>
<td>3452.3</td>
<td>887.0</td>
<td>22</td>
</tr>
<tr>
<td>subdry</td>
<td>49.6</td>
<td>0</td>
<td>399.9</td>
<td>94.5</td>
<td>54</td>
</tr>
<tr>
<td>fresh</td>
<td>11.6</td>
<td>0</td>
<td>399.9</td>
<td>56.2</td>
<td>86</td>
</tr>
</tbody>
</table>
Figure 26: Mean number of winter pellet groups per site type.

The scattergraph (Figure 27) of winter pellet groups versus reindeer lichen biomass proves that grazing pressure differs according to site type because dry sites show high Cladonia biomass values.

Figure 27: Scattergraph of winter pellet groups by Cladonia biomass separated by site type.
4.3 Role of Oulanka National Park for Alakitka herding cooperation

4.3.1 Total biomasses of reindeer winter food plants

Depending on which food plant one looks at, Oulanka National Park is of bigger or lesser importance. A graph like figure 28 showing total biomass of each food plant inside and outside the park can be misleading because it does not take into consideration the circumstances under which reindeer use the plants. The graph is still useful to demonstrate how *Deschampsia flexuosa* is four times as abundant as each of the other food plants. The proportions of each food plant can be seen from the pie graph (Figure 29).

![Figure 28: Distribution of food plants inside and outside Oulanka National Park](image)

![Figure 29: The proportions of reindeer lichen, arboreal lichen and hair grass of total food biomass.](image)

4.3.2 Usable biomass of winter food plants

More important than total amounts is the biomass actually available to reindeer. For reindeer lichen, it is the biomass of dry sites because only there are the cover percentage and biomass high enough to induce grazing (Helle 1984). *Deschampsia flexuosa* is grazed where its biomass is 200 kg*ha$^{-1}$ or higher (Helle & Saastamoinen...
This is true for 35 % of all fresh pasture sites in Alakitka. Arboreal lichens can be used where they grow up to 2 meters in height and when they are blown off the trees. Jaakkola et al. (2005) gives the first figure as 6-7 % of total biomass. For the second figure, there is insufficient data. Since the growth rates lie between 6 % and 20 % of total biomass, the litter fall must be lower and is here estimated as 10 % of total biomass. The usable biomass is shown in figure 30. It is approximately a fourth of total biomass (Figure 31). Reindeer lichen pastures are distributed equally inside and outside the park so it is clear that closing the national park off to reindeer herding would eliminate a major part of the mid- and late winter food for reindeer. Hair Grass is only exploitable outside the park.

![Figure 30: Usable biomass of reindeer lichens, hair grass and arboreal lichens.](image)

![Figure 31: Comparison of total and usable biomass for each food plant.](image)
Figures 32 and 33 clarify how the different forest condition inside and outside the national park lead to completely different pasture situations for reindeer. The young-growth forest outside the park support a very high hair grass biomass but negatively affects arboreal lichen biomass. Inside the park, old-growth forests dominate favouring arboreal lichen growth. Total Biomass of reindeer lichens inside and outside the park is actually the same, even though their proportion of the food plants biomass suggests otherwise.

**Outside Oulanka NP**

- Reindeer lichen: 7%
- Arboreal lichen: 8%
- Hair Grass: 85%

Figure 32: Proportions of usable biomass outside Oulanka National Park.

**Inside Oulanka NP**

- Reindeer lichen: 71%
- Arboreal lichen: 29%

Figure 33: Proportions of usable biomass in Oulanka National Park.
5 Discussion

5.1 Ground vegetation structure

The ground vegetation structure of dry sites in Oulanka National Park shows clear signs of moderate to heavy grazing pressure. The grazing pressure is not so intense as to induce formation of bare soil patches, described by Väre et al. (1996), as a sign of heavy grazing. Grazing pressure is high enough to lead to the total disappearance of *Cladonia stellaris* except in places where reindeer do not reach the lichens, for example on rocks or cabin roofs.

Reindeer prefer to graze in places where the cover of moss and of dwarfshrub is low. The correlations of lichen cover and moss or dwarfshrub are therefore negative. On the other hand, lichens grow longer where moss or dwarfshrub coverage is high.

The study shows that growth conditions for other *Cladonia* species are dependent on the microclimate and that the multi-layered structure of the ground vegetation is decisive for its composition. The best example to support this assertion is the behaviour of moss coverage in relation to forest characteristics. Since mosses prefer moist, dark growing conditions, one would expect the moss cover to decrease as the forests grow older and less dense. Instead, the study results in highly significant positive correlations for moss cover and stand age or cubic volume. The same can be observed for dwarfshrub coverage. Both can only be explained with reference to microclimate. The number of pine seedlings per hectare was very high and increasing with age and cubic volume, indicating that regeneration of old Scots pine forests is well in progress. The seedling trees provide dense, shadowy, moist growth conditions that favour mosses, *Vaccinium* species and *Empetrum nigrum*. *Ledum palustre* grows high enough to function as a canopy for these species as well. Where cubic volume, thus seedling density and thus moss cover is high, reindeer grazing is less intense and reindeer lichen can grow longer.

Even though some seedlings are damaged when reindeer crater for lichen, regeneration does not seem to be affected negatively as the number of live pine seedlings per hectare is very high. Helle and Moilanen (1993) found that pine seedlings grow faster when the lichen cover has been removed because of the warmer soil.

In between the seedlings, light can easily reach the ground through the thin canopy of the old-growth forest. There, the light, dry conditions are advantageous for the growth
of Calluna and Cladonia species. Calluna vulgaris prefers open dry sites, therefore growing better with lower cubic volume.

Most interestingly, mean lichen biomass on dry Scots pine forest sites has actually increased by 67% in comparison to 1971 (Helle et al. 1975) (figure 34). Reindeer lichen pastures have likely profited from the new herding practice to keep 90% of the reindeer in corrals in winter and thus off the lichen areas.

Figure 34: Mean reindeer lichen biomass 1971, 1983 (Helle et al. 1990) and 2004 on dry Scots pine forest sites in Oulanka National Park.

5.2 Grazing pressure by semi-domesticated reindeer

Suominen and Olofsson (2000) postulate, based on the Finnish National Forest Inventories (1976-78, 1982-84, 1992-93) (Mattila 1981, 1988, 1996), that the proportion of more productive forest types has increased at the expense of dry lichen-type forests. In 2004, only 2% of pasture land could be classified as dry, with an equal distribution inside and outside the national park. The importance of these areas is high because only there the reindeer lichen biomass is high enough to warrant the energy expense of digging and grazing by reindeer in wintertime. On subdry and fresh sites, competition by moss is too intense for reindeer lichens to reach high cover percentages. Grazing pressure is therefore highest on dry sites.

If the area of dry sites decreases, grazing pressure ought to increase. Nevertheless, the number of winter pellet groups has dropped from 3131 per hectare in 1983 (Helle et al. 1990) to 933 per hectare in 2004, parallel to the increase in mean lichen biomass
since 1971 on dry sites. Both, as already mentioned, is probably due to coralling of reindeer herds for the winter.

As forestry activities do not affect reindeer lichen biomass for long (Helle & Saastamoinen 1979, Helle et al. 1983, Helle et al. 1990), there is no correlation between forest age or cubic volume and lichen biomass. Subdry sites are an exception. There, highly significant positive correlations exist between biomass and cubic volume or age. After clear-cutting, lichen biomass decreases at first. On subdry sites, mosses are then more competitive than lichens due to the dense, moist growth conditions of seedling stands. As the forests get older and thinner, lichens can successfully compete with moss again. However, even in old-growth subdry forests, lichen cover and biomass are never high enough to induce grazing.

In Helle, Aspi and Kilpelä’s study (1990), the number of faecal groups increased with stand age, an effect explained with litter hindering grazing on clear-cut pastures. This effect could not be observed in Alakitka, probably because half the lichen-rich ranges are located inside the park where cutting does not occur. Too little data exist on the dry lichen ranges outside the park to say if the such a relationships exists in Alakitka or not.

5.3 Hair grass and arboreal lichens

The total biomass of Deschampsia flexuosa is considerably higher in Alakitka than the biomass of other food plants. This agrees with Helle and Saastamoinen’s finding (1979) that hair grass is on average more important as winter food than lichens. Hair grass grows most abundantly on young fresh sites and only there its biomass is higher than 200 kg*ha⁻¹. Even though hair grass abundance decreases sharply 35-45 years after clear-cutting, there is at the moment no danger that total biomass will decline to a great extent. With a forest rotation time of only 120 years, 33 % of fresh sites are young-growth forest at all times. At the moment, almost 40 % of fresh pastures outside Oulanka National Park are younger than 40 years.

Arboreal lichens suffer from the same situation that benefits hair grass. Arboreal lichen biomass is highest for forests older than 100 years. The short rotation time in the forested areas does not permit arboreal lichens to build substantial biomass, especially since dispersal mechanisms do not work well in large clearings (Jaakkola et al. 2005). Arboreal lichens grow more abundantly on subdry and especially on fresh sites because the percentage of spruce there is higher. Spruces provide a better microclimate and have more branches as substrate than pines. Thus, as proportion of
these site types have increased (Helle & Saastamoinen 1979), arboreal lichens could
benefit greatly if rotation times in Alakitka were increased.

It was not possible in the end to make a comparison between total arboreal lichen
biomass in the 1950 before cutting started and today. The necessary data on forest
characteristics in 1953 exist but were not made available in time to be included in this
study. Once the data have been provided, computations should be easy because the
forest situation in Oulanka National Park today is still similar today to the forest
situation in the whole of Alakitka reindeer herding association in the 1950s. If one
compares arboreal lichen classes now and then based on this assumption (using the
national park class percentages for the 1950s), then the arboreal lichen biomass
outside the park is less than one third than in 1953. However, this is still an
overestimation of today’s biomass because of the effects of pollution and because the
proportion of fresh sites with high biomass is higher outside than inside the park.

5.4 The importance of Oulanka National Park for Alaktika herding association

The area of Alakitka reindeer herding association is characterized by a very low
percentage of lichen-rich dry ranges. This means that the available ranges are all the
more important for the reindeer. Half of the lichen-rich ranges are inside the national
park on the high banks of Oulanka river. Grazing pressure on these sites is not
necessarily heavy because reindeer density is generally too high but because all free
reindeer come together to feed there in wintertime. The national park is also important
for reindeer because of arboreal lichens. About 25% of the usable arboreal lichen
biomass is located in the park even though it comprises only 13% of Alakitka’s
pasture area. Due to their high carbohydrate content, lichens are still the most
preferred food for reindeer (Helle 1981).

In order to judge if reindeer grazing actually threatens the ecosystem of lichen-rich
ranges in Oulanka, it is first necessary to consider the meaning and relevance of the
term overgrazing.

5.4.1 Over-grazing and nature conservation

Over-grazing by livestock has historically been and still is a great worldwide
environmental and economic problem since even now about 75% of meat and dairy
production takes place in natural or semi-natural pastures. Over-grazing degrades
pasture quality, negatively affects animal production, and at worst results in irreversible
erosion. Over-grazing is also commonly used when describing the impacts of semi-domesticated reindeer on vegetation – Google.com gives 743 hits for the search terms “semi-domesticated reindeer” and “overgrazing”. Over-grazing in the Oulanka national park was also the principal reason for this study. In the Finnish discussion the term over-grazing is a relatively new one. It was taken into use in the 1970s but the phenomenon itself is of older origin. For instance, Metsähallitus (Finnish Forest and Park Service) (1907) reported in 1907 to the Imperial Senate “the number of semi-domesticated reindeer has increased so much that the natural reindeer pastures, lichen heaths, have been depleted… Reindeer lichens are almost totally eaten. The length of lichens is only some few millimetres and dry sites are flecked with black and white”. According to the first pasture survey carried out in the 1910s (Porolaidunkomissionin mietintö 1914, translated by T. Helle), lichen pastures in the southern most part of the reindeer management area “were heavily used and therefore in poor condition”.

The basic problem of the over-grazing discussion is that the term has been used in very different ways without a clear definition. The following part attempts to define over-grazing such that it is relevant to Oulanka national park and nature conservation. The main issue there is the poor condition of reindeer lichen vegetation on dry sites. According to this study, about 50 % of dry sites of the whole Alakitka herding association are located in Oulanka National park.

In pasture science, over-grazing is commonly defined as a state where the standing crop (existing biomass) of the feeding plants does not, due to intense grazing, allow the maximal primary production of plants (e.g. Caughley 1976). That definition is also commonly used in reindeer research (Kärenlampi 1972, Skogland 1986, Helle et al. 1990, Moxness 1998, Kumpula et al. 2000). It can be estimated that primary production will be maximized when the standing crop is about 50 % from the maximum biomass (Caughley 1976). The maximum biomass is referred to as ecological carrying capacity (K) which is the equilibrium state where primary production equals mortality. Regarding reindeer lichens, the maximum biomass is reached in climax associations: The cover percentage of lichens is almost 100 % and height of the living part of the thallus about 35-45 mm (Kärenlampi 1972, Kumpula et al. 2000). In such lichen vegetation the tips of the individual lichens still grow but the lower parts of them are dying and turning to detritus. The climax association is a result of a long succession. After a forest fire, for instance, its development takes 100 years or even more (Ahti 1961).

In northern Finland, the primary production of reindeer lichens on dry sites in relation to the standing crop has been estimated in two studies. Kärenlampi (1972) reported the
optimum lichen biomass as about 1 500 kg/ha and Kumpula et al. (2000) about 2 400 kg/ha. In the first case, the annual primary production was about 150 kg/ha and in the other one about 180 kg/ha. In Alakitka, the present mean lichen biomass of 340 kg/ha is, despite a 67 % increase since 1971, only 23 % and 14 % from these optimums, respectively. From the viewpoint of productivity the lichen pastures are heavily over-grazed.

The models to maximize the meat production of wild and semi-domesticated reindeer are based on the assumption that availability of reindeer lichens strongly influences productivity, i.e. the reproductive rate, mortality, and carcass weights (Skogland 1986, Moxness 1998). However, these models can be applied only in conditions where alternatives to reindeer lichens are not available. Our study area, the herding association of Alakitka, represents a multi-pasture grazing system which is the prevailing system in the whole southern part of the Finnish reindeer management area (cf. Mattila 1981). Reindeer lichens are the reindeers’ most preferred food but in early winter they vasty use the common hair grass (*Deschampsia flexuosa*), too. As shown in this study, its total biomass is about 5-fold in comparison to reindeer lichens. With regard to primary production the difference is much greater since the annual growth rate of reindeer lichens is about 11 % (Kärenlampi 1972) while that of hair grass amounts to 100 %, i.e. it grows new leaves and stems every year in spite of possible grazing. In the 1970s, reindeer turned to the use of arboreal lichens in mid-January in forests or forest felling sites (Helle 1975). Later on, arboreal lichens were replaced by supplemental or corral feeding.

In such a multi-pasture grazing system, the biomass of the most preferred feeding plants, like reindeer lichens for reindeer, can strongly decline. The situation where it will go down exists if the limited availability of the most preferred plants does not decrease the reproductive rate or increase mortality and thus reduce the number of the animals (Noy-Meir 1981). Therefore, over-grazing of lichen pastures does not have to result in poor condition and ensuing low production of the animals. As mentioned above, the mean lichen biomass on dry sites in Oulanka National park increased between 1971 and 2004 by 67 %, a phenomenon most likely associated with the intensification of feeding reindeer in corrals in winter. In 1971 reindeer were still totally dependent on natural winter food resulting in heavy grazing pressure on lichen-rich dry sites. The present management system, where the reindeer are taken into corral feeding already from the round-ups in late autumn and early winter, developed during the 1980s. At present about 90-95 % of the reindeer are fed in corrals in mid- and late winter, thus being kept off natural pastures. The decrease in grazing pressure is evidenced also by the fact that pellet-group density declined from 1983 to 2004 by 70 %.
The second commonly discussed aspect of over-grazing deals with the impacts of reindeer grazing on the diversity of vegetation and occurrence of rare or threatened plant species (e.g. Helle & Aspi 1983, Väre et al. 1995, 1996, Olofsson et al. 2002, Olofsson & Oksanen 2005). In Kuusamo, no rare or threatened species grow on Scots pine dominated dry sites. The basic findings of this study support Grime’s (1973) hypothesis which predicts that moderate disturbance increases the number of plant species. In the case of lichen vegetation, untouched climax association is dominated (about 95% of the cover percentage) by Cladonia stellaris, which is very competitive against other lichen species, mosses and even dwarf shrubs (Helle & Aspi 1983). Trimming and thinning of the lichen mat by reindeer frees space for other plants. The number of species and the diversity index are highest in conditions where grazing pressure is moderate or high; on the other hand, only rather few species (horn lichens, small-sized Polytrichum species) resist very intense and repeated grazing (Helle & Aspi 1983). In this study, the analysis of vegetation was too rough to calculate the number of plant species and the diversity index of vegetation. However, one may conclude on the basis of estimated lichen biomasses (cf. Helle & Aspi 1983) that the number of species on dry sites is close to maximum due to grazing. On the other hand, it seems that Cladonia stellaris has totally disappeared from dry Scots pine forests; it occurs, however, abundantly on great rocks and cliffs reindeer cannot reach it. Disappearance of Cladonia stellaris from winter pastures is not a recent event. In the southern part of the Finnish reindeer management area its proportion of the total lichen biomass came to 1% in the mid-1970s (Mattila 1981).

Scientific knowledge of the impacts of reindeer grazing on insect fauna and other invertebrates is based on studies carried out elsewhere in northern Finland. As far as the comparisons deal with dry sites, however, it can be applied to Oulanka national park as well. Suominen et al. (1998) compared the abundance of ground-dwelling invertebrates in un-grazed and grazed lichen grounds. Total invertebrate abundance and the abundance of most invertebrate taxa were higher on grazed areas. Terrestrial gastropods were the only taxon that was significantly more abundant in un-grazed controls. Both vegetation and animal species richness were higher in grazed areas. This is in accordance with Grime’s (1973) intermediate disturbance hypothesis. The impacts of grazing on the abundance of Nematoda and Enchytraeidae have also been studied (Kojola et al. 1998). They found that the abundance of Enchytraeidae was about 50% lower in grazed areas than in un-grazed controls, whilst for Nematoda the difference was not significant. The ecological importance of the difference in the number of Enchytraeidae can not be evaluated, but it is known that great variation
occurs also in the impacts of forest fires on the abundance of *Enchytraeidae* that is likely related the age of a burned area (Kojola et al. 1998).

The third concern about over-grazing relates to its effects on ecosystem functions which might affect the vitality of forests. About once in 20 years conditions occur that are characterized by heavy frosts in autumn before the permanent snow cover (Solantie 1998). This happened for example in 1986-87, resulting in root damage in Scot pines in eastern Lapland and northern Kainuu, including Kuusamo (Jalkanen 1990, 1993, Tikkanen & Raitio 1990). A thick lichen carpet is an effective insulator and it was reasoned that it would provide shelter for the roots in such conditions. A hypothesis was put forwards that root damage might be associated with the short and sparse lichen vegetation ensuing from heavy reindeer grazing (Jalkanen et al. 1995).

Helle & Nöjd (1992) compared the radial growth of mature Scots pines in un-grazed and grazed lichen vegetation by means of the width of annual rings in three areas in northern Finland. One of the study areas, Salla, is located rather close to Oulanka National park. They reported a retarded radial growth in summer 1987, but there was no difference between Scots pines growing in un-grazed or heavily grazed area. Similarly, Helle et al. (1998) found a clearly retarded length growth in young Scots pines in northern Kainuu in summers 1987 and 1988, but the cessation of growth there was likewise not related to the characteristics of the lichen cover. This suggests that the insulation capacity of a deep lichen carpet in such conditions has been overestimated. This is in accordance with the result of this study indicating a good regeneration success in Scots pine in dry sites in Oulanka national park, which is verified also in another study south of Kuusamo (Helle & Moilanen 1993).

Thus it seems to be clear that reindeer grazing in Oulanka national park does not threaten species conservation and ecological functions. Rather, short and sparse lichen vegetation is an obvious aesthetical nuisance for park visitors who are used to or expecting to see beautiful white lichen carpets. That annoyance could probably be relieved if visitors were informed that reindeer management has been practiced in the area for several hundred years and that the state of vegetation is rather stable.

5.4.2 **Practical remarks**

The purpose of this study was to examine the condition of lichen vegetation in dry sites in Oulanka national park and, if needed, to make recommendations how to improve the
condition of lichen pastures. In order to understand the present situation, this study related the winter food resources in the park to those in other parts of the herding association, and additionally to the changes in management practices.

It is often said that especially in nature conservation areas semi-domesticated reindeer should “return back to nature” (e.g. Miller 2003). However, this idea of a ‘natural state’ is problematic. As long as Finland belonged to Russia, semi-domesticated reindeer could freely move between summer and winter ranges and graze in winter beyond the old border in areas with excellent lichen pastures because the original wild forest reindeer (*Rangifer tarandus fennicus* Lönn.) was exterminated there. Use of these winter ranges ceased in 1918 when the “unnatural” (Väre et al. 1996) border between Russia and Finland was closed (Helle 1981). In the association’s own area on the Finnish side lichen pastures were so limited, only 2% of the total land area as shown in this study, that herding on lichen pastures until spring was impossible. Under the new free-ranging management system, reindeer were therefore fed from the beginning of February on arboreal lichen which they got from trees felled just for that purpose by reindeer owners (ibid). Such reindeer cuttings were the only way by which reindeer could be kept together and under control. That was necessary to defend reindeer from wolves and wolverines. When the reindeer cuttings were prohibited (because forests had got commercial value for forest industry), reindeer had to spread over the whole herding association to seek arboreal lichens in growing forests in mid and late winter. They were not under the control of reindeer owners anymore who in turn devoted themselves, instead of to herding, to the hunting of great predators. That kind of reindeer management was as “natural” as the earlier one where reindeer were herded on lichen pastures in Russia. Arboreal lichens are regularly used winter food for Eurasian wild forest reindeer and American woodland caribou (Banfield 1961).

Commercial cuttings, which started in the mid 1950s, offered reindeer easy access to arboreal lichens but at the same time the area of old forests rich in arboreal lichens decreased. The present management system where reindeer are fed mid and late winter in yard corrals has developed during the last 30 years (Helle & Saastamoinen 1979). Return ‘back to nature’ is impossible because such a nature supporting earlier animal numbers does not exist any more.

Paradoxically, the condition of lichen vegetation is now better than in the early 1970s representing the final phase of natural or traditional reindeer management. In general, intensive supplemental feeding in winter seems to lead to gradual deterioration of lichen pastures (Mattila 1998) because population crashes providing recovery time for lichens do not occur. In earlier management systems, crashes were normally being
triggered by a combination of food shortage and exceptionally difficult snow conditions. Fortunately, in Alakitka herding association the present practice collecting reindeer into yard corrals already in late autumn or early winter has decreased the grazing pressure and made possible recovery of lichen vegetation. A paradox again: artificial feeding, which did not belong to traditional reindeer management, improves the state of lichen vegetation.

Fig. 35. The relationship between reindeer density and and volume of lichens dm³/m³ in the Finnish reindeer management area in 1995 (means for 1974-95) (Kumpula et al. 2000). Each plot represents a single herding association. The circle Alakitka 2004 is based on Mattila's study (1981) that suggests that the proportion of dry sites is 7% of total land area. Using the value of this study (2%) the plotted circle would fall outside the range to a density of 130 reindeer per km².

One of the most common suggestions to improve the condition of lichen vegetation is the reduction of the number of reindeer. This includes the well-meaning idea that the condition of reindeer will be improved at the same time and therefore the economy of the reindeer herding livelihood as well. As shown earlier this does not hold true in a multi-pasture system if the maximal production of reindeer lichens is less than that of the other feeding plants, i.e. Deschampsia flexuosa and arboreal lichens, or there is supplemental feeding. As shown in Fig 35, the condition of lichen vegetation is strongly dependent on the animal density per km² of lichen pasture. In Alakitka, the proportion of lichen-rich dry sites has been determined as 2 and 7% in different studies (this study, Mattila 1981) which corresponds, using the present highest permitted number of
reindeer (1 500), to a density of 130 and 30 reindeer per km² of lichen pasture, respectively. The measured lichen biomass (here expressed by the volume: percent cover x height of lichens) for both values deviates clearly from the general pattern; in fact, the higher density value falls out of the range of the figure. However, even the lower density value illustrates how drastic a reduction in the number of reindeer would be needed in order to increase lichen volume or biomass in cases such as this one where the present density calculated per lichen pastures is high. To reduce grazing pressure on reindeer lichens only by regulating the number of reindeer therefore seems to be rather ineffective. Lowering the density to 10 reindeer per lichen pasture km² potentially allows the improvement of lichen vegetation. However, as visible in figure 35, an improvement is not certain because of the strong variation. To reach a density of 10 reindeer per km², a 70-% reduction in reindeer numbers would be required in Alakitka. This is unrealistic as long as the main goal of reindeer husbandry is meat production.
As has been demonstrated above, the question of whether overgrazing occurs in Oulanka is not easily answered with yes or no. It is impossible not to see impacts of reindeer herding in the park: the grazed lichen ranges and high amounts of reindeer droppings are hard to miss. Maybe it is the very visibility of these effects that obscures the view on other areas and food plants that are equally or more important for reindeer. 95 % of pasture land in the park, the subdry and fresh sites, do not display the signs of apparent overgrazing. Are they more natural than the dry sites, more truly wilderness?

Alain Grenier’s thesis on the nature of nature tourism (2004) may help to shed some light on the question why grazing effects are considered so distressing by foreign visitors and not so by Finnish people. In his research, Grenier found that

while the American vision of wilderness excludes humans, Finnish people (especially outside large urban areas of the south) perceive themselves as part of the environment with a sense of ‘belonging’ with nature. […] This concept of wilderness includes some traces of human presence. The occasional log cabin, sauna, shelter and marked trails are part of the Finnish wilderness landscape while they would be perceived as intrusive and a reminder of society in North America. The Finnish Wilderness Act includes people: its objectives are to maintain wilderness, to secure the Sami culture and traditional way of livelihood, and to develop multiple uses of natural resources. (p. 119).

The wilderness concept used by the PAN Parks foundation, presented in the introduction, resembles the North American wilderness concept where nature is undisturbed by human influence and people are visitors who do not remain (Grenier 2004, p. 113). Neither concept is truer or better than the other. Both interpretations are human constructs without tangible reality. Knowing about both may help each site to see the other’s point of view.

Total exclusion of semi-domesticated reindeer from the national park cannot be a desirable goal. The reindeer are part of the forest ecosystem, exerting according to Suominen and Olofsson (2000) a top-down effect on vegetation as ecosystem engineers. The researchers stress that grazing and trampling have been shaping the ecosystems during their development since the last glacial epoch and because reindeer and humans have interacted since, it is of little use to talk about the natural state of vegetation in the Nordic countries (ibid). Tourists do not only expect pristine lichen carpets, they also want to see wild animals (though some might wonder why supposedly wild animals can be seen wearing reflective collars).
The condition of lichen pastures of dry sites is indeed affected by grazing: it prevents the climax vegetation state from being reached. However, reindeer lichen ranges are not irreversibly altered or damaged. The lichen species most susceptible to grazing pressure, *Cladonia stellaris*, is not extinct but has moved to grazing-pressure-free niches. Its removal as dominant species allows the growth of other *Cladonia* species and dwarf shrubs, thus increasing biodiversity. Tree regeneration is not prevented. Due to herding techniques that make use of other food sources including supplemental feeding, reindeer lichen biomass has actually been increasing on dry sites.

Considering the results of the study, the author of this thesis would like to recommend fencing a few small “show sites” for park visitors along the main hiking path, possibly next to the camp area. Information of the tourists about the history of reindeer herding in the park and its ecological effects might be beneficial. Fencing of larger areas does not appear to be in the interest of visitors who hardly want to walk caged in between two fences on each site of the path, nor does it appear fair to the reindeer herders to take away such important pasture grounds.
The impacts of reindeer grazing on Cladonia lichen ranges have been receiving increasing attention from both scientists and the general public. Often, grazing pressure is seen as too high and as endangering lichen vegetation ecosystems. During the PAN Park verification process in Oulanka National Park in north-eastern Finland, a study was requested to evaluate the condition of lichen ranges and, if needed, to make recommendations for improvements. In addition to the requested information, this thesis examined the situation of other reindeer winter food plants and the role of Oulanka National Park as part of the pasture area of Alakitka reindeer herding association.

Fieldwork was carried out in June and July 2004 on 21 dry Scots pine forest sites in and adjacent to the national park. Ground vegetation characteristics, stand characteristics and biomass of arboreal lichens were measured or estimated on 15 plots per sample site. Fieldwork data collected by other team members for the whole of Alakitka herding association were used as well. Statistical analysis, including correlation analysis and analysis of variance, was carried out using SPSS for Windows and WinStat for Microsoft Excel.

Cover percentage and correlations of ground vegetation species on dry sites were used to assess grazing impacts. Grazing pressure was found to be correlated to lichen biomass. Since only 2 % of pasture lands are dry, lichen grazing by reindeer is concentrated on a small area only. Nevertheless, the vegetation cover results support the theory that moderate grazing increases biodiversity by preventing the establishment of species-poor climax states. Even though pastures seem heavily overgrazed from the viewpoint of productivity, neither reindeer survival nor species composition nor forest vitality are negatively affected.

Total and usable biomasses of reindeer lichens, *Deschampsia flexuosa* and arboreal lichens were calculated for the national park and the other part of Alakitka herding cooperation. The park is important for reindeer lichens because half of the dry pastures are situated there and for arboreal lichens because of the park’s old-growth forests. The outside part of Alakitka is essential for hair grass biomass because of the large areas with fresh young-growth forest.

The only possibilities to improve the condition of lichen pastures seem to be a radical reduction in reindeer numbers or fencing off the national park against reindeer use. Both appear unrealistic. However, the new herding technique of keeping most reindeer in corrals all winter has led to an improvement in lichen biomass and a reduction of grazing pressure on dry sites already.
Die Folgen intensiver Rentierbeweidung für Rentierflechtenbestände kommen zunehmend in die Diskussion. Der Weidedruck wird häufig als zu stark und mit negativen Folgen für das Waldökosystem verbunden betrachtet. Im Nationalpark Oulanka in Finnland wird das Thema als besonders wichtig erachtet, weil der Park Teil eines europäischen Wildnis-Netzwerk (PAN) werden soll. Deshalb wurde eine Studie in Auftrag gegeben, die die Folgen der Rentierbeweidung auf die Bodenvegetation, insbesondere auf Rentierflechten, erforschen und mögliche Verbesserungsvorschläge vorbringen sollte. Diese Diplomarbeit ist Teil der Studie und versucht neben den genannten Fragestellungen auch die Rolle anderer Winterfutterpflanzen und des Nationalparks als Teil des Alakitka Rentierzuchtverbunds zu begutachten.


Flächenanteil und Korrelationen für verschiedene Arten der Bodenvegetation auf trockenen Waldflächen gaben Auskunft über Beweidungseffekte. Weidedruck war korreliert mit Flechtenbiomasse. Da nur 2 % der Weideflächen trocken sind, ist die Flechtenbeweidung durch Rentiere auf diese kleine Fläche konzentriert. Dennoch erlauben die Daten die Unterstützung der Hypothese, dass durch moderate Beweidung die Biodiversität erhöht wird dadurch dass sich nicht die artenarme Vegetation des Sukzessionshöhepunkt entwickeln kann. Obwohl vom Gesichtspunkt der Produktivität die Flechtenbestände stark überweidet sind, hat dies keine negativen Auswirkungen auf die Rentierbestände, Biodiversität oder Waldgesundheit.

REFERENCES


## APPENDIX II

### SAMPLE AREA:

<table>
<thead>
<tr>
<th>PLOT NO.</th>
<th>GPS: COORDINATES</th>
<th>CALLUNA SP.</th>
<th>V. VACCINIUM</th>
<th>V. MYRTILIS</th>
<th>V. ULLIGINOSUM</th>
<th>EMETRUM SP.</th>
<th>LEDUM SP.</th>
<th>MOSS</th>
<th>CLADONIA STELLARIS</th>
<th>OTHER CLADONIA</th>
<th>LICHEN HEIGHT</th>
</tr>
</thead>
<tbody>
<tr>
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**ARB. LICHEN CLASS: 0 = NO, 1 = LITTLE, 2 = ABUNDANT, 3 = VERY ABUNDANT**
APPENDIX III

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