THE EFFECTS OF SALT STONES ON MOOSE BROWSING IN MANAGED FORESTS IN FINLAND

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ABSTRACT: Forest trees mainly used by moose are known to contain relatively small amounts of sodium. Young Scots pine stands are an important food source for moose in winter, and are often used for several years after the risk of stem damage is over. The lateral twigs of advanced pine saplings represent considerable browse reserves. The availability of sodium can gradually decrease in areas that are permanently subjected to high-density moose browsing. Sodium losses can be compensated by providing salt stones. The provision of salt stones was studied in relation to winter browsing during 1995-96 in central Finland. In autumn 1994 and 1995, a 10 kg stone was placed in each of 17 advanced young Scots pine stands. Experimental stands were selected according to the accessibility of food on the pines estimated on the basis of the height of the lowest living twigs. Each stand was inspected after winter in 1995 and 1996 using 17 plots (50 m^2) centered around the stones. In 1996, 10 control stands without stones were also included. During the first winter, on average, 8.3 kg/ha of pine twigs were consumed by moose in stands with low twig accessibility and 72 kg/ha in those with high twig accessibility. The total consumption from saplings of different tree species was respectively 10.9 kg/ha and 79.3 kg/ha ($P < 0.05$) and the number of pellet groups 113 and 429 per ha ($P < 0.05$). During the second winter the amount of pine consumed was 7.1 kg/ha and 45.3 kg/ha ($P < 0.05$), respectively. In the control stands twig accessibility was also relatively high and the consumption (14.1 kg/ha) was significantly less than in salt stone stands with high twig accessibility ($P < 0.01$). The total consumption per ha was 11.7 kg, 53.3 kg, and 17.2 kg ($P < 0.01$), respectively, and the corresponding number of pellet groups per ha was 71, 205, and 106 ($P < 0.01$). The average weight of the salt stones by the end of the winter was 4.8 kg in the low-consumption stands and 2.3 kg ($P < 0.01$) in the high-consumption stands. Twig biomass consumption correlated negatively with the weight of the salt stones ($r = -0.67$, $P < 0.01$). The amount of pine consumed by moose decreased with increasing distance from the salt stones. There was relatively little damage in seedling stands near the salt stone stands. Using salt to direct moose browsing in winter could be used to increase the residence time in habitats with a high food availability and thus reduce the risk of damage in young stands.

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The importance of sodium (Na) for moose (*Alces alces*) has been reported in several studies (see review by Jordan 1987). In inland, boreal regions of North America, this mineral nutrient is known to be present in only small amounts in woody plants, which are the main constituents of the moose diet (Jordan *et al.* 1973, Jordan 1987). Owing to a lack of dietary sodium during winter, moose search for mineral-rich sources such as aquatic vegetation and licks in spring and summer (Fraser and Reardon 1980, Fraser *et al.* 1982, Risenhoover and Peterson 1986). In Scandinavia the moose populations tend to inhabit traditional winter range areas for long periods (Sweanor and Sandegren 1989, Andersen 1991). Gathering in specific forest areas leads to above average population densities and increased browsing pressure. This can subsequently reduce access to natural sources of less available minerals. Changes caused by forest management in

Finland, such as the extensive drainage of mires, have reduced the availability of several emergent plants. As a result, we suggest that sodium is becoming a limiting factor among the mineral nutrients, and affects habitat use by moose.

In addition to natural mineral sources, sodium can be ingested by moose as NaCl, which is commonly used to meet the nutritional needs of mammalian herbivores (Maynard and Loosli 1969). Placing salt stones in forest areas is a well known method in moose management in Fennoscandia, and attention has been paid to combining their use with feeding habitats and practical forestry (Lääperi 1990). In Finland salt is often used in moose management to ascertain the availability of sodium and to keep moose in hunting areas.

Managed forests are divided into compartments representing different age classes, causing high food availability for moose on deciduous and coniferous saplings of young stands. Young plantations risk heavy browsing in moose areas (Lavsund 1987, Heikkilä and Härkönen 1993). Stem breakage on commercially valuable trees, as well as long-term impacts of browsing on vegetation, have to be taken into account when assessing moose carrying capacity.

Landscape characteristics are related to habitat use by moose in managed forest areas. The small-scale fragmentation of different-aged stands typical of forests in Nordic countries is generally beneficial for moose throughout the year (Cederlund and Okarma 1988, Heikkilä *et al.* 1996). Owing to the importance of Scots pine (*Pinus sylvestris*) in the moose winter diet in Europe, large amounts of food are consumed in young sapling stands (Morow 1976, Cederlund *et al.* 1980, Bergström and Hjeljord 1987). In managed forests the feeding habitats also include large areas of advanced young pine stands with a high availability of pine shoots, as well as considerable amounts of deciduous browse in the form of undergrowth.

The lateral twigs of taller young pines can be extensively used by moose (Heikkilä and Mikkonen 1992). After the top parts of young pines have grown out of the reach of moose, the lateral twigs are still accessible for several years. This source of winter food is considered an alternative to young seedling and sapling stands, the browsing of which may considerably reduce the potential to maintain a high moose population. The aim of the present study is to determine the effect of salt stones on moose feeding intensity in advanced young Scots pine stands and to estimate the effects of moose damage in seedling stands.

STUDY AREA

The study area was part of a large managed forest area in central Finland (62°54'N, 25°38'E), where the average moose density was about 0.4 per km^2 in summer and increased to ca. 0.8 per km^2 in winter due to migration from summer ranges. The experiment was conducted in a ca. 3,000 ha subarea, which according to fixed-wing aircraft surveys, had a moose density of ca. 2 per km^2 in winter 1996. The forests were intensively managed with regular logging each year. The forest sites were mainly dry and dominated by Scots pine, whereas on fertile sites Norway spruce (*Picea abies*) was the main climax tree species. Most stands had an admixture of deciduous trees, mainly white birch (*Betula pubescens*) and silver birch (*B. pendula*). Aspen (*Populus tremula*), rowan (*Sorbus aucuparia*), and willows (*Salix* spp.) were common food plants. Grey alder (*Alnus incana*) and juniper (*Juniperus communis*) also grew in the area. The average size of the forest compartments was relatively small, less than 5 ha, and there were also some lakes and brooks in the area making it

relatively suitable for moose in all seasons. Snow depth during the study period was ca. 30-60 cm. Precipitation in December 1994 - April 1995 was on average 44.0 mm and in winter 1995-96, 22.4 mm (The Finnish Meteorological Institute 1994-96).

METHODS

This study began in autumn 1994 when salt stones weighing 10 kg each and containing more than 99% NaCl were placed in 17 advanced young Scots pine stands in different parts of the area. The stands were randomly selected from a forestry map. There was no longer any risk of stem breakage in the experimental pine stands because the average height of the trees was more than 4 m (Heikkilä and Mikkonen 1992). The stones were placed in the middle of the stands on posts (unbarked pines ca. 15-cm diameter) at a height of ca. 2 m with the distance between adjacent stones being at least 300 m. Stones had not previously been used in the area and moose had therefore not become conditioned to visiting certain habitats for salt. Stands were divided into 2 groups according to the accessibility of pine twigs for moose. The shorter pine stands (n = 9) had, on average, more lateral branches within reach of moose than the taller stands (n = 8), which could not be browsed as easily during winter.

A network of 17 experimental plots (50 m^2 in size) was marked out around the stones. Stones were located at the midpoint of the first plot. The nearest 4 plots were placed 20 m from the stones to the north, south, east, and west, and the other 12 plots at an additional 50, 80, and 110 m along the same lines, respectively.

New stones were placed in the stands prior to winter 1995-96. They were weighed again (50-g precision) after the experimental period in order to estimate the amounts of salt removed, and to compare salt removal with browsing. We assumed that moose accounted for essentially all mass loss in the stones (cf., Faber *et al.* 1993). The sample plots were inspected in spring 1995 and 1996. Ten additional advanced young pine stands without stones were inspected as controls in 1996. Their height class was comparable to the shorter stone stands where lateral branches were well within reach of moose. The control plots were marked and measured in the same way as the salt stone stands.

The twig biomass consumption and availability were measured using twig/diameter calculations for different tree species according to Heikkilä and Härkönen (1993). Only new browsing was included in the calculations. The number of fecal pellet groups was also counted.

Moose browsing intensity in 30 young pine seedling stands in the study area was inspected in order to estimate the amount of damage at different distances from the salt stone stands. The seedling stands were located less than 1 km (n = 11), 1-2 km (n = 12), and over 2 km (n = 7) from the salt stone stands.

The one-way analysis of variance with Bonferroni corrections, Student t-test and Pearson correlation analysis were used in statistical analyses.

RESULTS

In winter 1994-95 moose had browsed 40% of the pines in the salt stone stands with good lateral branch accessibility, and 15% of the pines in stands with branches located higher up the stem (i.e., low accessibility; Fig. 1). The twig biomass utilized from pine was significantly higher in the former stands; over 70 kg/ha compared to less than 10 kg/ha in the latter stands (Fig. 2). There was no significant difference between stands in pine density (2,098 stems/ha $\pm$ 253 SE vs. 2,454 stems/ha $\pm$ 297 SE, P = 0.37, respectively). The number of fecal pellet groups (Fig. 2) indicated a signifi-

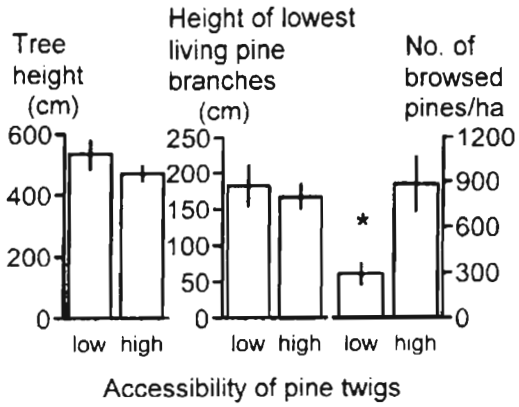

Fig. 1. Tree height, pine twig accessibility determined as the height of the lowest living branches, and the number of pines browsed by moose in advanced young stands containing salt stones in 1995. *=P<0.05.

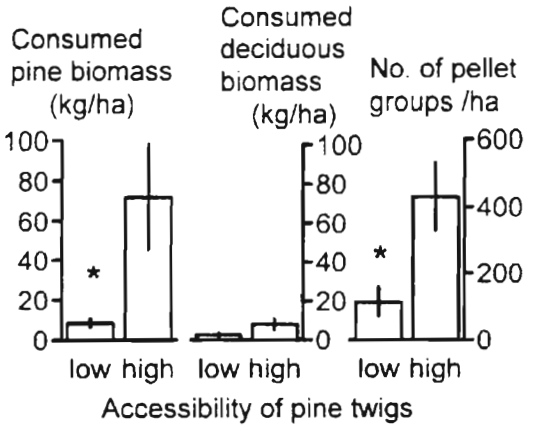

Fig. 2. Twig biomass consumed by moose and number of fecal pellet groups in salt stone stands with low and high pine twig accessibility in 1995. *=P<0.05.

cantly longer residence time for moose in stands with a higher accessibility and consumption of pine twigs.

The amount of biomass removed from deciduous saplings was considerably less, 11% and 32%, respectively, than that consumed from pines (Fig. 2). White birch was freely available, constituting on the average 59% of all deciduous tree species and 26% of the deciduous browse consumed. The respective proportions for availability and biomass consumption of silver birch were 18% and 23%. Aspen, rowan, and willows together constituted 23% of the availability and 51% of the consumption of deciduous trees. The stands had been used by moose during previous years and, as a result, 18-56% of the deciduous saplings of different species had lost their apical growth.

In winter 1995-96 the number of browsed pines was greatest in the salt stone stands with a high accessibility of pine twigs, although the difference compared to the control stands was not significant (Fig. 3). The average height of the pines was 5.29 m (± 0.38 SE) in the salt stone stands, and 4.40 m (± 0.39 SE) in the control stands. Moose consumed on average 22 kg/ha (± 6.6 SE) pine in the salt stone stands, which was somewhat greater than in the control stands, 14.1 kg/ha (± 3.8 SE). However, the difference was not significant (P = 0.26). Considerably less pine was used in 1995-96 compared to the previous winter. Consumption of deciduous trees was, however, at the same level as earlier (P = 0.72). The consumed deciduous tree biomass in the salt stone stands was on average 6.0 kg/ha (± 1.2 SE), and in the control stands 3.1 kg/ha (± 0.8 SE) (P < 0.05).

In 1995-96, moose consumed more pine in the salt stone stands with a high accessibility of twigs compared to the other stand types (Fig. 4). This was the case despite

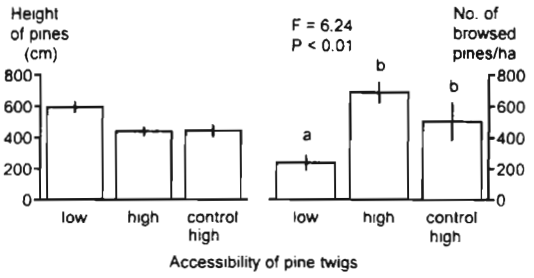

Fig. 3. Tree height, pine twig accessibility, and number of pines browsed by moose in salt stone stands and control stands in 1996. Means with the same letter are not different (P >0.05).

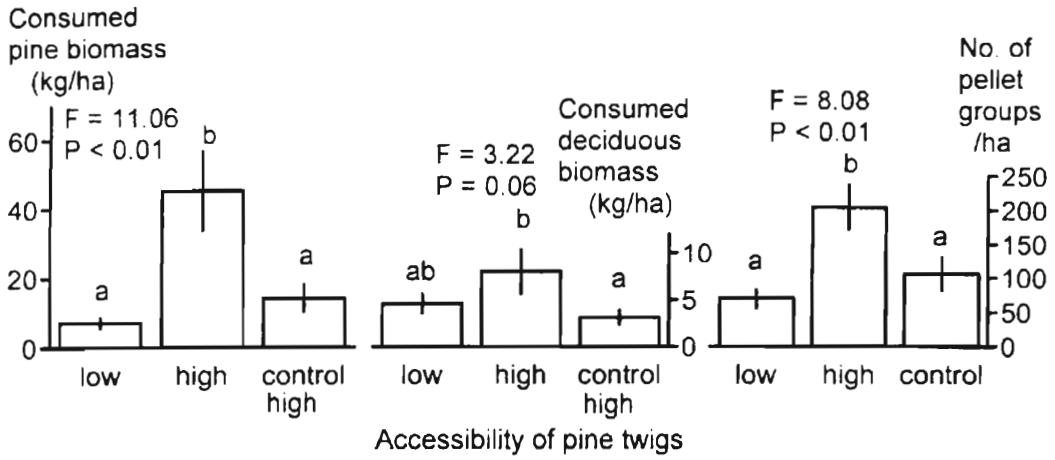

Fig. 4. Twig biomass consumed by moose and number of fecal pellet groups in salt stone stands with low and high pine twig accessibility and in control stands in 1996. Means with the same letter are not different ($P > 0.05$).

good pine twig accessibility in the control stands, where the average height of pine did not differ significantly from that in salt stone stands with good twig accessibility (Fig. 3). In addition, there was no significant difference in pine density between control stands (2,659 stems/ha ± 235 SE) and salt stone stands with high accessibility of twigs (2,460 stems/ha ± 260 SE, $P = 0.53$).

Deciduous trees were more heavily browsed in salt stone stands with high pine twig accessibility compared to control stands (Fig. 4). There was no significant difference in the density of preferred deciduous browse (aspen, rowan, and willows) in control stands (1,996 stems/ha ± 626 SE) and in salt stone stands with high accessibility of pine twigs (1,686 stems/ha ± 633 SE) ($P = 0.74$). The number of fecal pellet groups was relatively high in the salt stone stands where lateral pine twigs were readily available. This result was in agreement with biomass consumption.

The twig biomass consumed by moose on pines during winter increased with increasing removal of salt (Fig. 5). The original weight of stones was 10 kg and the average weight of stones in spring was 2.3 kg (± 0.8 SE) in the stands with a high pine

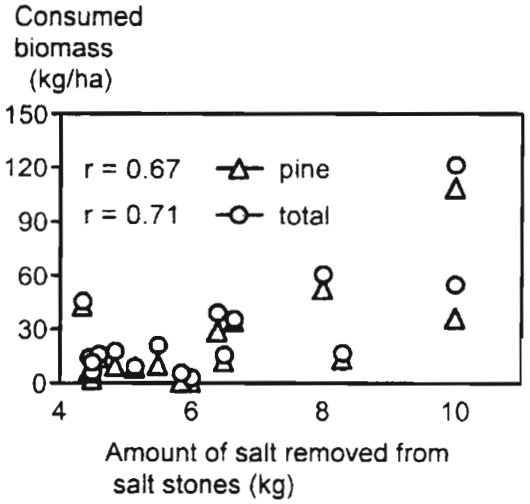

Fig. 5. Biomass consumed by moose in salt stone stands in relation to amounts of salt removed in 1996.

accessibility and 4.8 kg (± 0.2 SE) in the other stands ($P < 0.01$).

The twig biomass consumed by moose in salt stone stands decreased with increasing distance from the salt stones (Fig. 6 A,B). The decrease for the winter 1994-95 was not as clear as that for the following winter, probably due to a lighter browsing pressure in 1995-96. Also in control stands the consumed pine biomass correlated negatively with the distance from the network

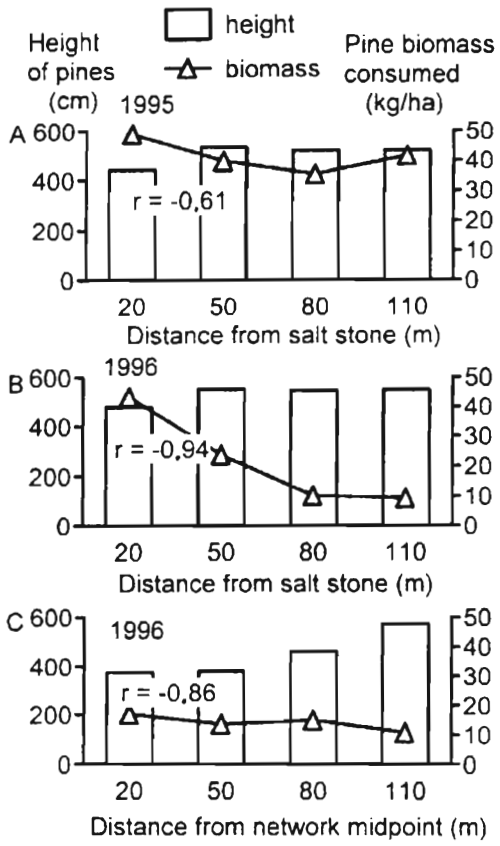

Fig. 6. Tree height and correlation between the amount of pine consumed and distance (m) to salt stones in the stands. A,B = salt stone stands, C = control stands.

midpoint (Fig. 6 C). In turn, in control stands twig accessibility tended to be relatively high on the plots located farther away.

The total consumption of pine and deciduous twigs correlated in a similar fashion to that between pine consumption and the distance from the stones (Fig. 7 A,B). The number of pellet groups generally appeared to follow the amount of feeding on pine except in the control stands (Fig. 7 C). Moose browsing intensity tended to be higher in pine seedling stands located relatively distant from salt stone stands than in those located near stones (Fig. 8).

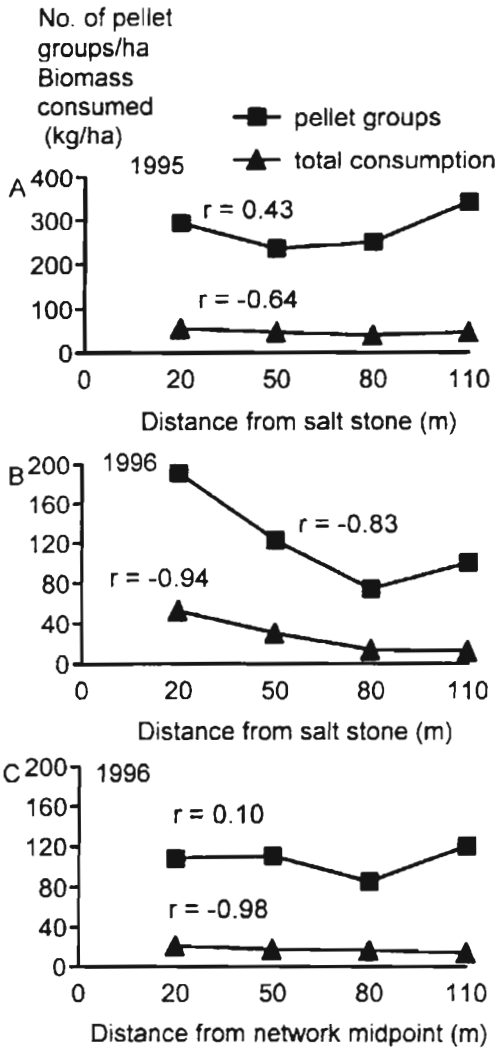

Fig. 7. Number of fecal pellet groups and total consumption by moose in relation to the distance to the salt stones in the stands. A,B = salt stone stands, C = control stands.

DISCUSSION

Salt (NaCl) stones are a widely used wildlife management practice to benefit game, particularly deer, in the Nordic countries. The results of the present study indicate that it is important to take into account the effects on moose browsing of pine when using salt. Earlier attempts have been made to increase moose feeding on alternative food sources away from the youngest Scots pine stands. Lääperi (1990)

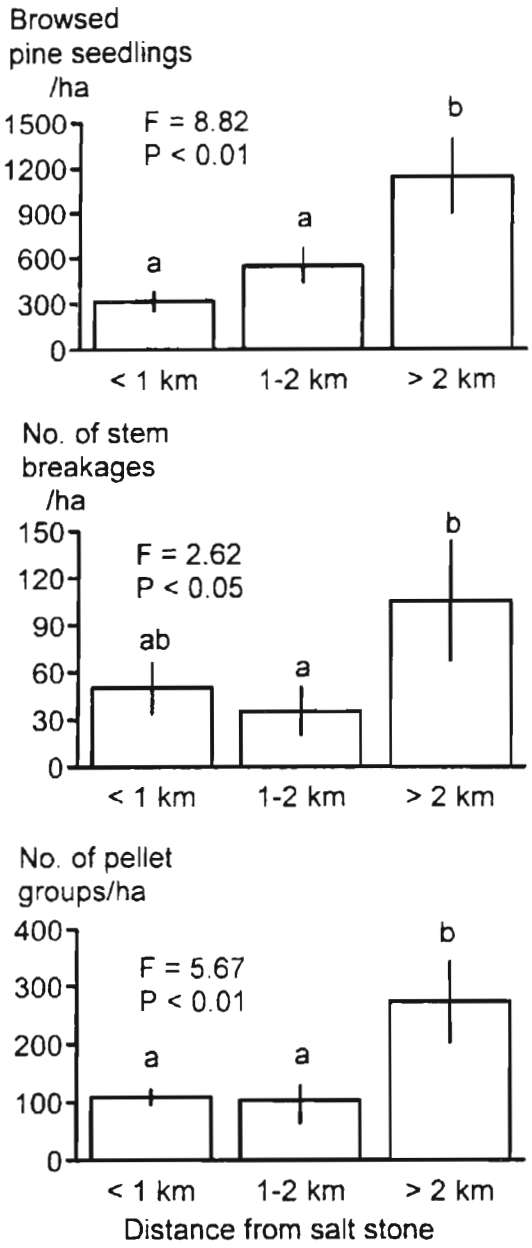

Fig. 8. Moose browsing intensity in seedling stands at different distances from salt stone stands in 1996. Means with the same letter are not different ($P > 0.05$).

reports that the establishment of special feeding stations equipped with salt stones encourages regular moose visits. Artificially provided sodium may be an important factor in dictating home ranges. Miller and Litvaitis (1992) found that moose regularly visited salted roadsides and included them in their home ranges.

We tested salt stones to find out if they can be placed in forest stands with a high food supply in winter. Advanced young pine stands are widely available in managed forests and the lateral twigs of pine are often intensively used by moose. However, nutritional status of the twigs depends also on stand density (Heikkilä and Mikkonen 1992), and intensive browsing in dense stands can be explained by availability and by the effects of shading on food quality.

Our results indicate that providing an additional source of sodium in the form of salt stones can increase moose winter feeding in advanced young pine stands. Differences in use between stands were largely attributed to variation in lateral twig accessibility. Although a height of about 1.5 m is preferred (Löyttyniemi and Piisilä 1983), browsing frequently occurs at heights over 2 m depending on snow conditions. Higher consumption in salt stone stands compared to control stands, where pine twigs were highly accessible, lends support to the importance of salt stones in relation to feeding intensity. Regarding average stand densities and heights,it was concluded that the availability of neither pine nor preferred deciduous browse was sufficient to attract moose to browse more in salt stone stands.

The characteristics of neighboring forest stands may also be important for habitat selection. Residence time of moose in winter may for example be greater at forest edges with dense undergrowth and in freshly cut areas (Histøl and Hjeljord 1993, Heikkilä *et al.* 1996).

The habitat choice of deer species depends on several qualitative factors related to the characteristics of forests (Telfer 1970). The amount of browsing in the salt stone stands indicates that feeding intensity correlates negatively with distance from the stones. According to Lääperi (1990),

moose use feeding stations containing both cut tree tops and salt stones relatively frequently compared to nearby sapling stands. In addition to the effect of cutting residues, the ongoing studies on habitat affinity in our study area have shown that some forest habitats such as peatland compartments are commonly used by moose (cf., Heikkilä and Härkönen 1993).

The amount of salt and minerals ingested by moose may be related to a number of physiological effects. According to the review by Jordan (1987), seasonal requirements for sodium intake have been suggested to be related to potassium:sodium (K:Na) imbalance in early summer and the demands of growth and reproduction processes of animals. It has also been assumed that sodium losses in mammals can result from feeding on plants with higher contents of certain secondary compounds (Palo *et al.* 1983, Pehrson 1983). In this study it was not possible to elucidate the driving mechanism in moose consuming salt and pine browse. According to preliminary results of ongoing studies (R. Heikkilä and S. Härkönen, *unpubl. data*), it appears that browsing of pine increases after providing salt stones. Moose are able to avoid the harmful effects of excess sodium, if sufficient water is available. However, when attempting to balance sodium availability by means of supplementary salt, the natural conditions in forest areas with regards to mineral supply and related aspects should be known. In managed forest habitats these questions obviously should be understood in relation to browsing effects.

Although feeding on pine increased along with increasing removal of salt stones, it cannot be directly concluded that moose used more pine than without any salt stones in the area. In winter, moving activity is low and feeding bouts short (Cederlund 1989), and the importance of salt stones would more likely be in directing browsing to certain subareas. The study area has been subjected to relatively high browsing pressure and the preferred deciduous tree species have been highly utilized. The moose is known to prefer deciduous tree habitats in the summer and autumn in order to improve their physical condition for winter. Moose are adapted to ingest a lot of food in a short time with rapid passage (Renecker and Hudson 1990) and a high intake of pine shoots is typical during the winter. Pine-dominated feeding habitats can be found in seedling and sapling stands, as well as in advanced young stands. Stem damage in seedling stands distant from salt stones may indicate an uneven dispersion of the moose population in relation to salt stones. Information about characteristics and situations of habitats used by moose in winter in other stand types could be important for comparisons. By improving habitat affinity in winter ranges, the effects of moose browsing may be distributed in a way that increases the sustainability of the forests.

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