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Foto: Mikael Wallén

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The distribution of Moose (*Alces alces*) during winter in southern Sweden: A response to food sources?

Habitatval hos älg i södra Sverige under vintern:
En respons på födotillgång

Mikael Wallén

Keywords: Moose (*Alces alces*), Bilberry *(Vaccinium myrtillus)*, Fox berry *(Vaccinium vitis-idea)*, Heather *(Calluna vulgaris)*,Browsing damages, Supplemental feeding, winter range

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Abstract

The traditional Swedish way of dealing with browsing damages made by moose, is to reduce the moose population. However, a growing way of dealing with damages made by several ungulate species, including wild boars in particular is to redistribute them with supplementary food sources. Attracting them to settle in habitats less vulnerable to damages made during foraging. This study we tracked collared moose in southern Sweden from January throughout April in the year of 2009. From the tracking data their “favourite” positions was selected and visited in order to study the features that attracts moose during winter. Later the results from this survey was analysed in order to determine how these feature affects the distribution of moose. The main hypothesis tested in this study are, that moose could be redistributed in their home range by providing supplementary food sources. The results of the study indicates that moose are attracted to supplementary feeding stations set up by man, which give forest managers an opportunity to use them as a tool to redistribute moose into areas with less vulnerable forest stands, with a maintained overall density of moose. Like many other studies this one also results in Pine and Birch are the bulk food source to moose, but this study also suggests that shrubs like bilberry, foxberry and heather are preferred food sources to moose in southern Sweden.

Sammanfattning

Ett traditionellt sätt att hantera betesskador från älg är att reglera populationen via jakt. En växande metod för att hantera skador från ungulater, speciellt när det gäller vildsvin, och att omferdela deras utbredning i landskapet är att förse dem med en alternativ födokälla iform av stödutfodring. På detta sätt attraherar man dem till att uppehålla sig i områden som är mindre känsliga för skador. I den här studien så användes data från älgar märkta med GPS/GSM halsband. Från januari till och med april, via dessa data var det möjligt att välja ut områden som älgen favoriserade. Dessa platser besöktes för att samla information om platsen och vilka egenskaper i landskapet som attraherade älg under vintern. Resultatet från detta fältarbete analyserades senare i syfte att studera hur de olika egenskaperna påverkade fördelningen av älg. Den huvudsakliga hypotesen som testats i denna studie är; kan älg omfördelas i sitt hemområde genom att förse dem med stödfoder? Resultatet av studien indikerar att älgen attraheras av de foder som placeras ut artificiellt. Detta ger skogsförvaltare en möjlighet att uttnyttja stödutfodring för att omfördela älg och genom det minska betesskador lokalt, men utan att behöva påverka täthet av älg i området. I likhet med många andra studier som kommer denna studie fram till att tall och björk är huvudföda för älgen. Men denna studie pekar också tydligt på att bärris som blåbär, lingon och ljung är en viktig födokälla för älg i södra Sverige.

Introduction

Adapting to seasonal changes is widely spread among various forms of organisms, and the most common adaptation is to migrate. This can be either temporal or spatial. One example of temporal migration is dormancy, common among plants which have seeds that often wait in dormancy until right circumstance to start grow appears (Chrungoo, 1992). Other well known examples is to hibernate like the brown bear (Ursus arctos) (Elfström and Swenson, 2009), hedgehogs (Erinaceidae spp.) (MacDonald and Barrett, 1993) or bats (order Chiroptera) (Boyles et al. 2006)) which spends their winter in a den sleeping. Other ways to endure harsh conditions are like the Badger (Meles meles) building a fat layer which provides the animal with energy during long periods of inactivity (Kowalczuk et al. 2003). Storing supplies is another way of dealing with the problem. MacDonald and Barrett (1993) describes how common mole (Talpa europaea) storage up to 2 kilograms of earthworms paralysed by decapitation in caches.

Migration is a diverse phenomena and considering the spatial scale, migration could either be caused by reproduction like Salmonoids (Fraser and Bernatchez, 2008), or a movement to an environment that could provide more resources to use like the Harbour seal (Phoca vitulina) in the St Lawrence

River estuary (Lesage et al.2004). Partial migrating within a population is quite common among deer's living in areas with dense coverage of snow during winter. Ramanzin et al.(2007) describes how 40% of the roe deer (Capreolus capreolus) population in the eastern parts of the Italian Alps, migrates towards areas with lower altitude and less snow during winter. Snow depth is according to Lundmark and Ball (2008) also a big difference between summer and winter ranges for moose in northern Sweden, where moose seems to migrate to locations with less snow depth. Furthermore Sweanor and Sandegren (1989) concluded in their study that snow depth over 70 centimetres over a longer period of time tends to decrease the area of winter range. Indicating that movement in areas with thick snow coverage is expensive in terms of energy.

Thus, snow depth may be a catalyst for migration and thereby influence moose selection of dwelling places within winter range in northern Sweden (Ball et al. 2001). However, little is known about which locals that attracts moose most during winters in areas were moose are more stationary, and snow depth seldom exceeds 20 centimetres for more than a few days. In this study it is investigated whether moose use most of their time foraging and therefore most likely to be found at a food resource or if they spend much of their time at other places where they feel safe while resting and ruminate. During winter some wild animal are able to feed upon food sources provided by man, and these feeding stations could either be directed to the wildlife or just a coincidence, such as leftovers from agricultural activities. An increasing population of wild boars (Sus scrofa) have rendered in an increased amount of feeding stations, since they are considered to be an important tool in wild boar management. With the objectives of either provide the wild boar with an alternative food source to farmland crops, or simply to lure the animals near hunting stands (Lemel and Truwé 2008). Little is known whether moose also use these sites. Hence, a question is whether moose do use these artificial food sources, or are they indifferent.

This study tracked some collared moose in southern Sweden from January throughout April in the year of 2009. From the tracked data their "favourite" positions was selected and visited in order to study the features that attracts moose during winter. Later the results from this survey was analysed in order to determine how these feature affects the distribution of moose. The main hypothesis tested in this study are, that moose could be redistributed in their home range by providing supplementary food sources.

Method

In this study positional data from 25 moose (20 female and 5 male) marked with GPS/GSM collars during the period January– April 2009 where used. The first data are from 6 January when the first moose was marked. The collar carried by the marked moose contains a Global Positioning System (GPS) receiver that collect and save the position every 30 minute (Dettki et al 2004) The collar also contain a Global System for Mobile communications (GSM) device that sends a Short Messaging Service (SMS) to a server located at SLU in Umeå located in the northern Sweden (63° 50' 0" N / 20° 15' 0" E) every 3,5 hour, this means that every SMS delivers 7 positions to a server where the positions are stored. If the device failed to deliver the SMS it was stored until it was possible to send. I choose to set 30 April as last date since after that date the moose behaviour may be more influenced by early spring juvenile vegetation, and cows are starting to approach their coming calving sites. This date, April 30, are estimated from the facts provided by SMHI (2010), stating that the period of vegetation starts when diurnal temperature in average exceeds +5°C. Furthermore, spring are defined as the period when mean diurnal temperature are between 0°C and +10°C, and spring are normally between March 25 and May 20 in the county of Södermanland. Considering these facts the assumption that the vegetation period started May 1 was made.

Study area

The area were the study was conducted is located in southern Sweden in the county of Södermanland (fig. 1) which according to Loman (2009) have an area of 620 thousands hectares.

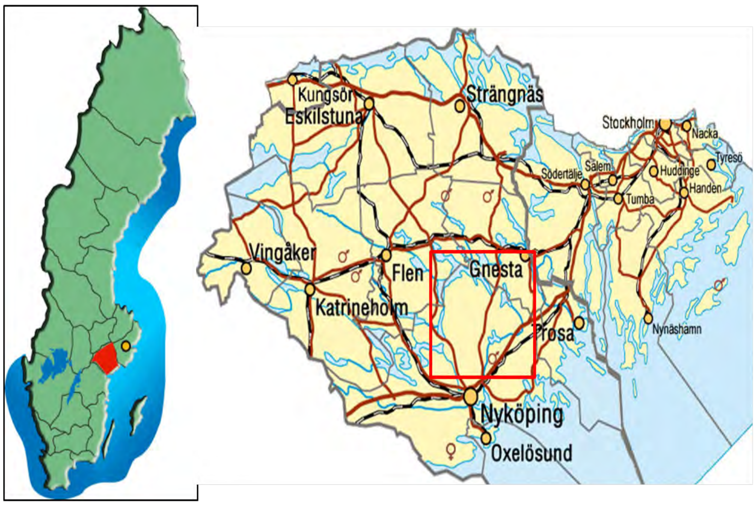

Figure 1. To the left the location of county of Södermanland (red) in Sweden and to the right a map over the county with study area marked with a red square.

In this area the land use classes are presented in figure 2. Landowners differ a bit from the rest of Sweden whilst two-thirds of Södermanland are owned by private landowners compared to Sweden in general, were half of the land is owned by private individuals. Of the whole area 342 thousands hectares are categorised as productive forest, 38 thousands hectares are in ages 0-10 year old, and 37 thousands hectares are 11-20 years old and could be considered as juvenile stands (i.e. approximately 21.9% of the forest stands could be considered as juvenile stands), the rest are middle-aged and old stands.

The average moose browsing damages according to national forest inventory ÄBIN 2004-2008 are 43% of Pine (Pinus sylestris) stems and 24% and 21% respectively for Silver Birch (Betula pendula) and Downey Birch (Betula pubescens).
The three composition in the county are 41% Spruce, 39% Pine, 18% deciduous forest and >1% Noble Broadleaved forest (Skogsstyrelsen, 2009) (Swedish definition of Noble Broadleaved forest contains following species Oak (Quercus robur, Quercus petrea), Beech (Fagus sylvatica), Elm (Ulmus glabra), Ash (Fraxinus excelsior), Lime (Tilia cordata), Maple (Acer platanoides), Hornbeam (Carpinus betulus) and Wild cherry (Prunus avium)).

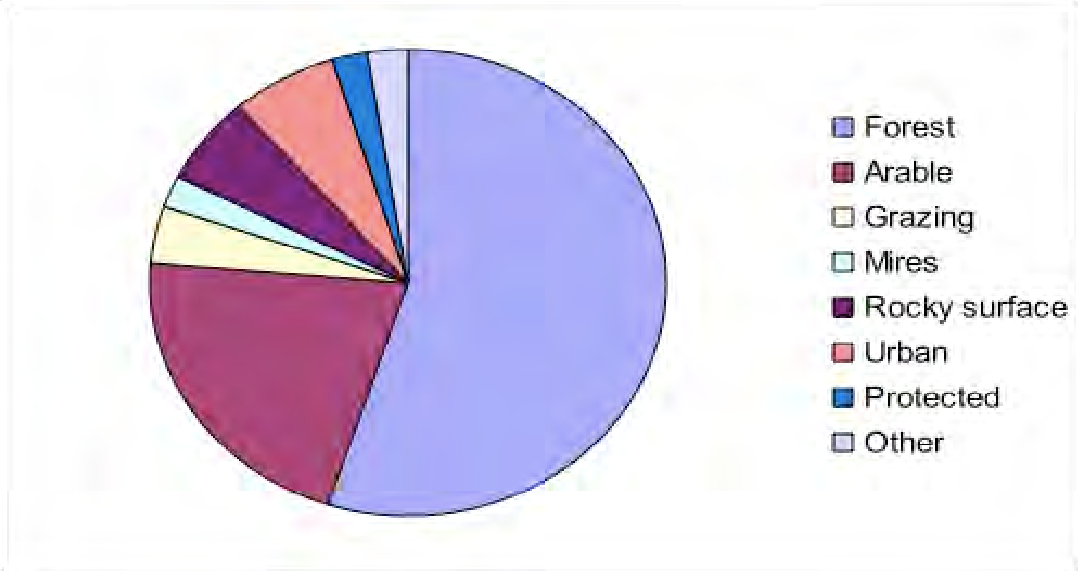

Figure 2. Land use in county of Södermanland (Swedish forest board 2009)

Preparation

The data set of collected positions were analysed in ArcGIS (ESRI 2008) with the application Point density in ArcToolbox. This application is used to calculate a magnitude per unit area from point features that fall within a neighbourhood around each cell. The size of unit area where set to 1 are (10 x 10 meters), and the neighbourhood was set by a circle of 100 metres. Thereafter the top 2% positions with highest moose density were selected and highlighted on a map (fig. 3). These selected positions where gathered in 67 different clusters sized between 0.01 hectare up to 34.10 hectare, besides sizing the clusters their middle point was set. This was made by drawing a circle or an oval (which of them who matches the cluster shape best) around the cluster in ArcGIS and then taking the middle point (Appendix 2). In order to not have any preconceived ideas of which features that would show up at each cluster, there was 20 simple maps prepared, which only displayed roads and whether it was forest or open fields. These maps were used to get as near as possible to each cluster by car.

Field studies

All the 67 clusters that the 25 marked moose had spent most time within 100 metres from were investigated. The field study was conducted during the time span between November 2 and November 7, 2009. Whilst visiting each spot, notes where made if any evidence of artificial food-source could be detected. Also browsing damages on trees and bushes were estimated according to a scale from 1-5 where 1 denoted no browsing damages detected and 5 denoted severe browsing damages. Since shrubs that have had a summer to regenerate from browsing damages there was an uncertainty whether browsing could be detected upon them, thus the estimation was made on trees. It is also important to keep in mind that the browsing damage is not a value on damages on the stands since this value was estimated in relation to available amount of food in browsing height up to 2.5 metres (also used by Kalén and Bergquist 2003). This implies that even if a high value is noted there is not necessarily any damages to the main-steam. All trees were also categorised into Pine (Pinus ssp) Spruce (Picea ssp, and Abies ssp) and Broadleaves with defined subcategories Birch (Betula ssp.), Oak (Querqus ssp.) and Aspen (Populus tremula). Furthermore, it was noted if the areas contained any higher elevation than surrounding areas (i.e., hills and ridges).

Statistics

The 67 surveyed clusters where each multiplied with the amount of points they consists of (the area in hectare times 100 since each point have a size of 10 times 10 metres). This resulted in a total of 26 149 observations. This multiplication was made in Excel (Microsoft Office 2007) since the results from field studies where compiled in excel format. Therefore, it was straightforward to multiply the rows with the area representing each cluster. This calculation resulted in an Excel sheet, now containing 26 149 observations. This result was copied into Minitab 15 statistical software, where all the statistics were calculated.

First there was a calculation of basic statistics to determine how the typical sample site was featured. Second, ANOVA-General Linear Model with both size of area and browsing-pressure used as response variables was run. The size of area (i.e. size of the clusters) could be used as a measure of activity since the clusters with bigger area also had a higher amount of moose presence and therefore could be considered as more attractive to moose. Browsing pressure was used due since the moose obviously had visited the spot and browsed, indicating that there probably is some food resource attracting moose at the site. During ANOVA-GLM analysis of the results all possible exclusives of measured features was tested to find out if anyone was unimportant. However, since the ANOVA-GLM does not reveal in which direction the features pull the response, a regression analysis was made where a positive value increases the response. The probability was conducted as an F-test and calculated in Minitab 15 statistical software, moreover double checked against tables of critical values of the F distribution (Samuels and Witmer 1989). Regression analysis on the relation between cluster size and browsing pressure was also performed. Finally to find the relationship between all features, a multiple scatterplot with regression-line was made for each feature compared with the other ones.

Results

In Table 1 the mean values of each measured feature are displayed and this is also considered to be the probability, along with the standard deviation and standard error. The 95% Confidence interval is also shown. When studying this statistics also keep in mind that the N-value of 26 149 are based on features at 67 sites and if the differences in size between them is ignored we get the mean values displayed in table 2. Comparing these values we can also see that one factor, Oak decreases in mean-value (from 0.3433 to 0.3410). The probability of finding the other factors increases (Juvenile from 0.4627 to 0.6046, Pine from 0.7761 to 0.7850, Spruce from 0.6418 to 0.7338, Deciduous from 0.7761 to 0.8245, Aspen from 0.1045 to 0.1654, Birch from 0.597 to 0.7615, Shrubs from 0.403 to 0.5000, Height from 0.597 to 0.6248, feeding stations from 0.1493 to 0.2767 and browsing pressure from 4.3134 to 4.3549) when 26149 observations are made instead of 67.

The results from ANOVA-GLM with Size of cluster area as a response (Table 3), gives that the factor investigated explains 68.70% (R-square) of the variance in moose activity. The regression in table 4 indicate that presence of following factors increases the size of cluster-area Shrubs (13.86 ± 0.12 (±SE, $p<0.001$) hectare), deciduous trees (11.60 ± 0.23 (±SE, $p<0.001$) hectare), Aspen (7.46 ± 0.13 (±SE, $p<0.001$) hectare), Spruce (5.74± 0.12 (±SE, $p<0.001$) hectare), Birch (5.62 ± 0.19 (±SE, $p<0.001$) hectare), Pine (3.18 ± 0.14 (±SE, $p<0.001$) hectare) and Feeding station (2.61± 0.12 (±SE, $p<0.001$) hectare). Whilst Juvenile stand (-8.69± 0.11 (±SE, $p<0.001$) hectare), Oak (-5.25 ± 0.12 (±SE, $p<0.001$) hectare), Height (-2.69 ± 0.13 (±SE, $p<0.001$) hectare) and Browsing pressure (-1.19 ± 0.05 (±SE, $p<0.001$) hectare) are factors that decreases Moose activity (size of cluster area). The investigated factors could explain 54.90% of the variation using Browsing pressure as a response (Table 5) in ANOVA-GLM. In this analysis Minitab 15 statistc software gave an error in the p-value, when controlling the F-test for Aspen F= 7.44 the table-value (Samuels and Witmer 1989) gave that $0.01>p>0.001$ instead of $p=0.000$ that Minitab suggested. The regression analysis (Table 6) show us that presence of Deciduous (1.40834± 0.0274 $p<0.001$), Birch (0.49915± 0.02275 $p<0.001$), Pine (0.33498± 0.01693 $p<0.001$), Height (0.28807± 0.01613 $p<0.001$), Shrubs (0.24583± 0.0146 $p<0.001$), Juvenile (0.08648± 0.01415 $p<0.001$) and Aspen (0.07123± 0.01622 $p<0.001$) increases the Browsing pressure inside the clusters of investigated positions. Note that in table 4 we find that larger size of cluster area has reducing effect on browsing pressure.

Table 1. Mean value of the different factors (valued 0 or 1) except Browsing pressure that has a value ranging from 1 to 5

Variable	N	Mean	StDev	SE Mean	95% CI
Juvenile	26149	0.6046	0.4889	0.0030	(0.5987; 0.6105)
Pine	26149	0.7850	0.4109	0.0025	(0.7800; 0.7899)
Spruce	26149	0.7338	0.4420	0.0027	(0.7284; 0.7391)
Decidious	26149	0.8245	0.3804	0.0024	(0.8199; 0.8291)
Oak	26149	0.3410	0.4741	0.0029	(0.3353; 0.3467)
Aspen	26149	0.1654	0.3715	0.0023	(0.1609; 0.1699)
Birch	26149	0.7615	0.4262	0.0026	(0.7563; 0.7666)
Shrubs	26149	0.5000	0.5000	0.0031	(0.4940; 0.5061)
Height	26149	0.6248	0.4842	0.0030	(0.6190; 0.6307)
Browsing pressure	26149	4.3549	1.1532	0.0071	(4.3410; 4.3689)
Feeding stations	26149	0.2767	0.4474	0.0028	(0.2713; 0.2821)

Table 2. Mean values where each cluster is considered to be one observation regardless size.

Variable	N	Mean	StDev	SE Mean	95% CI
Juvenile	67	0.4627	0.5024	0.0614	(0.3424; 0.5830)
Pine	67	0.7761	0.4200	0.0513	(0.6756; 0.8767)
Spruce	67	0.6418	0.4831	0.0590	(0.5261; 0.7575)
Decidious	67	0.7761	0.4200	0.0513	(0.6756; 0.8767)
Oak	67	0.3433	0.4784	0.0584	(0.2287; 0.4578)
Aspen	67	0.1045	0.3082	0.0377	(0.0307; 0.1783)
Birch	67	0.5970	0.4942	0.0604	(0.4787; 0.7153)
Shrubs	67	0.4030	0.4942	0.0604	(0.2847; 0.5213)
Height	67	0.5970	0.4942	0.0604	(0.4787; 0.7153)
Browsing pressure	67	4.3134	1.3167	0.1609	(3.9982; 4.6287)
Feeding stations	67	0.1493	0.3590	0.0439	(0.0633; 0.2352)

Table 3. ANOVA-General Linear Model Analysis of Variance for Area size, using Adjusted SS for Tests

Source	Seq SS	Adj SS	Seq MS	F	P
Juvenile	1.107E+09	1.319E+09	1,319E+09	3 378	0.000
Pine	1.735E+09	0.162E+09	0.162E+09	416	0.000
Spruce	3.459E+09	0.990E+09	0.990E+09	2 536	0.000
Deciduous	2.774E+09	0.758E+09	0.758E+09	1 941	0.000
Oak	0.021E+09	0.650E+09	0.650E+09	1 665	0.000
Birch	1.380E+09	0.386E+09	0.386E+09	990	0.000
Aspen	4.263E+09	1.350E+09	1,350E+09	3 459	0.000
Shrubs	6.735E+09	5.431E+09	5,431E+09	13 912	0.000
Height	0.217E+09	0.107E+09	0.107E+09	274	0.000
Feeding station	0.346E+09	0.146E+09	0.146E+09	375	0.000
Browsing pressure	0.358E+09	0.358E+09	0.119E+09	306	0.000

S = 625

R-Sq = 68.70%

R-Sq(adj) = 68.69%

Table 4 Regression analysis with area size as response

Predictor	Coef	SE Coef	T	P
Constant	-402	23	-18	0,000
Juvenile	-869	12	-76	0,000
Pine	318	14	23	0,000
Spruce	574	12	47	0,000
Deciduous	1160	23	50	0,000
Oak	-525	12	-45	0,000
Birch	562	19	30	0,000
Aspen	746	13	57	0,000
Shrubs	1386	12	116	0,000
Height	-269	13	-20	0,000
Browsing pressure	-119	5	-24	0,000
Feeding station	261	12	22	0,000

S = 629
R-Sq = 68.3%
R-Sq(adj) = 68.3%

Table 5 ANOVA-General linear model, Analysis of Variance for Browsing pressure, using Sequential SS for Test.

Source	Seq SS	Adj SS	Seq MS	F	P
Juvenile	822	22	822	1370	0.000
Pine	1078	235	1078	1796	0.000
Spruce	1026	2036	1026	1709	0.000
Deciduous	10710	1586	10710	17850	0.000
Oak	3182	1067	3182	5304	0.000
Birch	354	289	354	589	0.000
Aspen	5	12	5	7	0.000
Shrubs	366	170	366	610	0.000
Height	202	192	202	336	0.000
Feeding station	1348	1348	1348	2246	0.000

S = 0.775
R-Sq=54.90%
R-Sq(adj)=54.88%

Table 6 Regression analysis with browsing pressure as response and the regression equation displayed below the table

Predictor	Coef	SE Coef	T	P
Constant	3.1791	0.0200	159.08	0.000
Juvenile	0.0865	0.0142	6.11	0.000
Pine	0.3350	0.0169	19.79	0.000
Spruce	-0.8288	0.0142	-58.25	0.000
Deciduous	1.4083	0.0274	51.40	0.000
Oak	-0.5901	0.0140	-42.17	0.000
Birch	0.4992	0.0228	21.94	0.000
Aspen	0.0712	0.0162	4.39	0.000
Shrubs	0.2458	0.0146	16.84	0.000
Height	0.2881	0.0161	17.86	0.000
Feeding station	-0.6722	0.0142	-47.39	0.000

S = 0.7746
R-Sq = 54.9%
R-Sq(adj) = 54.9%

Discussion

In Sweden shrubs are traditionally considered to be a food source to moose during autumn. Described by e.g. Jensen (1993) and Svensson (2008) as a transitory food source, between a diet of leaf and herbs in the summer and the winter diet dominated by shoots and twigs from trees or a complement to herbs during summer (Kalén and Bergquist 2004). This is also the case in for example north-east of Russia where Zheleznov-Chukotsky and Votiashova (1998) found that moose in their study used Vaccinum spp. during summer, they have also observed moose paw in the snow in digging out various species of grass (Poacheae/Gramineae), sedge family (Cyperaceae) and other species. This behaviour of moose actively searching for ground vegetation seconds our findings, to consider shrubs being a preferred food source throughout entire winter. Rendering shoots and twigs from trees a less preferred food source. This is second by Månsson (2009) that found that there is more available forage from shrubs in stands older than 30 year, than in stands younger than 30 years. In this study it was also concluded that moose were found in older stands more frequently with a snow cover less than 0.1 metres deep. This coincide with this study were we also conclude a negative association between juvenile stands and shrubs (Appendix 3), and our results also suggests that shrubs are more likely to be found on a higher elevated areas with pine as the dominant tree species. Hence, we assume that moose tend to use elevations in the landscape.

Dettki et al. (2003) found in their study moose location data were linked to low-altitude habitats. This contradicts our results of moose being attracted to heights, or at least the shrubs more likely to be found there. However this difference could be explained by the fact that Dettki conducted their study in the northern Sweden with dense snow coverage during winter, which probably prohibited moose from utilising shrubs as a food source.

Dettki et al. (2003) also found that moose was more likely to be found in younger tree stands, which this study would reject when using area of the cluster as a measurement of moose activity (Table 4). On the other hand our study also suggest that moose are 3 times more likely to be found in a juvenile stand than they would have been if they dispersed randomly throughout stands of all ages (Table 1) (Loman 2009). The contradicting result in this study could be a result of that the average size of stands in county of Södermanland are smaller than the average size of cluster in this study, also keep in mind that there is no measurement of time spent by moose at each cluster, other than they represent the 2% most visited positions by the GPS-collared moose in the research area.

Kalén and Bergquist (2004) found in their study that a pine provides most available biomass to brows upon at the height-classes between 2-4.5 metres, and Birch peaks at 4 metres of height. This indicates that a moose have the highest available browsing in juvenile stands if we consider that they also contains a high density of trees, which would give a browsing moose low energy cost in search of food.

Looking at different tree species the results in this study suggests that Spruce (Picea spp, abies spp.) increases the activity of moose, which contradicts earlier studies suggesting that moose avoids spruce (Suring and Sterne 1998, Månsson et al. 2007, Shipley et al. 1998, Kalén and Bergquist 2004). The divergent result in this study could be a factor of sampling technique, were the measurement was presence or absent of Spruce, and the probability to find Spruce increases with an increasing size of cluster. Another explanation could be that we found a positive relation between presence of Spruce and deciduous trees and Birch in particular (Appendix 3), and that birch are considered to be a dominant food source to moose (Cassing et al. 2006, Shipley et al. 1998, Månsson et al. 2007). Regardless which of these explanations or a combination of both represent the truth; neither of them suggests that moose are attracted by Spruce. This is further supported in this study when considering the results for browsing pressure, were spruce trees is the factor decreasing browsing pressure most.

Both Månsson et al. (2007) and Shipley et al. (1998) found that pine represents a large part of the food source to moose during winter. This is supported by this study to the point that pine are the most common tree species on moose “hotspots”, and increases both activity of moose and browsing pressure on trees. Although pine is the most common among tree species in this study, deciduous trees are far more attractive to moose and are the second largest factor to increase moose activity and enlarge browsing pressure most of all factors investigated. Deciduous trees are also associated with juvenile stands which indicate that they provide moose with large quantities of available food source (Kalén and Bergquist 2004).

Deciduous tree species being attractive to moose are described worldwide from Alaska were moose prefer habitats dominated by either Black cottonwood (Populus trichocarpa) or a mixture of Willow (Salix spp.)and Alder (Alnus spp.) (Suring and Sterne 1998). To north-east of Russia where moose according to Zheleznov-Chukotsky and Votiashova (1998) feed upon “Alnus, Salix Sorbia, Ribes and other shrubs”. In Sweden Månsson et al. (2007) found that Rowan (Sorbus aucuparia), Willow (Salix spp.) and Aspen (Populus tremula) had 14 times higher probability of being browsed than Scots pine (Pinus sylvestris) and Downey birch (Betula pubescens) and Silver birch (Betula pendula) had 3.5 higher probability of being browsed by moose, this is further second by Shipley et al. (1998). These studies agree with our result, that Aspen (Populus tremula) rendered the highest increase in moose activity among specified deciduous trees. However, this also contradicts with our result that presence of Aspen only have a small increase in browsing pressure. One explanation could be that after browsed upon during January-April, there was a recovery from browsing damages in the summer before the study conducted in November. This could also be the case with the results that presence of Oak (Quercus spp.) contribute to a decrease of browsing pressure in this study. Contradicting the expectation from Götmark et al. (2005) who found that Oak is an object to higher browsing intensity than other deciduous species, supported by the fact that Oak provides a high forage quality to ungulates (Svendsen 2001). The results also suggest that oak decreases moose activity, with oak associated with small clusters in this study could be caused by Oak having a sparse distribution in the research-area only occurring as solitary individuals. That in this study attracts moose to small patches in search of sources to brows upon.

In this study feeding stations increased moose activity, which revealing that moose utilises artificial food sources. This was also found by Andreasen et al. (2005) who found that moose could be redistributed with supplementary feeding, thereby lowering the amount of train-moose collisions. Gundersen et al. (2004) found in their study that moose could be relocated by supplementary feeding, but moose need time (years) to learn how to benefit from new food sources. This also answers our hypothesis that supplementary feeding could redistribute moose during winter, and properly placed decrease damages made by browsing moose.

Concluding remarks

During the field work I came across several persons with interests in the local moose-population, they where landowners and hunters both professionals and amateurs. They all expressed a concern for the average moose decreases in size and giving birth to few and small calves. I reflected on this and since the shrubs seem to be important to moose in this area, as a food source. During my field studies I intercepted very much Fallow deer (Dama dama) feeding upon shrubs, which could indicate that an increasing population of fallow deer consumes a resource vital to moose during winter. Carlström (2005) state in his book about fallow deer that bilberry (Vaccinum myrtillus), lingonberry (Vaccinum vitis-idaea) and heather (Calluna vulgaris) are the natural food source along with browsing on various deciduous trees. Also von Petrak (1987) found that shrubs are considered as a quantity food-source for fallow deer in Germany.   In that case moose may be doomed to starvation because forage is sparse, or is there a possibility to adopt other feeding habits. The fact that they not seem to have adopted other habits yet may be caused by moose reluctant to change habits. Compare this with Sweanor and Sandegren (1988) findings that moose learn whether to migrate or not by their mother. Sahlsten et al. (2010) found whilst trying to intercept moose migration, by setting up feeding stations along migration routes that moose ignored the food source and kept on migrating like previous year. Andersen (1991) also found that moose in Gausdal/Vestfjell in Norway migrate to a poor winter range just because their ancestors' always have utilised this area which once had high quantity of quality forage available to moose.

Management implications

Since shrubs seem to be a vital food source during winter, at least with a thin snow-coverage, I would suggest that forestry should consider measures that favour shrubs. The easiest way should be to use pine when regenerating areas where shrubs are available before cutting. Some people might object to this since juvenile pine stands are considered to be vulnerable to browsing damages caused by moose. However, my point is that if we shall have moose in our forests we also have to provide moose with forage. In additional to this I also would suggest foresters to maintain a rich resource of deciduous browsing, since moose need a food-source compensating for shrubs being unavailable during winters with dense snow-coverage. It would have been interesting to conduct this study again 2010 when the snow coverage has been dense and unable moose to feed upon shrubs. Will they seek forage in juvenile stands at higher rate, causing severe browsing damages? Furthermore, will they use same areas as in this study, resulting in starvation and lower birth-rate in summer of 2010 than in summer of 2009. The results of this study also suggests that moose are attracted to feeding stations, and if they are placed in areas with middle-aged stands that would not suffer from browsing damages. Non-migrating Moose could at least be redistributed by man to areas with less vulnerable forest stands. Regarding migrating moose Sahlsten et al. (2010) failed to intercept moose by placing supplementary food-sources along their migrating routes, but suggesting the possibility to use supplementary feeding when moose have reached their winter-habitats. This fact could be usable to protect vulnerable forest in that area. Gundersen et al. (2003) found that it takes time for moose to start utilising feeding stations, suggesting the possibility to intercept migrating moose. My suggestion would be to conduct a study on intercepting migrating moose over several years.

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Appendix 1

Table displaying features of the cluster-areas

Area	Juvenile yes=1 no=0	Pine yes=1 no=0	Spruce yes=1 no=0	Deciduous yes=1 no=0	Oak yes=1 no=0	Birch yes=1 no=0	Aspen yes=1 no=0	Shrubs yes=1 no=0	Height yes=1 no=0	Browsing pressure Scale 1-5	Feeding station yes=1 no=0
1.1	1	1	0	1	1	1	0	1	1	5	1
1.2.1	1	0	1	1	1	1	1	0	0	3	0
1.2.2	0	1	1	1	1	0	0	0	1	1	0
1.2.3	1	0	1	1	0	1	0	0	0	5	0
1.2.4	0	1	0	1	0	1	0	0	1	5	0
1.2.5	0	1	1	0	0	0	0	1	1	5	0
1.2.6	0	1	0	0	0	0	0	1	1	5	0
1.3.1	0	1	0	1	1	1	0	0	1	5	0
1.3.2	0	1	1	1	1	1	0	0	1	5	1
1.4.1	1	1	1	1	1	0	0	0	1	4	0
1.4.2	1	0	1	1	0	1	0	0	0	4	0
1.4.3	1	0	1	1	0	1	0	1	1	5	0
1.4.4	1	0	1	1	0	1	0	0	0	5	0
1.4.5	1	1	1	1	0	1	0	0	0	5	0
1.4.6	0	1	0	0	0	0	0	1	1	5	1
2.1	1	1	1	0	0	0	0	1	1	3	1
2.2	0	1	1	1	0	1	0	0	1	5	0
2.3	0	1	1	1	0	1	0	0	1	5	0
2.4.1	1	0	0	1	0	0	1	0	0	5	0
2.4.2	0	0	1	0	0	0	0	0	0	1	0
2.4.3	0	1	0	0	0	0	0	1	1	5	0
2.5	1	1	0	1	1	1	0	1	1	4	0
3.1.1	0	1	0	0	0	0	0	1	1	5	0
3.1.2	0	1	0	1	0	1	0	1	1	5	0
3.1.3	0	1	0	1	0	1	0	1	1	5	0
3.2	1	1	1	1	0	1	0	0	0	5	0
3.3	0	0	1	0	0	0	0	0	0	1	1
3.4	1	1	1	1	0	1	1	0	0	5	0
4.1	1	1	1	1	1	1	1	1	1	4	1
4.2	1	1	0	1	1	1	0	1	0	5	0
4.3	1	1	1	1	0	1	0	0	1	5	0
4.4.1	1	1	1	1	0	1	0	0	1	4	0
4.4.2	1	1	1	1	0	1	0	1	1	4	1
4.5.1	0	1	0	0	0	0	0	1	1	1	0
4.5.2	0	1	0	0	0	0	0	1	1	1	0
4.5.3	1	0	1	1	0	1	0	1	0	5	0
4.5.4	0	1	1	1	1	0	0	1	1	5	0
4.5.5	0	1	1	1	1	0	0	0	0	5	0
4.5.6	0	1	1	1	1	0	0	0	1	5	0
4.6.1	0	1	1	1	1	1	1	0	0	5	0
4.6.2	0	1	1	1	1	0	0	0	1	5	0
4.7.1	0	1	0	0	0	0	0	1	1	5	0
4.7.2	1	1	0	1	0	1	0	1	1	5	0
4.7.3	0	1	0	0	0	0	0	1	1	5	0
4.8.1	1	1	1	1	0	1	0	0	1	5	0

4.8.2	1	0	1	1	0	1	0	0	0	4	0
4.9.1	1	0	1	1	0	1	0	0	0	5	0
4.9.2	0	1	1	1	0	1	0	1	1	5	0
4.10.1	0	1	0	1	1	0	0	1	1	5	0
4.10.2	0	1	1	1	1	1	1	1	1	5	0
4.10.3	0	1	1	1	1	0	0	0	1	5	0
4.10.4	0	1	0	1	1	0	0	1	1	5	0
4.10.5	1	1	1	1	0	1	0	0	0	5	0
4.10.6	0	1	0	1	1	0	0	1	1	5	0
5.1	0	1	1	0	0	0	0	0	0	1	1
5.2	1	1	1	1	1	1	0	0	0	5	0
5.2p	0	1	0	0	0	0	0	0	0	1	0
5.3.1	1	1	0	1	1	1	0	0	0	5	0
5.3.2	1	1	0	1	1	1	0	0	0	5	0
5.3.3	1	0	0	1	0	0	1	0	1	5	0
5.4	1	1	1	1	0	1	0	0	1	4	0
5.5	0	1	1	1	1	1	0	0	1	5	0
5.6	1	0	1	1	0	1	0	0	0	5	0
5.7	1	0	1	1	0	1	0	0	0	4	1
5.8	1	1	1	1	0	1	0	0	0	4	1
6.1	0	1	1	1	0	1	0	1	1	5	0
6.2	0	0	1	0	0	0	0	0	0	1	0

Appendix 2

Table Displaying location (midlepoint) in RT-90 coordinates and size of each area. Multiply the Size in square kilometres with 10000 and you will get the amount of positions in that cluster.(e.g. subarea 1:1 got 1273 positions)

AREA	SUBAREA	LOCATION (grader/decimalgrader, WGS-84)		SIZE square kilometers
1	1:1	16,907156 dd	58,932608 dd	0,1273
	1:2:1	16,946143 dd	58,972056 dd	0,0501
	1:2:2	16,943876 dd	58,974005 dd	0,0289
	1:2:3	16,953579 dd	58,974323 dd	0,0605
	1:2:4	16,95911 dd	58,979038 dd	0,0088
	1:2:5	16,964007 dd	58,980942 dd	0,0157
	1:2:6	16,968631 dd	58,983934 dd	0,0696
	1:3:1	16,991689 dd	59,004824 dd	0,0113
	1:3:2	17,008627 dd	59,007664 dd	0,0303
	1:4:1	16,999647 dd	58,976294 dd	0,0115
	1:4:2	17,005534 dd	58,972369 dd	0,0972
	1:4:3	17,006333 dd	58,967213 dd	0,0231
	1:4:4	17,012453 dd	58,965716 dd	0,0757
	1:4:5	17,017476 dd	58,967745 dd	0,0114
	1:4:6	17,028387 dd	58,964352 dd	0,0270
2	2:1	17,06848 dd	58,95663 dd	0,0489
	2:2	17,093131 dd	58,949884 dd	0,0489
	2:3	17,100747 dd	58,974823 dd	0,0132
	2:4:1	17,121859 dd	58,966287 dd	0,0628
	2:4:2	17,11911 dd	58,964829 dd	0,0389
	2:4:3	17,120443 dd	58,960707 dd	0,0162
	2:5	17,136391 dd	58,975989 dd	0,0698
3	3:1:1	17,093728 dd	59,015933 dd	0,0348
	3:1:2	17,094601 dd	59,014259 dd	0,0052
	3:1:3	17,09773 dd	59,016879 dd	0,0074
	3:2	17,113086 dd	59,017753 dd	0,0132
	3:3	17,147947 dd	59,031144 dd	0,0297
	3:4	17,164468 dd	59,031872 dd	0,0227
4	4:1	17,180626 dd	58,981743 dd	0,2674
	4:2	17,205477 dd	58,987045 dd	0,0465
	4:3	17,213727 dd	58,984125 dd	0,0699
	4:4:1	17,219495 dd	58,982591 dd	0,0187
	4:4:2	17,222963 dd	58,981861 dd	0,0187
	4:5:1	17,2276 dd	58,977043 dd	0,0223
	4:5:2	17,230703 dd	58,975582 dd	0,0042
	4:5:3	17,226614 dd	58,972844 dd	0,0357
	4:5:4	17,231688 dd	58,97299 dd	0,0109
	4:5:5	17,228658 dd	58,970544 dd	0,0056
	4:5:6	17,227636 dd	58,970216 dd	0,0028
	4:6:1	17,228622 dd	58,961966 dd	0,0273
	4:6:2	17,230666 dd	58,960542 dd	0,0158

	4:7 west	17,240705 dd	58,983979 dd	0,0364
	4:7 middle	17,243516 dd	58,982007 dd	0,0480
	4:7 east	17,248955 dd	58,980438 dd	0,0158
	4:8 south	17,210953 dd	59,001538 dd	0,0863
	4:8 north	17,21621 dd	59,005517 dd	0,0269
	4:9 west	17,215991 dd	59,001173 dd	0,0329
	4:9 east	17,219276 dd	58,997741 dd	0,3410
	4:10:1	17,215804 dd	58,994045 dd	0,0039
	4:10:2	17,221921 dd	58,994935 dd	0,0009
	4:10:3	17,21893 dd	58,990307 dd	0,0173
	4:10:4	17,221633 dd	58,988453 dd	0,0020
	4:10:5	17,225584 dd	58,99159 dd	0,0322
	4:10:6	17,231996 dd	58,989354 dd	0,0020
	5:1	17,147072 dd	58,922365 dd	0,0993
	5:2	17,154234 dd	58,921773 dd	0,0527
	punkt	17,15193 dd	58,927439 dd	0,0001
	5:3 big	17,166211 dd	58,934525 dd	0,0728
	5:3 north	17,166664 dd	58,938611 dd	0,0007
	5:3 east	17,171835 dd	58,936877 dd	0,0012
	5:4	17,184164 dd	58,940541 dd	0,0100
	5:5	17,184175 dd	58,946598 dd	0,0339
	5:6	17,189133 dd	58,948206 dd	0,0110
	5:7	17,196692 dd	58,94692 dd	0,0165
	5:8	17,198746 dd	58,8985 dd	0,0585
6	area	17,264349 dd	58,944745 dd	0,0066
	point	17,264727 dd	58,944136 dd	0,0001
Total	67 areas		Total size	2,6149
			Average size	0,039

Appendix 3

Scatterplots of all features in relation to each other

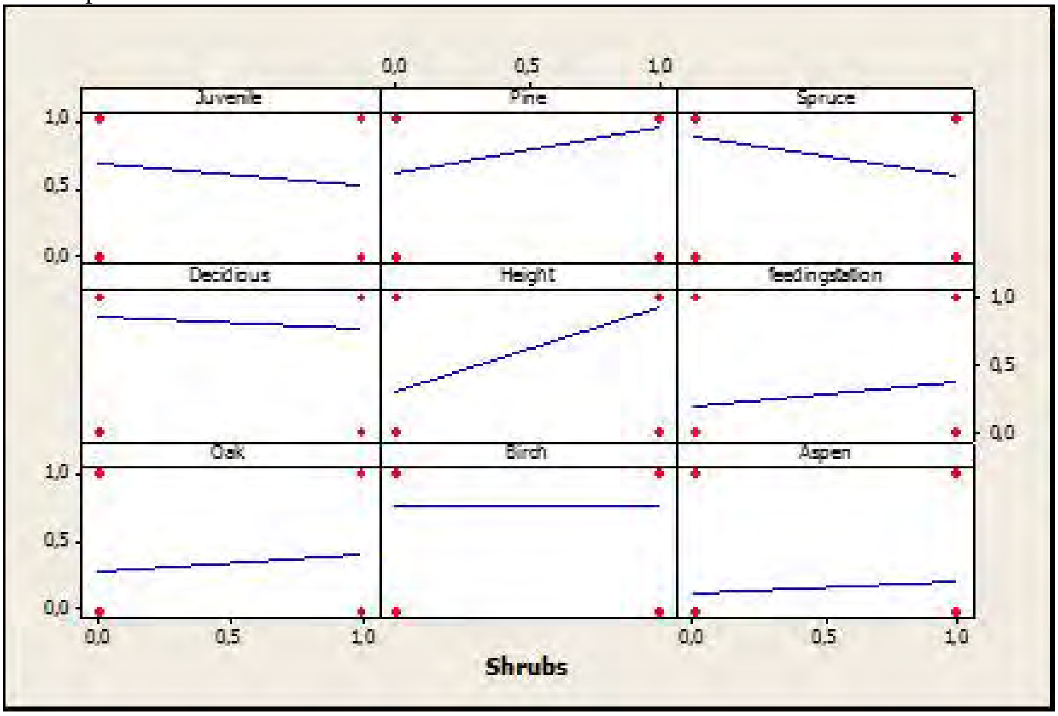

Figure 1. Scatterplots with Shrubs presence/absence on x-axis versus presence/absence of the other 9 factors on y-axis, with regression lines in blue.

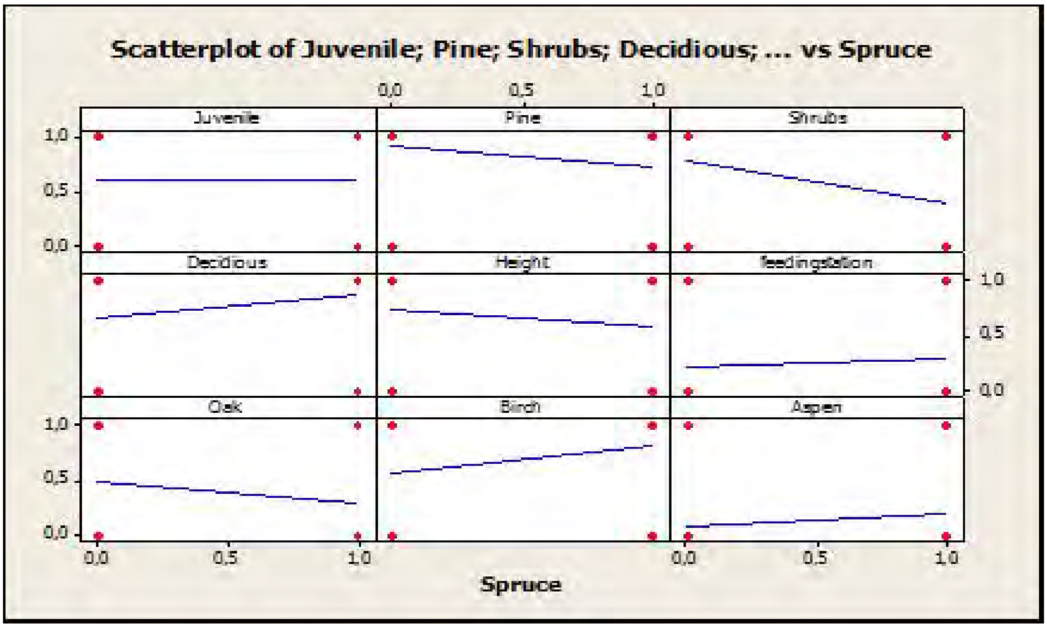

Figure 2. Scatterplots with Spruce presence/absence on x-axis versus presence/absence of the other 9 factors on y-axis, with regression lines in blue.

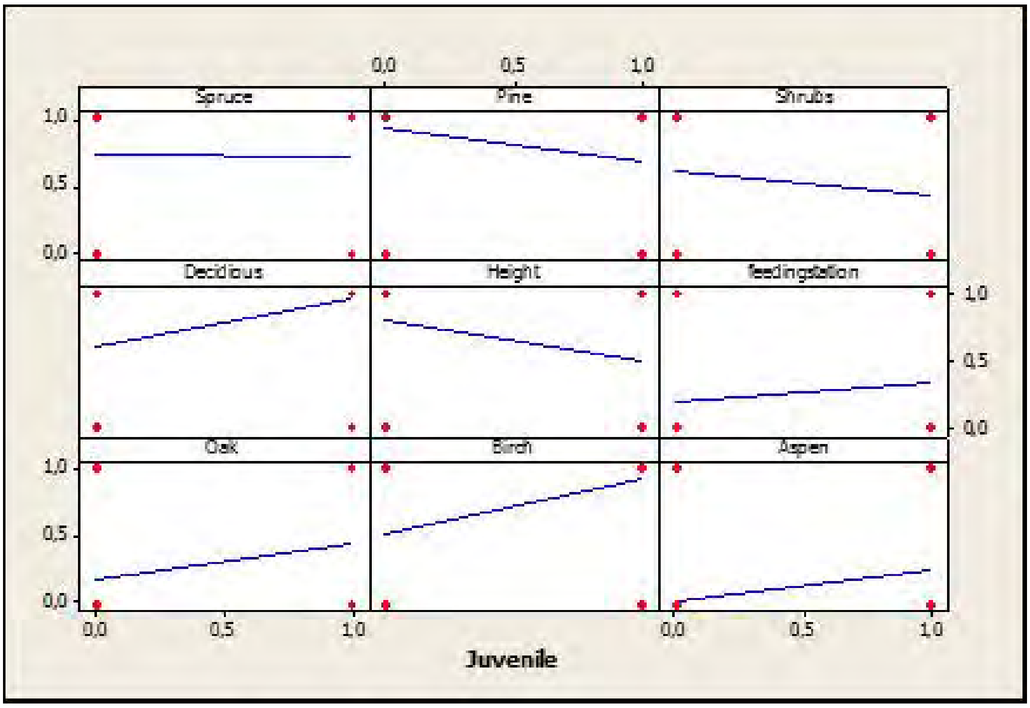

Figure 6. Scatterplots with Juvenile stand presence/absence on x-axis versus presence/absence of the other 9 factors on y-axis, with regression lines in blue.

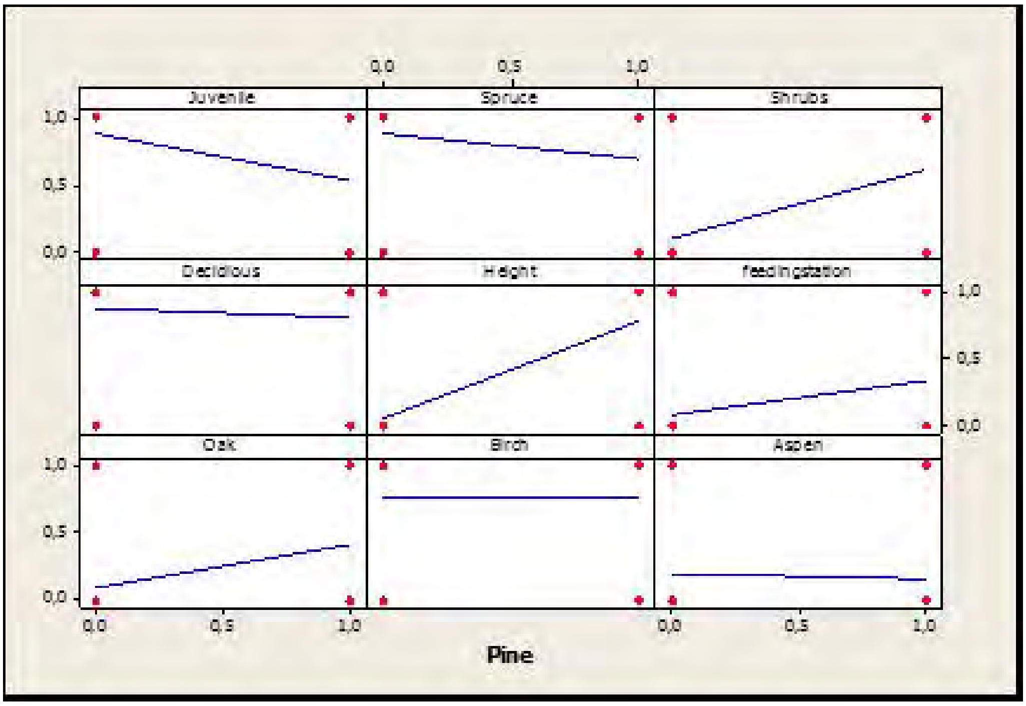

Figure 7. Scatterplots with Pine presence/absence on x-axis versus presence/absence of the other 9 factors on y-axis, with regression lines in blue.

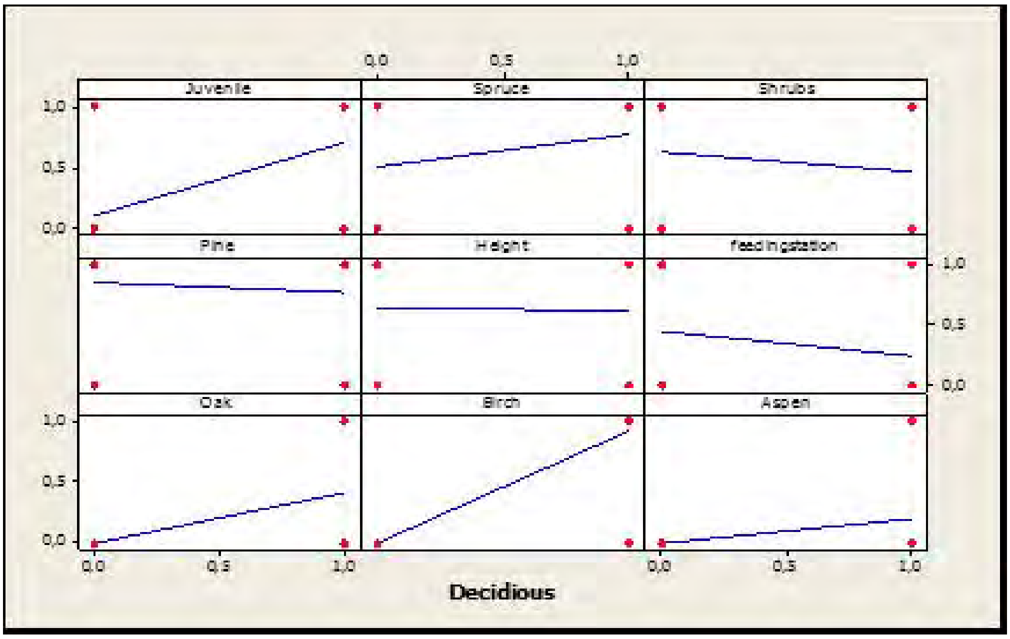

Figure 8. Scatterplots with Deciduous trees presence/absence on x-axis versus presence/absence of the other 9 factors on y-axis, with regression lines in blue.

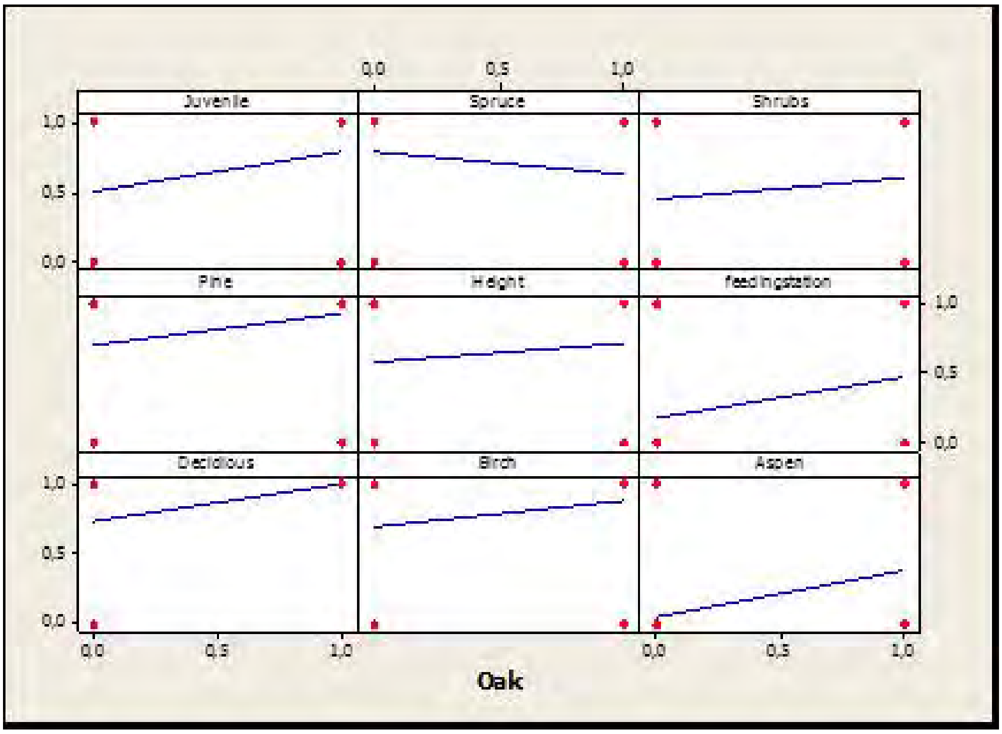

Figure 9. Scatterplots with Oak presence/absence on x-axis versus presence/absence of the other 9 factors on y-axis, with regression lines in blue.

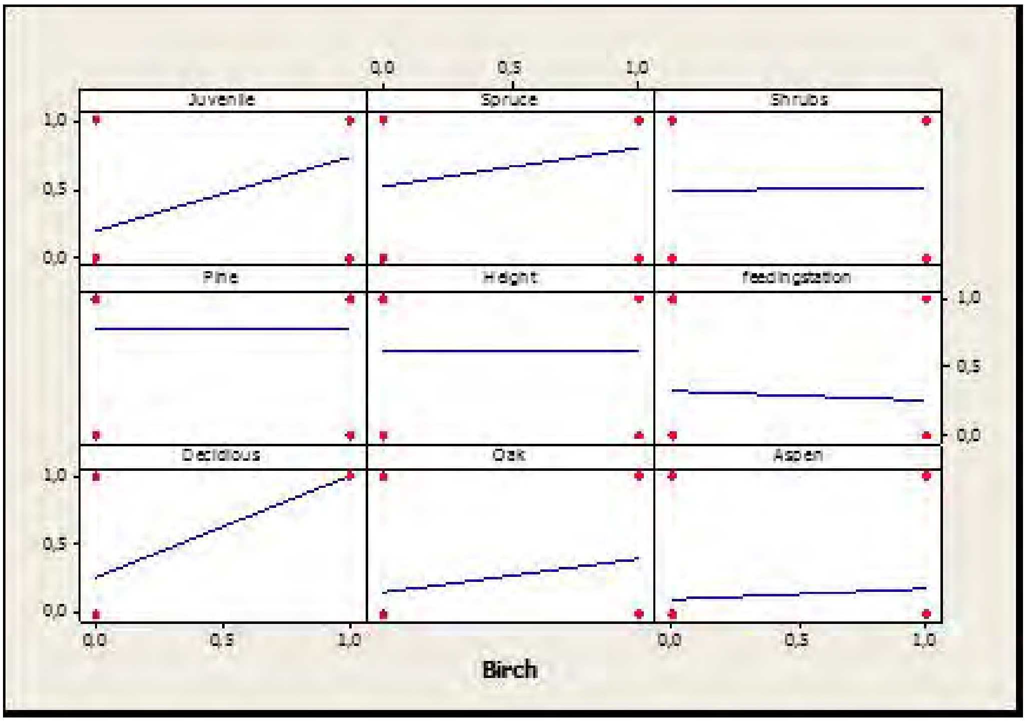

Figure 10. Scatterplots with Birch presence/absence on x-axis versus presence/absence of the other 9 factors on y-axis, with regression lines in blue.

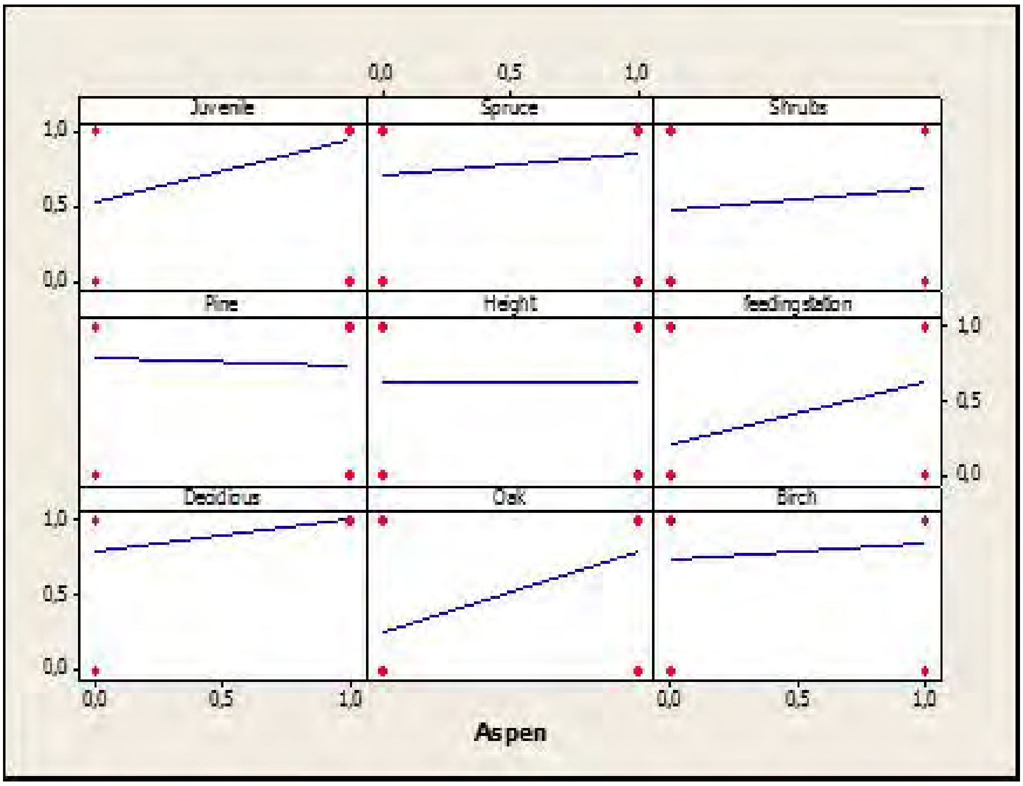

Figure 11. Scatterplots with Aspen presence/absence on x-axis versus presence/absence of the other 9 factors on y-axis, with regression lines in blue.

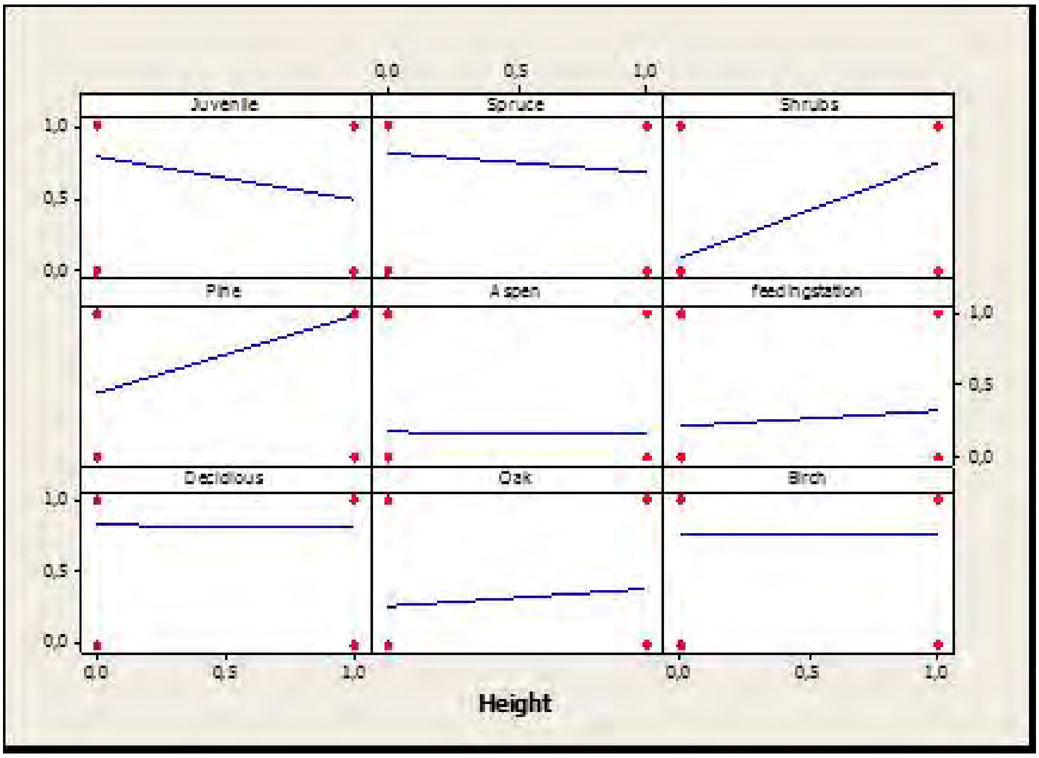

Figure 12. Scatterplots with Height presence/absence on x-axis versus presence/absence of the other 9 factors on y-axis, with regression lines in blue.

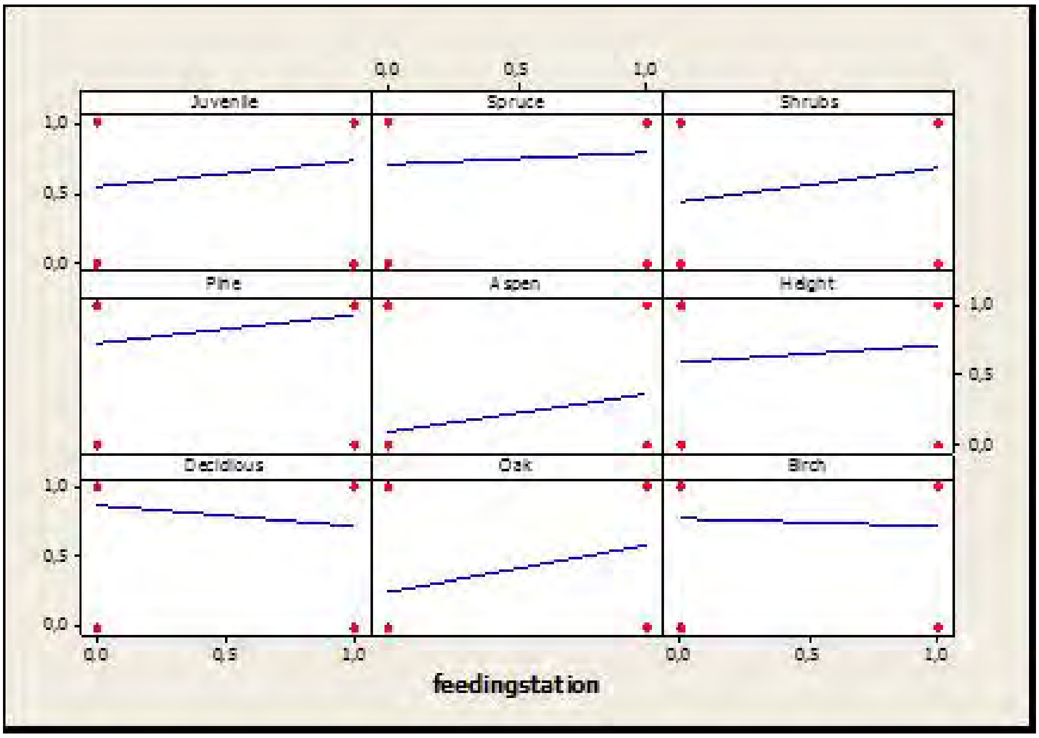

Figure 13. Scatterplots with Feeding-station presence/absence on x-axis versus presence/absence of the other 9 factors on y-axis, with regression lines in blue.

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