EFFECTS OF A POWER LINE ON AREA USE OF SEMI-DOMESTICATED REINDEER (*RANGIFER TARANDUS TARANDUS*)

EFFEKT AV EN KRAFTLEDNING PÅ AREALBRUKEN HOS TAMREIN (*RANGIFER TARANDUS TARANDUS*)

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Preface

This thesis represents the final 30 credits of my Master of Science degree in Natural Resource Management.

I would like to thank the following persons for the accomplishment of this thesis: my supervisor Dr. Jonathan Edward Colman (UMB/UiO), Sindre Eftestøl (UiO), Marte Lilleeng (UMB), Ole Tobias Rannestad and Knut Marius Hauglin (UMB). I would also like to give special thanks to Dr. Vidar Selås (UMB) for statistical help.

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Abstract

Because of extensive use of large areas by reindeer (*Rangifer tarandus*), they are particularly vulnerable towards anthropogenic development that might reduce pasture availability through aversion. As a result of increasing demands for energy as well as political ambitions for more renewable energy, the power grid system in Norway is in continuous expansion and power lines may have substantial aversion effects on reindeer. Possible power line related aversion effects on semi-domesticated reindeer were investigated through pellet group counts during summer and autumn of 2009 in the Essand reindeer herding district in the municipality of Tydal, Norway. This is the first study in the literature to use faecal pellet group counts to study possible effects of power lines on reindeer area use. Indications were found that reindeer avoided the power line. The results were based on both Poisson and logistic regression modeling of reindeer pellet group count data that signified an increase in pellet group counts that were directly related to distance from power line, since multiple variables were included in the models. The distance related increase of pellet group counts with regard to power lines diminished above the tree line. A possible effect of construction work that started on the power line in summer of 2008 likely influenced these results, causing an increase in reindeer aversion towards the power line below the tree line.

Sammendrag

Ettersom rein (*Rangifer tarandus*) bruker store landområder, er de spesielt sårbar overfor antropogen utvikling, fordi dette kan lede til at rein unnviker potensielt verdifulle beiteområder. Økt behov for energi samt politiske målsetninger om å bygge ut mer fornybar energi**,** har ført til at ledningsnettet for overføring av strøm i Norge er under kontinuerlig utbygging. Dette kan føre til utstrakt negativ påvirkning på rein som følge av dyrenes aversjon overfor ledningene. Mulig kraftlednings relatert aversjon hos tamrein ble studert basert på telling av reinmøkk i løpet av sommeren og høsten 2009, i Essand reinbeitedistrikt i Tydal kommune, Norge. Dette representerer det første vitenskapelige studiet som anvender telling av møkk for å undersøke mulige effekter av kraftledninger på reinens arealbruk. Jeg fant indikasjoner på at reinen viste aversjon overfor ledningene. På grunnlag av Poisson- og logistiske regresjonsmodeller av telledata av reinsmøkk og hvor flere variabler var inkludert i modellene, ble det funnet en økning i møkk som direkte var relatert til avstand fra kraftledningen. Denne avstands relaterte effekten avtok over tregrensen. Det er mulig at anleggsarbeidet som startet i 2008 i forbindelse med anlegging av ny kraftledning, kan ha påvirket resultatene i form av økt aversjon hos rein overfor ledningene i områder under tregrensen.

Introduction

Linear features, such as power transmission lines, pipe lines, roads and railroads, crossing animal habitat may have aversion effects or cause stress in animals caused by disturbances associated with the linear object, such as noise or movement from vehicles or people (Wolfe et al., 2000). Such features` visual appearance in the landscape may also influence animal movement if an animal recognizes the feature as an obstacle. For reindeer (*Rangifer tarandus*) residing in open alpine terrain or tundra, power lines may have substantial aversion effects on the animals because of the distinct appearance of such constructions in the scanty landscape.

Reindeer are dependent on vast areas of land for their existence. Their energy demands during winter are met by utilizing areas with moderate precipitation and snow depths where lichens constitute the pasture. This habitat however, is not sufficient for reindeers` nutritional demands. Their growth and survival rely on an annual shift of habitat and the use of more nutrient rich areas during spring, summer and autumn. In early summer, reindeer progressively follow the altitudinal melt-off gradient in alpine terrain grazing on fresh and nutritious plants. In the middle of summer during insect attacks, they are confined to higher altitudes for the relief from insects. At the end of the insect season, lower terrain is used more frequently (Skogland, 1984). During insect attacks in summer, circardian movements between higher altitudes serving as refuge during day, and lower altitudes where food quality is higher, has been documented (Skarin et al., 2010).

Because of this extensive movement and use of land by reindeer, these animals are particularly vulnerable towards anthropogenic development that might reduce pasture availability or quality, disturb the animals and reduce optimal grazing, or that constitute a hindrance for their movement within a region (Flydal et al, 2004). Such developments might in the worst case cause reindeer to completely abandon grazing lands. This may lead to effects on population dynamics of the species, because of a lowered ecological carrying capacity of the suboptimal area that they are restrained to, and thereby reduced general condition and weight of the animals (Skogland, 1990; Skogland, 1994; Colman, 2000).

As a result of increasing demands of energy as well as political ambitions for more renewable energy, the power grid system in Norway is in continuous expansion. By 2004, there were almost 30000 km of high voltage (>33kV) power lines in the country, many of which cross mountain regions inhabited by wild or semi-domestic reindeer (Flydal et al., 2009). Knowledge on the potential effects these constructions might have on reindeer is lacking. Although many studies have been carried out, the results vary greatly. Some studies conclude that power lines have not had negative effects on reindeers` use of grazing lands or migration patterns in their study areas (Reimers et al., 2007), while other studies have reported negative effects up to several kilometers away from the actual line in question (Nellemann et al., 2001; Nellemann et al., 2003; Vistnes & Nellemann, 2001; Vistnes et al., 2001, 2004).

Two different methodical approaches have been employed in the study of anthropogenic development and its potential disturbance on reindeer: (1) direct observations that are based on observations of animal behavior and/or physiological response of individual groups of animals to disturbances, and (2) indirect observations that consist of regional or population-level observations of animals, or indices of range use or their demography that may suggest avoidance of some areas and increased use of remaining areas (Reimers & Colman, 2006). When applying the direct observation method, general behavioral changes in terms of avoidance are identified, or reactions of flight, fright, restless behavior or physiological responses are measured. In this method, the observer may have the advantage of control on environmental variables. However, this method provides little information on the animals' past experience or acquired behavior. Also, it may be difficult to reveal clear results when correlations exist between variables, or if sample size is too small (Reimers & Colman 2006).

Indirect observations refer to identification of animal distribution and area use by measuring range properties such as lichen cover and/or height or faecal pellet group counts, and test these data within increasing distance zones from infrastructure. In the lichen approach, lichen cover and height is assumed to directly reflect grazing pressure from reindeer. The weakness of the lichen approach lays in its demands of painstaking knowledge on environmental variables that influence movement patterns or range use by reindeer, as well as knowledge on lichen ecology (Reimers & Colman 2006). Conclusions drawn by Dahle et al. (2008) from their study on reindeer avoidance of a highway, pinpoints the possible pitfalls when using lichen cover and height as a measure of grazing pressure by reindeer when not taking into account important environmental factors that affect lichen biomass, such as precipitation, exposure and snow cover. The lack of consistency between results from different studies on reindeer and possible affects of anthropogenic features may be explained by the shortcomings of the methods used.

The primary purpose of this study was to investigate whether power lines affect reindeer area use by employing the method of faecal pellet group counts (Campbell et al., 2004). Reindeer habitat selection studies have been carried out using this method (Helle & Sarkela, 1993; Quayle & Kershaw 1996; Teterukovskiy & Edenius, 2003; Skarin et al. 2004), but this method has never before been used to study possible effects of power lines on reindeer area use. Avoidance of infrastructure development has frequently been associated with changes in reindeer distribution (Bradshaw et al., 1997; Dyer et al., 2001; Nellemann et al., 2001; Nellemann et al., 2003; Vistnes & Nellemann, 2001; Vistnes et al., 2001, 2004; Wolfe et al., 2000). Infrastructure is likely associated with hunting by humans (Dau & Cameron, 1986; Frid & Dill, 2002) and avoidance to reduce exposure to stress or hunting primarily takes place if alternative habitat is available, even if inferior (Gill et al., 2001). On this basis, I expected reindeer avoidance of areas close to power lines. My first hypothesis is therefore:

1. *The power line will have an aversion effect on reindeer that should be reflected by an increase in reindeer pellet groups with increasing distance from the power line.*

I also expected reindeer gain of altitude to have an easing effect on aversion towards power lines. As already mentioned, high altitude terrain might provide fresh and nutritious plants as well as insect relief. But increased elevation may also generate a buffer effect towards power lines, as there is usually an increase of horizontal distance to power lines with increasing altitude. Additionally, open terrain at higher altitudes may be perceived by the animal as more controllable with regard to spotting of potential danger. High elevations above the tree line have been shown as preferred for calving caribou, serving as an enlarged buffer against predators in the valley below (Bergerud & Page 1987). Bearing in mind that both predation and nonlethal disturbance stimuli such as power lines create similar effects of avoidance (Frid & Dill 2002), my second hypothesis is therefore:

2. *Potential aversion effects of power lines on reindeer may diminish or completely cease above the tree line, which should be reflected by insignificant changes in number of reindeer pellet group counts with increasing distance from the power line in terrain above the tree line.*

A possible aversion effect of the power line on reindeer may however not only be caused by the power line itself. It is likely that construction work on the power line during and before our field surveys would contribute to a possible aversion effect. Therefore, and because this study was conducted during the construction period, the time span and scope of this study inhibits a separation of the power line itself and the construction activities associated with it. Thus, for both of my hypotheses, a possible aversion by reindeer would be the combined effect caused by the power line infrastructure itself together with the potential effects caused by the construction work.

The results from my methodical approach (faecal pellet group counts) may hopefully contribute to a better understanding of if /and how reindeer are affected by power transmission lines, as well as anthropogenic development in general.

Methods

Study area

Fieldwork was conducted within a 10 km radius of the northern end of Lake Essand (from here after Essandsjøen) in the municipality of Tydal in Sør-Trøndelag, Norway (Fig.1). The studied area covered roughly 140 km^2, with its centre located at Sankåvika bay (63°7'N; 11°54'E) of Essandsjøen (Fig.1). This area was situated within spring, summer and autumn grazing lands for the Essand reindeer herding district. Reindeer are both herded through the area on spring and fall migrations and graze freely here from April to October.

The region was within low alpine and middle alpine zones, and altitude of the studied area ranged from 733 m.s.a.l. (the altitude of Essandsjøen), to 1251 m.a.s.l. at the summit of Øfjellet. Best estimates of local weather parameters for the years 1961-1990 were as follows: annual precipitation of 850 mm based on data from Aunet weather station (63° 3'N; 11° 34'E), mean temperature in July at 11.4 °C based on data from Røros weather station (62° 34'N ; 11° 21' E) (eKlima, Norwegian Meteorological Institute, 2011).

A new and an old power line that extended parallel to each other crossed through the study area and ran alongside a road from Essandsjøen and westwards. These power lines stretched from Järpströmmen in Sweden to Nea in Norway. The older 300 kV power line was built in the 1950s. Building of the new 420 kV power line started summer 2008 and was completed in autumn of 2009 (Statnett, 2011). Road traffic in the study area is open only upon payment at a gate lower in the valley, and therefore remains relatively low. Use of the road is mostly by people working for Statnett (Norway's national power grid company), reindeer- and sheep herders, people that own and/or use buildings/cabins in the area and some tourists. Buildings in the area encompass for the most part smaller huts, but also a few private cabins along the length of the road and one tourist cabin at the end of the road with rooms for overnight guests. Private cabins in the study area are mostly found near the Sankåvika bay at the northwest end of Essandsjøen, while the tourist cabin is located about 3 km further east at Storerikvollen, also nearby the shore of Essandsjøen. Thus, buildings built to house people are mostly located at lower altitudes near Essandsjøen in areas partly covered with forest, making them less visible. Only a few buildings in the study area are found in open terrain constituting only smaller huts, some of which are used by reindeer herdsmen.

Vegetation is dominated by heaths and grass heaths that are dispersed along a rather wide altitudinal range up to about 950 m.a.s.l. Mires also constitute a considerable part of the vegetation in the area, while birch forest is frequent at lower altitude around Essandsjøen.

Reindeer pellet group counts

Faecal pellet group counts have widely been used to study relative animal abundance and habitat selection of ungulates. The two basic approaches of pellet group counts are FSC method (faecal standing crop), and FAR method (faecal accumulation rate) (Campbell et al., 2004). In the FSC method, pellet groups are counted on first visit to a plot. By this method, count numbers reflect longer term accumulation of pellet groups, limited by the decay rate of pellets. In the FAR method, countings are performed at plots that have previously been cleared of pellets.

Counts were first carried out in early summer of 2009, between 24th of June and 7th of July, and then again between 25th and 27th of September the same year. Plots were cleared of pellets after the first visit. Thus, reindeer pellet group counts from early summer represents FSC data, while recounts from autumn represents FAR data. Because of snowy weather during the autumn survey period, only 496 of all 644 plots were recounted.

Square grids on a Norwegian map of the M711 series were used as the basis for systematic and random distribution of pellet group count plots in the terrain (Fig. 1). Plots were selected every 200 meters along the vertical and horizontal 1 km grid lines.

Using a handheld GPS, a wooden stick was placed in the ground upon the first visit to the plot, representing the plots center position. A piece of rope 2.52 m long attached to the end of the wooden stick was then used to outline the 20 m^2 circle plot sampled.

As reindeer often move when defecating, pellets from a single pellet group may either be spread over a larger area or be separated in smaller groups. When more than 10 pellets with same features (coloration, size and shape) were found within the boundaries of the plot, it was defined as a single pellet group. The number of pellet groups was counted and vegetation types were register for each plot.

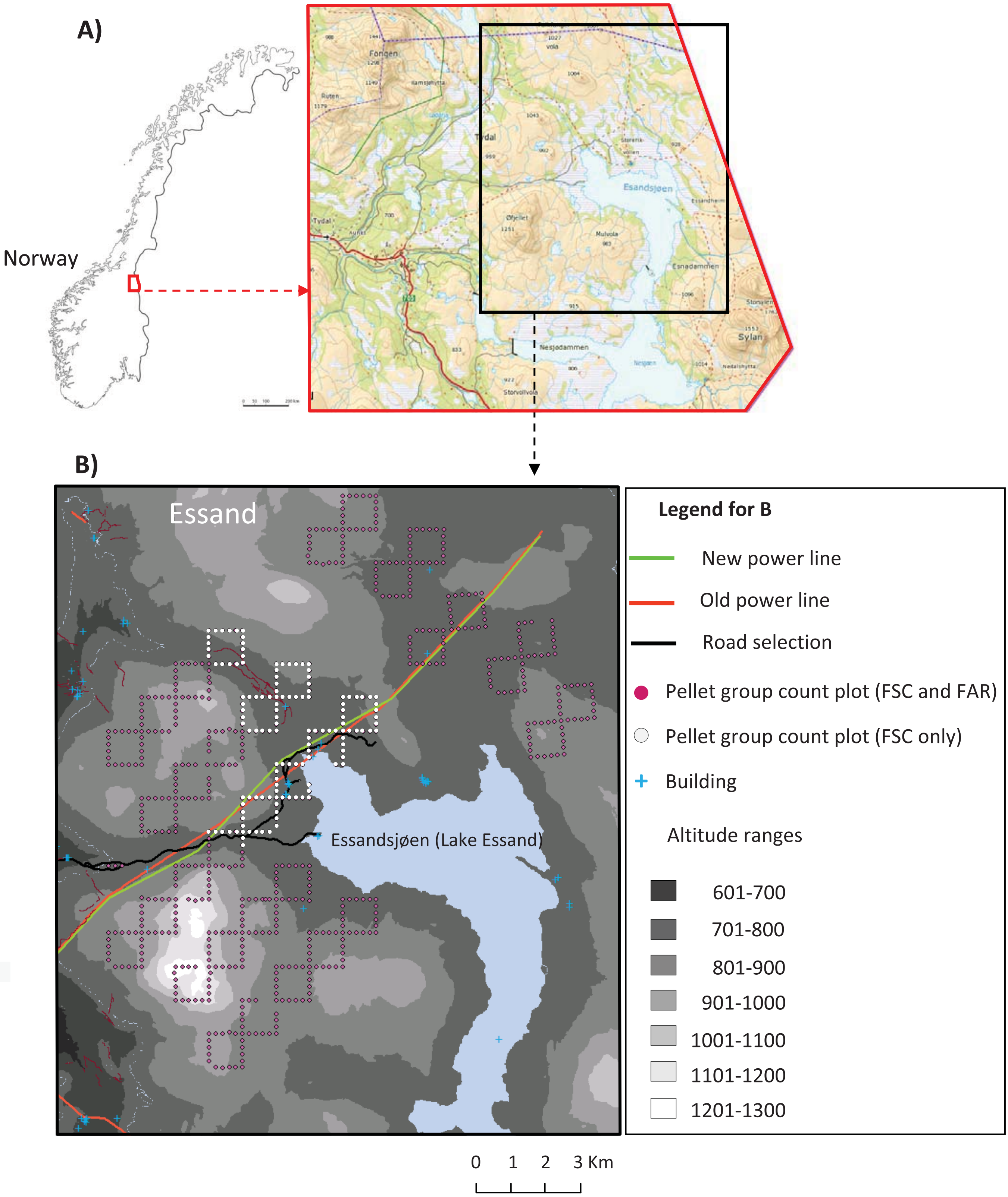


Figure. 1 **A**. The study area Essand (outlined in black) located in Tydal (outlined in red), close to the Norwegian – Swedish national border. **B.** The study area, shown with altitude ranges, power lines, road, reindeer pellet group count plots and buildings (key to symbols at right).

Data Variables

All spatial data were handled with Arcgis 9.3™ software (Environmental Systems Research Institute, Redlands, CA). Digital maps were provided by the Norwegian Mapping Authority (NMA) in August 2010.

Distance

The Arcgis software provided distance from the center of each surveyed plot to the nearest road, building or power line. I did not discriminate between the new and old power line, and the distance between a given plot and power line was a measure of the length between the plot and the nearest of the two lines. This simplification was justified since both lines mainly follow the same pathway in a parallel manner. The reliability of the simplification was also examined by separately introducing distance to old and distance to new power line into a Poisson regression model, revealing p-values virtually alike. A road selection was performed in Arcgis, omitting roads that were regarded as not having an effect on reindeer, owing to low altitudinal positioning.

Altitude

Measurements of altitude were generated from a digital elevation model. Altitude of surveyed plots differed from 733 to 1243 m.a.s.l., with a mean altitude of 845 and a median of 828.

Vegetation

Vegetation was observed on first visit to a plot, and classified according to Satelitte based vegetation maps for Norway (Johansen et al., 2009). Fifteen different vegetation classes were identified. Based on common attributes, classes were further assigned to one of seven superior vegetation types with the following designations: Forest, Mire, Wet mire, Rocky, Ridge crest, Lee side and Snow bed (Appendix 1). Lee side constituted the vegetation of 45% of all FSC counted plots (644), and this vegetation was therefore the most common type. The remaining plots were constituted by Mire (20%), Forest (13 %), Ridge crest (8%), Snow bed (6%), Rocky (4%) and Wet mire (4%) (Fig. 5). Percent distribution of vegetation types among FAR counted plots were roughly equal to that of FSC counted plots, with the largest deviation seen for the vegetation type Forest, with a 4% lower occurrence in FAR counted plots as compared to that found in FCS counted plots (Fig. 5). Plots with Forest type vegetation were registered up to 850 m.a.s.l., and this altitude therefore was defined as the tree line for the study area.

Lee side defined plots were mainly found between 750 and 950 m.s.a.l. Mire and Wet mire were primarily found below the tree line, while Ridge crest, Rocky and Snow bed defined plots were mainly found above the tree line (Fig. 2). Percent contribution of different vegetation types at inventory plots, beneath and above the tree line within increasing distance intervals from the power line, was as shown in Table 1.

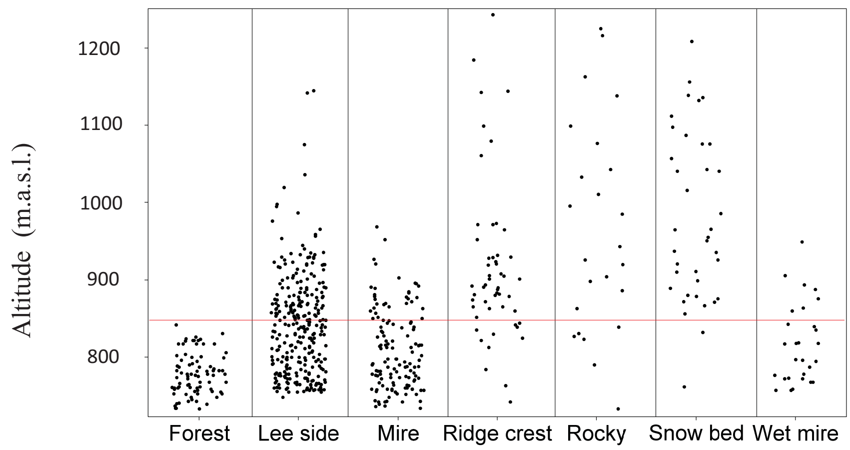


Figure 2. Distribution of plots within each vegetation type in relation to altitude. Each dot represents a single examined plot. The red line indicated the tree line.

Table 1. Percent contribution of different vegetation types at inventory plots, beneath (733-850 m.s.a.l.) and above (851-1243 m.s.a.l.) the tree line within increasing distance intervals from the power line.

		Distance intervalls (m)				
Altitude interval	Vegetation type	0-1000	1001-2000	2001-3000	3001-4000	>4000
733-850 (m.s.a.l).	Forest	26.3	20.0	15.9	11.6	23.2
	Lee side	41.9	52.9	44.9	36.5	34.8
	Mire	24.8	17.1	30.4	34.6	29.0
	Rocky	1.5	0.0	0.0	5.8	1.5
	Ridge crest	1.6	1.4	1.5	3.8	7.2
	Snow bed	0.8	0.0	0.0	0.0	1.4
	Wet mire	3.1	8.6	7.3	7.7	2.9
	Tot.no. of plots	*129*	*70*	*69*	*52*	*69*
851-1243 (m.s.a.l.)	Forest	0.0	0.0	0.0	0.0	0.0
	Lee side	58.6	50.0	45.7	40.0	53.9
	Mire	0.0	12.0	5.7	18.5	11.8
	Rocky	10.3	6.0	8.6	10.8	2.7
	Ridge crest	24.2	24.0	14.3	13.8	10.5
	Snow bed	6.9	4.0	25.7	13.8	17.2
	Wet mire	0.0	4.0	0.0	3.1	3.9
	Tot.no. of plots	*29*	*50*	*35*	*65*	*76*

Statistical analysis

The counted pellet group data in FSC- and FAR data revealed one tailed distributions suspecting a Poisson type of distribution of pellet group counts (Fig. 3). If the Poisson assumption were true, then the variance of the number of pellet groups should be roughly equal to the mean number of pellet groups. However, the FSC- and FAR counts showed variance to mean ratio being 2.29 and 1.38 respectively, thus indicating overdispersion. This overdispersion was adjusted for when applying Poisson regression analysis in JMP® 8 Software (SAS Institute Inc) by check markings for overdispersion. Overdispersion was thereby accounted for using a quasi–likelihood method with the introduction of an overdispersion factor ”phi” (computed with Pearson scale as □= Pearson chi-square / degrees of freedom). For both FSC and FAR counts, the over dispersion factor was well below 10, which generally is regarded as the uppermost acceptable value (Schwarz, 2011).

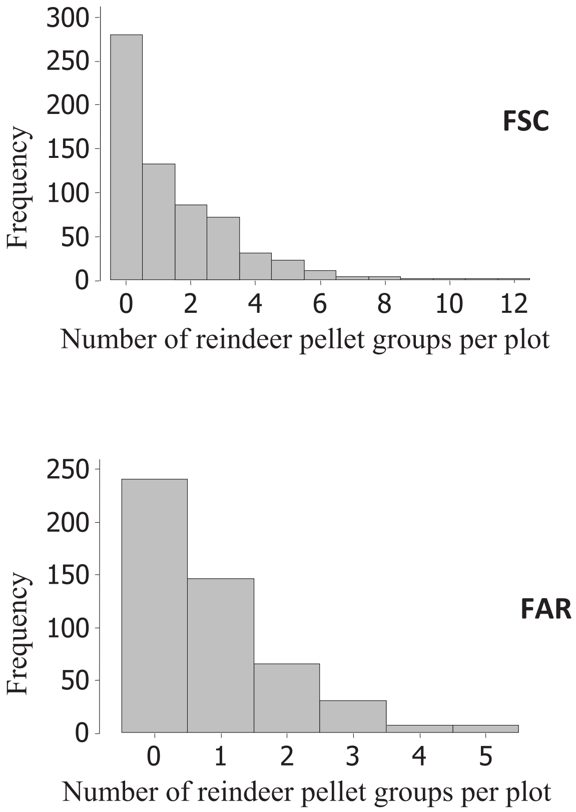


Figure 3. Distribution of the response variable: number of reindeer pellet groups per plot, from FSC and FAR counts.

Three different modeling approaches (Table 2) for FSC and FAR data were carried out in JMP software.

Modeling 1

In the first approach, a generalized linear model was selected, specifying distribution as Poisson and log as link function. Both FSC and FAR datasets were used. The number of reindeer pellet groups per plot was used as the response variable. The explanatory variables tested in the model were: Distance to power line, distance to road, distance to building, altitude (m.a.s.l.) and vegetation type. The null hypothesis states that neither of the input variables explains the spatial distribution of pellet group counts when employing a significance level of 5%. A final accepted model was approached by stepwise removal of the explanatory variable showing the highest non significant P-value, followed by rerunning of the model. The model was accepted when all explanatory variables had P-values less than 0.05.

Modeling 2

In this approach, plot content was assigned as nominal data with the differentiation between plots deficient of pellet groups and plots containing one or more pellet groups. Both FSC and FAR datasets were used. Logistic regression was then applied using the same explanatory variables that were employed in the first modeling approach (above), and with plots positive or negative of pellet groups as the response variable. The model was accepted when all explanatory variables had a P-value less than 0.05.

Modeling 3

Modeling 3 was conducted using Poisson regression as in modeling 1, but only with the FSC dataset. The same explanatory variables employed in the two other modeling approaches were also used here. Additional variables added in to this model were tree line and [tree line * distance to power line], with the latter signifying the interactive effect of the nominal variable tree line (being either altitude interval above or beneath the tree line) and distance to power line. Again, the model was accepted when all explanatory variables had a P-value less than 0.05.

Table 2. Two modeling approaches (modeling 1 and modeling 2) utilized in analyzing possible relationship between reindeer pellet group distribution and distance to power line, and a third modeling approach (Modeling 3) used for analyzing possible interactive effects of variables tree line and distance to power line on reindeer pellet group distribution.

	Modeling 1	Modeling 2	Modeling 3
Regression type	Linear - Poisson	Nominal Logistic	Linear - Poisson
Dataset	FSC / FAR	FSC / FAR	FSC
Respons variable	Number of pellet groups per plot	Plots positive or negative of pellet groups	Number of pellet groups per plot
Explanatory variable	Distance to power line	Distance to power line	Distance to power line
	Distance to road	Distance to road	Distance to road
	Distance to building	Distance to building	Distance to building
	Altitude	Altitude	Altitude
	Vegetation type	Vegetation type	Vegetation type
			Tree line - above or beneath
			Tree line * Distance to power line

Results

Reindeer pellet group counts in relation to distance to power line, altitude, road, and buildings

The mean number of pellet groups per plot (20 m^2) was 1.41 in FSC and 0.86 in FAR counts. A lower number of counts in FAR compared to FCS was expected. Pellets group counts showed a one tailed distribution with number of counts per plot in the range of 0-12 and 0-5 for FSC and FAR counts, respectively (see Appendix 2.1 and Appendix. 2.2 for scatterplots).

Both the FSC and FAR data revealed increasing probability of plots to contain pellet groups with increasing distance from the power line(s), and with increasing elevation (Fig 4). The probability of plots containing pellet groups also increased with increasing distance from road and buildings. There was one exception; FAR data showed an increasing probability of plots to contain pellet groups with declining distance from the road.

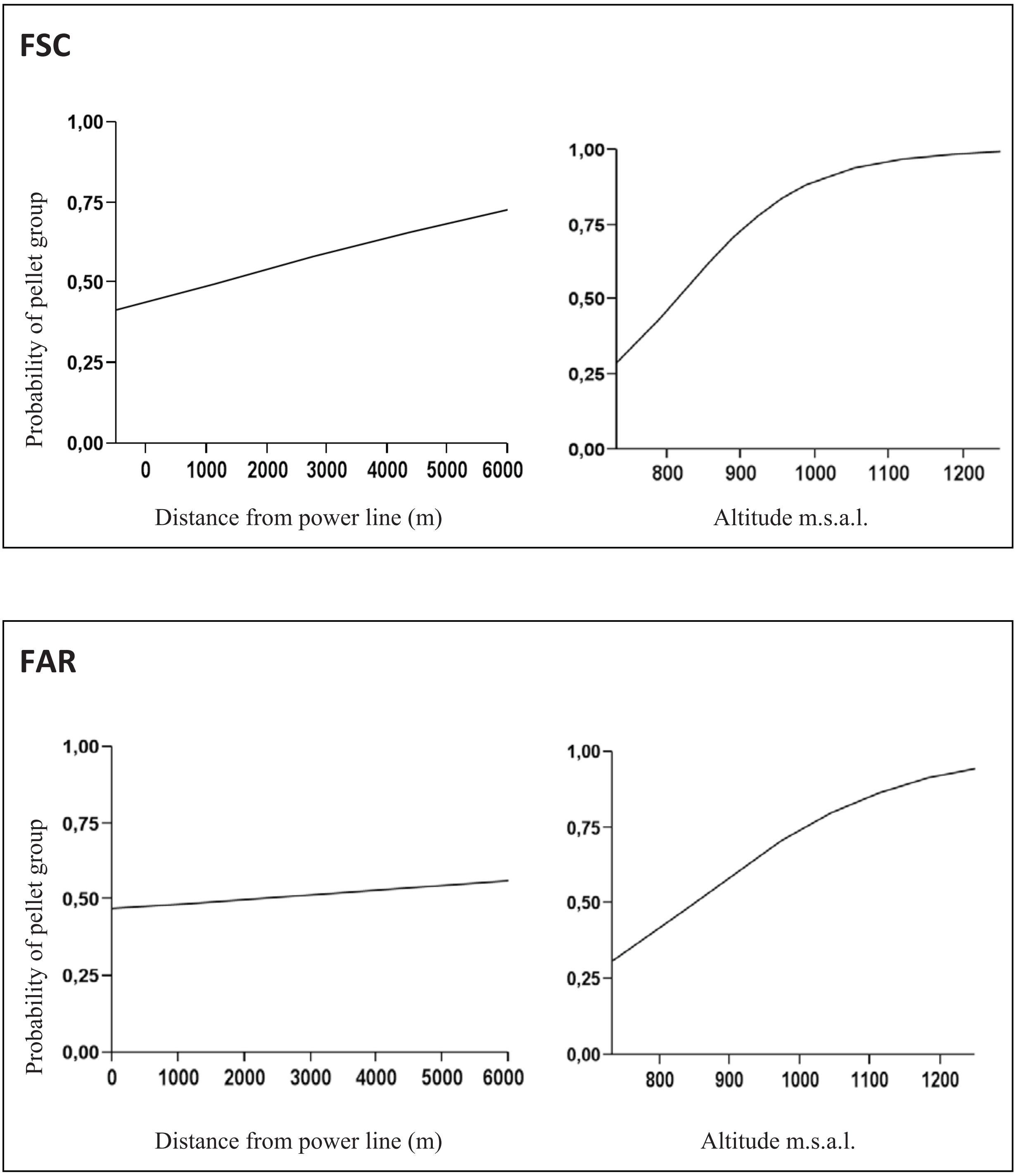


Figure. 4 From FSC and FAR data: probability of plots containing reindeer pellet group with increasing distance from power line and with increasing altitude .

Reindeer pellet group counts in distinct vegetation types

From FSC counts, I found overrepresentation of pellet groups in the following vegetation types: Ridge crest (2.2), Snow bed (1.9) and Lee side (1.2), with numbers in brackets representing the division {percent of pellet groups found in that vegetation type} / {percent availability of that vegetation type}. Pellet groups were underrepresented in Rocky vegetation (0.9), Forest (0.4), Mire (0.3) and Wet mire (1.1). FAR counts revealed very similar distribution of pellet groups within available vegetation types. Also here I found overrepresentation of pellet groups in Snow beds (1.9), Ridge crest (1.5) and Lee side (1.2) (Fig. 5).

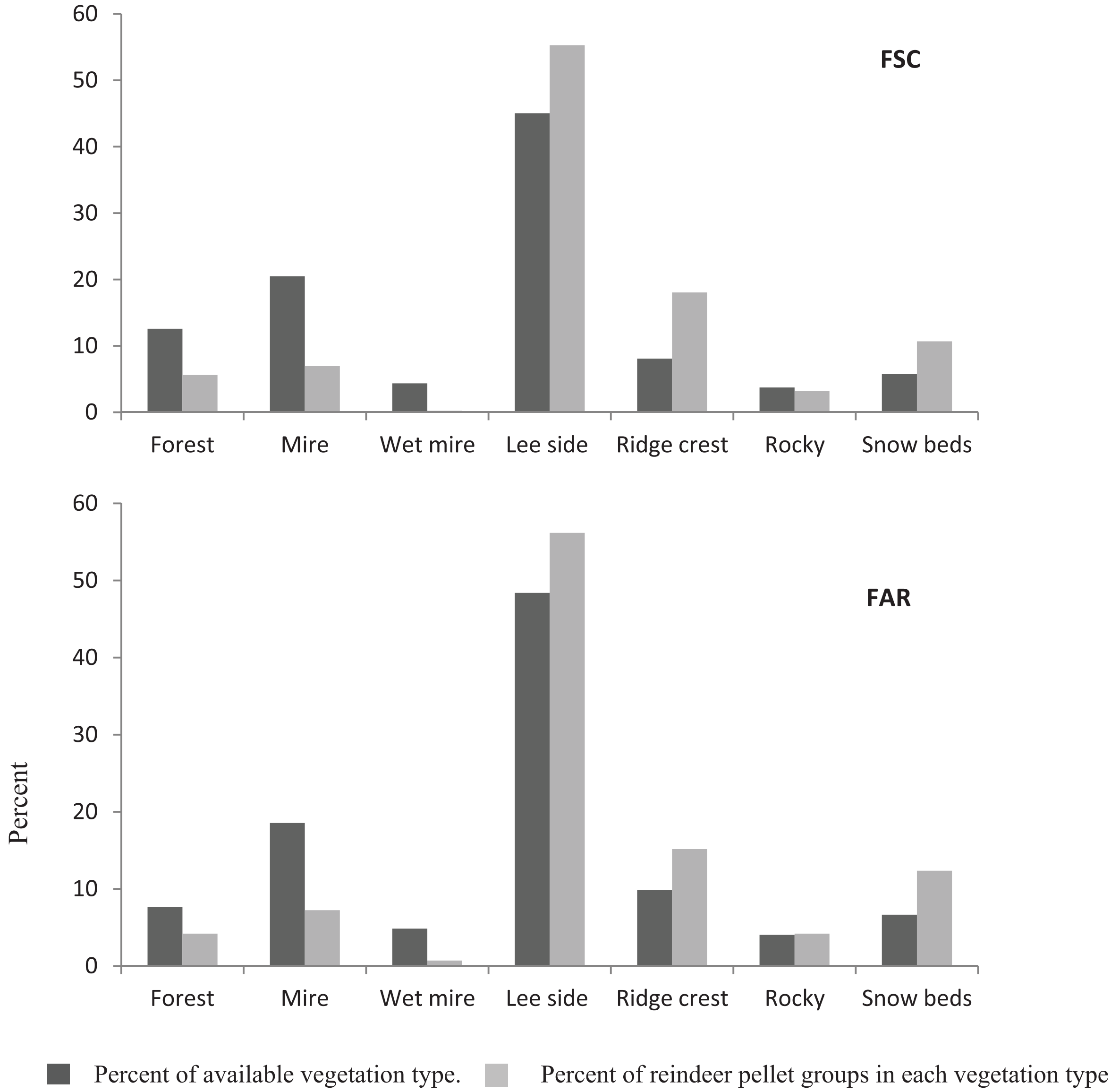


Figure 5. Percent available vegetation type and percent of total reindeer pellet groups in each vegetation type from FSC and FAR counts.

Reindeer pellet group counts in distinct altitude intervals

Within three distinct altitude ranges; low:{733-850}, middle:{851-950} and high:{951-1243}, I found pellet groups to be underrepresented in low ranges and overrepresented in middle and high ranges (Fig. 6).

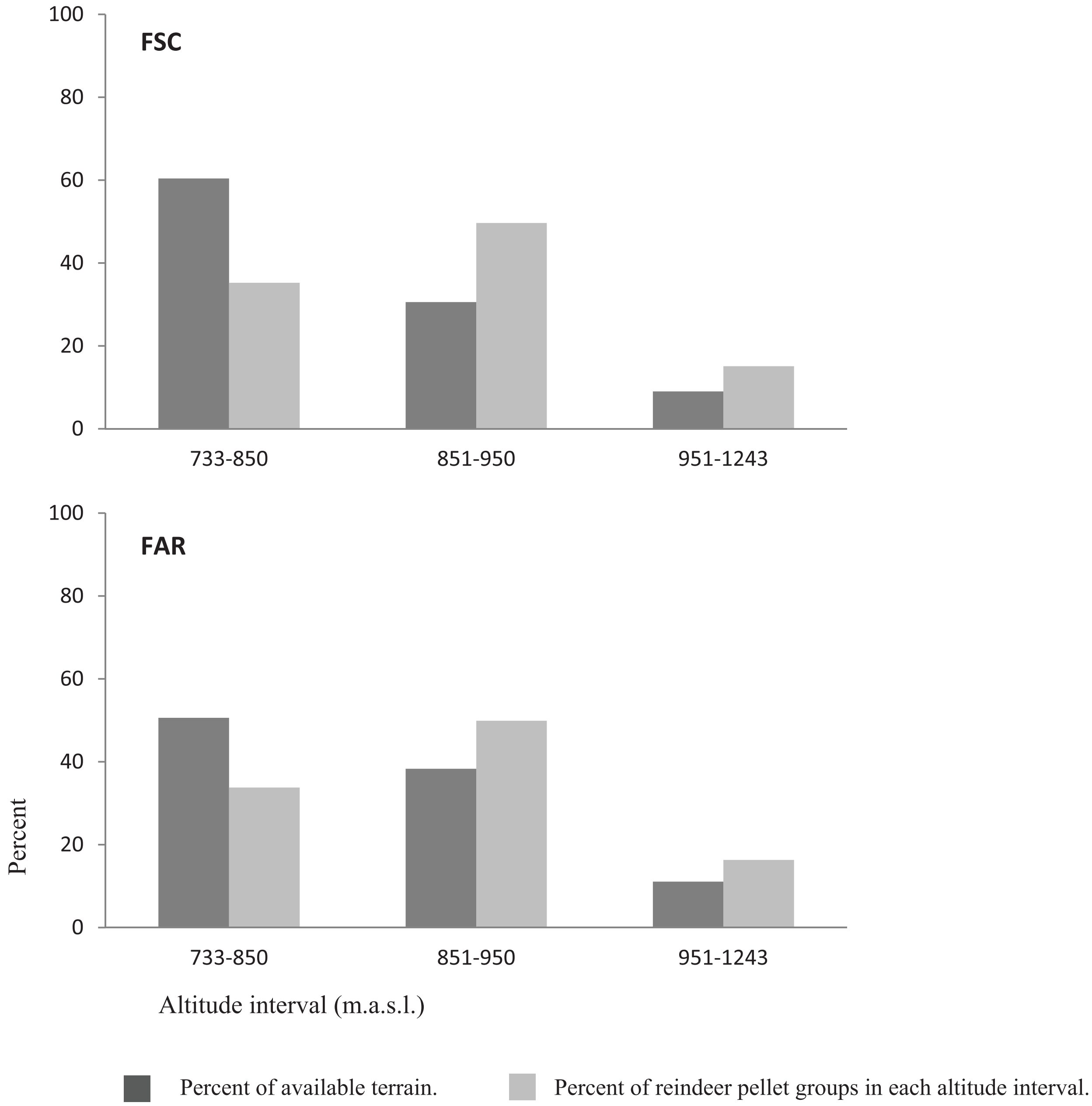


Figure 6. Percent of available terrain within three different altitude intervals; 733-850 (beneath the tree line) and 851-950 / 951-1243 m.a.s.l (above the tree line), and percent of total reindeer pellet groups from FSC and FAR counts, respectively.

Reindeer pellet group counts in relation to distance to power line, beneath and above the tree line

Analysis of FSC data showing increasing probability of plots to contain pellet groups with increasing distance from the power line(s), were confined to the altitude interval below the tree line, where percent of plots containing pellet groups increased from 32 to 54 between distance intervals up to 3000 meters. Above the tree line, percent of plots containing pellet groups within increasing distance intervals from power line did not change markedly. Also, percent of plots containing pellet groups were distinctly higher above the tree line, with four out of five distance intervals having values close to 80 percent, which was considerably higher than for distance intervals below the tree line (Fig. 7). This is in agreement with the results showing an average number of pellet groups per plot under the tree line of less than one, as opposed to an average of more than two above the tree line (Fig. 8).

Furthermore, I only found an increase in average number of pellet groups per plot when comparing altitude interval 733-850 and 851-950 m.s.a.l. Above the tree line, there was no clear change in the average number of pellet groups per plot between the two altitude intervals 851-950 and 951-1243 m.a.s.l (Fig. 8).

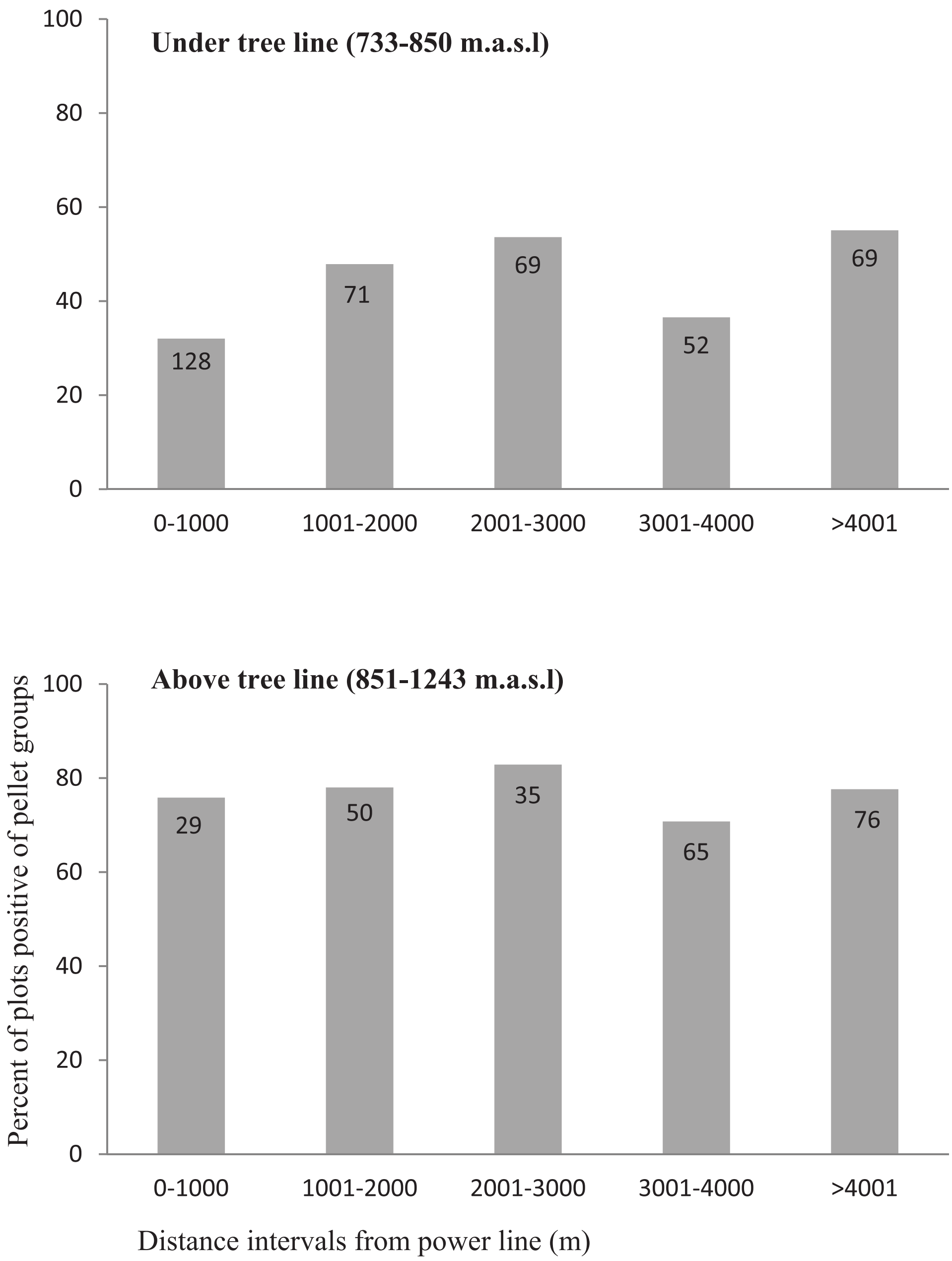


Figure 7. From FSC data: percent of plots containing one or more reindeer pellet groups with increasing distance from power line, beneath and above the tree line (850 m.a.s.l.). Total number of plots in each distance interval are indicated in upper part of each column.

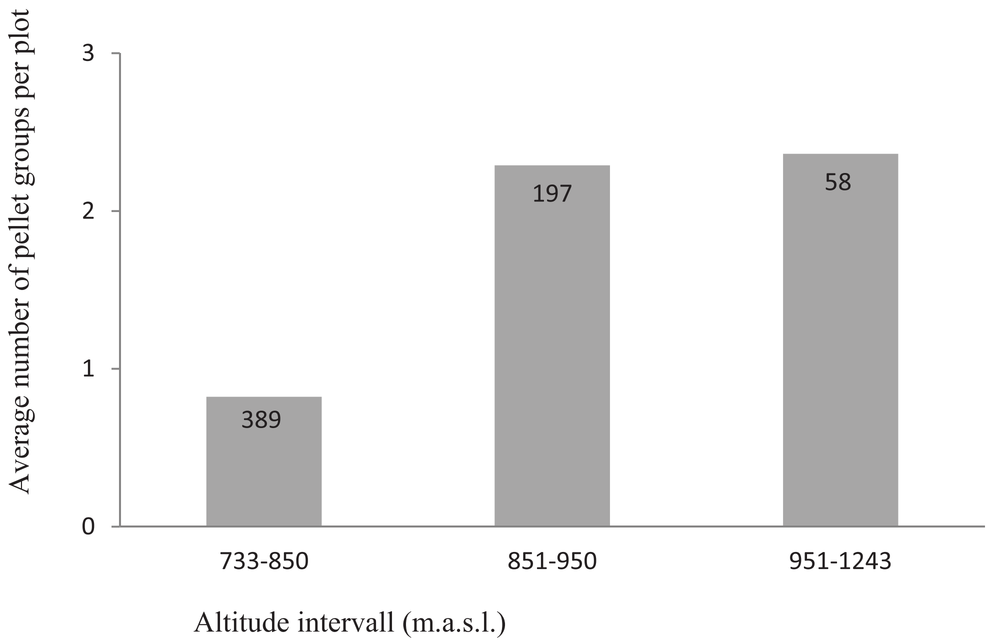


Figure 8. From FSC data; average number of reindeer pellet groups per plot under the tree line (altitude interval 733-850), and above the tree line (altitude interval 851-950 and 951-1243 m.a.s.l). Total number of plots in each altitude interval are indicated in upper part of each column.

Regression modeling

Modeling 1

In the first modeling approach; modeling 1, with pellet group distribution specified as Poisson, the accepted model for FSC counts held vegetation type, altitude (+) and distance to power line (+) as explanatory variables, with plus in parenthesis signifying a positive relationship between number of pellet groups and the variable (Table 3). Hence, the accepted model for FSC counts states an increase in number of pellet groups at higher altitude and with increasing distance from the power line, and also reveals a strong relationship between number of pellet groups and vegetation type. However, by virtue of vegetation type defined as a nominal variable, no direction of relationship can be ruled out, as with the continuous variables altitude and distance to power line. As shown by the dispersion factor, the model displayed an overdispersion of 1.79.

The accepted model for FAR counts held vegetation type, distance to road (-), distance to building (+) and distance to power line (+) as explanatory variables (Table 3). Thus, the accepted model for FAR counts states an increase in number of reindeer pellet groups with decreasing distance to road, and with increasing distance from buildings and the power line. Over-dispersion factor in the FAR model was 1.20.

Table 3. Modeling 1: parameter estimates of accepted models for FSC and FAR counts when specifying reindeer pellet group distribution as Poisson.

FSC

Term	DF	Estimate	Standard error	LR Chi-Square	Prob>ChiSq
Intercept		-2.09367	0.49572	17.65	<0.0001
Distance to power line	1	0.00007	0.00003	6.43	0.0112
Altitude	1	0.00199	0.00052	13.53	0.0002
Vegetation type	6			136.01	<0.0001

FAR

Term	DF	Estimate	Std Error	L-R ChiSquare	Prob>ChiSq
Intercept		-0.62846	0.18002	13.42	0.0002
Distance to road	1	-0.00016	0.00005	12.06	0.0005
Distance to building	1	0.00018	0.00007	7.57	0.0059
Distance to power line	1	0.00010	0.00005	4.38	0.0364
Vegetation type	6			63.17	<0.0001

Modeling 2

For modeling when employing logistic regression with the differentiation between plots deficient of pellet groups and plots containing one or more pellet groups, the accepted model for FSC counts held vegetation type, altitude (+) and distance to power line (+) as explanatory variables (Table 4). Thus, the model reveals a strong relationship between number of pellet groups and vegetation type. Further, the model states an increasing likelihood of finding plots containing pellet groups at higher altitudes and with increasing distance from the power line.

The accepted model for FAR counts when utilizing logistic regression held vegetation type, altitude (+), distance to power line (+), and distance to road (-) as explanatory variables (Table 4). So this model declares a strong relationship between number of reindeer pellet groups and vegetation type, and states an increasing likelihood of finding plots containing pellet groups at higher altitudes and with greater distance from the power line, but a decreasing likelihood of finding plots containing pellet groups with increasing distance from the road.

In summary, both Poisson and Logistic modeling approaches showed a positive relationship between increasing distance from power line and occurrence of reindeer pellet groups, and this applies for FSC data as well as FAR data.

Table 4. Modeling 2: parameter estimates of accepted models for FSC and FAR counts when differentiating between plots deficient of reindeer pellet groups and plots containing one or more pellet groups.

FSC

Term	DF	Estimate	Standard error	LR Chi-Square	Prob>ChiSq
Intercept		-7.11097	1.46454		
Distance to power line	1	0.00023	0.00007	9.87	0.0017
Altitude	1	0.00830	0.00177	25.88	<0.0001
Vegetation type	6			109.50	<0.0001

FAR

Term	DF	Estimate	Standard error	LR Chi-Square	Prob>ChiSq
Intercept		-4.22248	1.41100		
Distance to road	1	-0.00015	0.00007	4.77	0.0290
Distance to power line	1	0.00015	0.00008	3.88	0.0488
Altitude	1	0.00472	0.00156	9.94	0.0016
Vegetation type	6			48.69	<0.0001

Modeling 3

In modeling 3, with pellet group distribution specified as Poisson and with the same variables as used in modeling 1, but with the addition of variables tree line and [tree line * distance to power line], the accepted model for FSC counts held vegetation type, tree line and [tree line * distance to power line] as explanatory variables (Table 5). The model reveals a strong relationship between number of pellet groups and vegetation type. The model also states a strong positive relationship between pellet group counts and location shift from beneath to above the tree line. Furthermore the model reveals that the relationship between pellet group counts and distance to power line is dependent on whether pellet group count plots are beneath or above three line. Overdispersion factor in the model was 1.74.

To account for possible weaknesses in the regression models caused by correlations between variables, correlation analyses were preformed (Table 6).

Table 5. Modeling 3: parameter estimates of model for FSC counts when specifying reindeer pellet group distribution as Poisson, and with inclusion of variables tree line and [tree line * distance to power line].

FSC

Term	DF	Estimate	Standard error	LR Chi-Square	Prob>ChiSq
Intercept		-0.28864	0.16518	3.9261723	0.0475
Distance to power line	1	0.00006	0.00003	3.48	0.062
Vegetation type	6			111.42	<0.0001
Tree line 850 m.a.s.l	1	0.33452	0.05278	41.61	<0.0001
[tree line * distance to power line]	1	-0.00006	0.00003	4.53	0.0333

Table 6. Correlation in FSC and FAR data between continuous variables used in Poisson and logistic models. Correlation coefficients are shown with gray background. P-values are shown with blank background.

FSC

	Number of pellet groups	Distance to road	Distance to building	Distance to power line	Altitude
Number of pellet groups		0.030	0.150	0.134	0.333
Distance to road	0.453		0.613	0.646	0.055
Distance to building	<0.00	<0.00		0.579	0.385
Distance to power line	0.001	<0.00	<0.00		0.238
Altitude	<0.00	0.166	<0.00	<0.00	

FAR

	Number of pellet groups	Distance to road	Distance to building	Distance to power line	Altitude
Number of pellet groups		-0.11	0.119	0.065	0.247
Distance to road	0.014		0.502	0.488	-0.216
Distance to building	0.008	<0.00		0.488	0.119
Distance to power line	0.149	<0.00	<0.00		0.106
Altitude	<0.00	<0.00	0.008	0.018	

Discussion

Poisson and logistic regression modeling for both FSC and FAR data revealed distance to power line to be included as an explanatory variable for the distribution of reindeer faecal pellet groups, with a positive relationship showing a significant increase in pellet groups with increasing distance from the power line.

There was a weaker relationship between pellet group counts and distance from power line for FAR compared to FSC data (Fig. 4). For FSC data, the variable distance from power line had lower P values in the Poisson regression model (Table 3) as well as in the logistic regression model (Table 4). This may be explained by common attributes for the 148 plots (white plots in figure 1) that were not recounted in autumn because of snowy weather, and thus were omitted from FAR data. These plots were located in proximity to each other in lower terrain, and 52% of the plots were within 1 km from the power line (with an average distance from the power line of 379 meters). I therefore tested FSC data in logistic regression models after omitting these 148 plots (this dataset hereafter referred to as FSC-red.). Omitting the plots caused distance to power line to become insignificant with regard to the distribution of pellet groups, with P values changing from 0.0017 for FSC to 0.1247 for FSC-red. Thus, FSC-red. and FAR datasets showed similarly weak relationships as opposed to the FSC, where distance to power line was a significant ($P = 0.0017$) variable affecting distribution of pellet groups. There also was a distinct change in relationship between distance from road and distribution of pellet groups between FSC and FSC-red., demonstrated by the relationship turning negative for FSC-red., similar to that found for FAR data. Even though snow cover resulted in lack of sampling these locations, omitting these matching plots with regard to attributes from the data may represent nonrandom picks of plots causing bias of modeling results. In conclusion, modeling using my FSC data as opposed to FAR data better explains random samples for distance to power line and the distribution of pellet groups. Therefore, further discussion on reindeer pellet group distribution will be based on results from the FSC data. Similar results from counts of long term accumulated pellets (FSC) and counts of fresh pellets (FAR) as long as datasets are derived from the exact same plots (i.e. FSC-red versus FAR) support the validity of the FSC dataset.

In regression modeling 1 and 2, the variable distance to power line revealed a P-value of 0.0112 when specifying pellet group distribution as Poisson and 0.0017 when differentiating between plots with or without pellet groups, and in both models the estimate was positive (Table 3 and 4). Since both models account for other variables, this indicates that distance to power line directly effects distribution of reindeer pellet groups, shown as a distance related increase in total number of pellet groups (Poisson model), as well as a distance related increase in percentage of plots containing pellet groups (logistic model). This supports my hypothesis that the power line(s), and/or the extensive construction work being carried out on them, had an aversion effect on reindeer.

In both models, the variables vegetation and altitude expressed very significant, low P-values and thereby were accepted as explanatory for pellet group distribution. Low P-values for vegetation in both models may be explained by reindeers' preference for some vegetation types and avoidance of sparsely vegetated areas as well as forest (Skarin et al., 2008). The avoidance of forests may be explained by predator vigilance in spring when calves are small, and high abundance of insects in forest later in the season (Skarin et al., 2008). This is in accordance with distribution of pellet group counts within different vegetation types that indicates reindeer preferences for Lee side, Ridge crest and Snow bed as opposed to Forest (Fig. 5). Low pellet group counts in mires of this study is in agreement with low representation of reindeer pellet groups in mires documented by Skarin (2007), which the author proposed might be a result of pellet groups being less visible and disappearing faster in this moist vegetation type. Low P-values with a positive estimate for altitude in the models, also reflected by greater numbers of pellet group per available terrain for altitude intervals above the tree line (Fig. 6), may be explained by important altitudinal related factors such as vegetation quantity and quality, insect relief and predator vigilance (Skarin, 2007).

My hypothesis that the power line(s) (and construction work) had an aversion effect on reindeer, is supported by findings of an increase in percentages of plots containing pellet groups within increasing distance intervals up to 3000 meters in terrain under the tree line (Fig. 7). Lee side vegetation might have been favored by reindeer in our study area as displayed by overrepresentation of pellet group counts in Lee side vegetation (Fig.5), and since Lee side vegetation comprised 42% of plots under the tree line, distribution of this vegetation type might possibly have effected pellet group distribution. However, in spite of an increase in percentages of contribution by Lee side vegetation of 41.9, 52.9 and 44.9% within increasing distance intervals up to 3000 meters, the regression models still ascribed the variable distance to power line to be explainable for the distribution of pellet groups, thus supporting my hypothesis.

My results indicating that the power line (and construction work) may have an aversion effect on reindeer is supported by results from studies on wild reindeer in Nordfjella, southern Norway (Nellemann et al., 2001) and semi-domesticated reindeer in Reppafjord, northern Norway (Vistnes & Nellemann 2001). Reimers et al. (2007) found that a 60 kV power line without human traffic did not have an aversion effect on wild reindeer in North Ottadalen. Flydal et al. (2009) found no indication of reduced area use underneath the power lines for reindeer kept in enclosures underneath two parallel power lines (132 and 300 kV) and away from the lines, giving the animals the possibility to avoid the lines.

Direct observations of free ranging reindeer, such as in Nordfjella (Nellemann et al., 2001), Reppafjord (Vistnes & Nellemann 2001), and North Ottadalen (Reimers et al. (2007) is based on the assumption that registered area use within the limited time frame of a survey represents the animals' true area use on a larger time scale, such as a year or longer. This assumption may however be biased if environmental conditions in shorter time frames causes animals to use areas that they normally do not use. Such short term altering of environmental conditions could for instance be related to human activity, predators or insect harassment, causing temporary deflecting behavior of animals from their home range. Direct observations in more controllable environments as in the study of reindeer in enclosures (Flydal et al., 2009), the above mentioned conditions are better controlled for. Nevertheless, it might be difficult to transfer data from such studies to free ranging animals (Reimers & and Colman, 2006). As for direct observations, also indirect observation of reindeer area use by measuring lichen cover and/or height has shortcomings (Reimers & and Colman, 2006), acknowledged by Reimers et al. (2007), even though the authors partly concluded no power line aversion effect on reindeer on the basis of lichen measurements. Nevertheless, the authors emphasized numerous climatic, topographic and biotic influences that might have interfered on others as well as their own study when using lichen measurement to test reindeer area use.

By employing the method of pellet group counts in testing of reindeer area use, problems with validity of conclusions caused by defect in the methodical approach may be outmaneuvered. A reindeer pellet group found in a plot is proof that a reindeer has been in that plot. Systematic pellet group counts in an area therefore measures how the entire population uses an area over a longer time period (Skarin 2007), and the method is valid and can be made to yield reliable data under most field conditions (Neff, 1968). However, differences in pellet group decay rates between different types of substrates have been recorded (Skarin, A. 2008). Possible bias from differential decay may be greater when using the FSC- as opposed to the

FAR method, since FSC counts reflect a longer period of accumulation of pellet groups. Skarin (2008) found reindeer pellet group decay rates to be higher in forest, where pellet groups did not persist more than two years, as compared to alpine heath, where pellet groups persisted for at least four years, and suggests that this might be explained by higher moisture in forest. Furthermore, visibility of pellet groups declined in forested areas as a consequence of vegetation overgrowth. Thus, degree of moisture appears to affect both persistence as well as visibility of pellet groups.

Since the power line in my study area for the most part stretched through lower terrain below 800 m.a.s.l., adjacent areas to the power line may be moister. This in turn might lead to faster decay rates as well as reduced visibility of pellet groups closer to the power line. If this was the case, the FSC data from this study would thereby display a stronger (positive) relationship in pellet group counts with increasing distance from the power line than can be accounted for by reindeer area usage alone. However, the study area is located in a typical continental climate with low precipitation. The majority of plots were also located in rather dry vegetation types, including Forest plots of which 57% of these plots were categorized as vegetation class 7, which is characterized as dry forest (Appendix 1). I assumed therefore that the potential effects of differential decay rate and visibility of pellet groups between plots was of limited concern.

In regression modeling 3 when specifying pellet group distribution as Poisson, variables tree line and [tree line * distance to power line] revealed P-values of <0.0001 and 0.0333, respectively (Table 5). The model accounts for other explanatory variables, and therefore the low P-value for tree line clearly indicates that the tree line constitutes a major transition in important habitat related factors. This is supported by the increase in average number of pellet groups per plot from below to above the tree line, but with no further increase within altitude intervals above the tree line (Fig. 8). Furthermore, the low P-value for variable [tree line * distance to power line] not only indicates distance to power line to directly affect distribution of pellet groups, but that this effect also decreased above the tree line, as shown in figure 7. This supports my hypothesis that the aversion effect on reindeer from the power line did not exist above the tree line.

Since aversion effects of power lines on reindeer may be comparable to aversion effects from human activity (Nellemann et al., 2001), the latter results are supported by the study of Helle & Sarkela (1993). In this study, reindeer pellet group counts in three distance intervals from an outdoor recreational area revealed increase of pellet group counts between increasing distance intervals within birch and pine forest zones, but no increase of pellet group counts between distance intervals within alpine hilltop zones. The author suggested that reindeer respond to disturbance by shifting to an open habitat where they have superior control over their environment. In a sense, this active retreat from what an animal may perceive as danger, in this case an outdoor recreational area, with relocation to higher altitudes, is similar to the active retreat by calving caribou from valleys with predators to areas above the tree line shown by Bergerud and Page (1987). Reimers & Colman (2006) suggested that high vegetative production and less insect harassment in open alpine habitat could have caused reindeer to negate potential effects of disturbance in the study of Helle & Sarkela (1993). Nevertheless, the result that power line aversion diminishes or ceases above the tree line supports my hypothesis, and is interesting regardless of cause.

The results of this study is based on accumulated pellets groups (FSC) that may persist for up to four years in rather dry alpine terrain (Skarin, 2008). The fieldwork (for FSC counts) was performed between end of June and beginning of July 2009, and we may therefore have counted pellet groups that originate from as far back as 2005. The findings of an increase of reindeer pellet group counts based on this FSC data material, with increasing distance from power line below the tree line, may signify long term avoidance of the power line. However, a simplification was made when employing distance to power line as a measure of aversion. Construction work on the power line began in summer of 2008 and certainly contributed to the avoidance documented in this study. I had no control over how extensive the impact from construction work might have been on reindeer pellet group distribution, although it is reasonable to assume that periodic presence of people along the pathway of the power line and a considerable amount of helicopter traffic almost every day, contributed to the aversion effect. The possible impact of construction work on the pellet group data should be investigated by repeating pellet group counts a few years after the construction phase is over.

Conclusions

Opposite findings in the literature as to whether power lines cause aversion for reindeer, resulting in reduced area use in areas adjacent to the lines, may be reflected by shortcomings of methods at hand as well as differential use of these methods. This in turn makes a comparison of findings difficult. By applying the method of pellet group counts, I circumvented some of the difficulties in interpretation of data associated with these other methods, firstly because the finding of a reindeer pellet group is proof that a reindeer was at that spot. Furthermore, systematic pellet group counts in an area measure how an entire population uses an area over a longer time period. Regression modeling of reindeer pellet group count data in this study clearly signifies an increase in pellet group counts that is directly related to distance from power line, since multiple variables were included in the models. Additionally, I found this distance related increase of pellet group counts with regard to power lines diminished above the tree line. These results support both my hypotheses. However, a possible effect of power line construction work that started in summer of 2008 likely impacted my results causing an increase in reindeer aversion towards the power line below the tree line. Nonetheless, it may be difficult to distinguishing the impact from the power line itself as opposed to construction work. Repeated pellet group counts should therefore be performed in the future and for at least 3-4 years after the construction phase.

References

Bergerud, A.T. & Page, R.E. (1987). Displacement and dispersion of parturient caribou at calving as antipredator tactics. *Canadian Journal of Zoology-Revue Canadienne De Zoologie* 65: 1597-1606.

Bradshaw, C.J.A., Boutin, S. & Hebert, D.M. (1997). Effects of petroleum exploration on woodland caribou in northeastern Alberta. *Journal of Wildlife Management* 61: 1127-1133.

Campbell, D., Swanson, G.M. & Sales, J. (2004). Comparing the precision and cost-effectiveness of faecal pellet group count methods. *Journal of Applied Ecology* 41: 1185-1196.

Colman J.E. (2000). Behaviour patterns of wild reindeer in relation to sheep and parasitic flies. PhD thesis, University of Oslo.

Dahle, B., Reimers, E. & Colman, J.E. (2008). Reindeer (*Rangifer tarandus*) avoidance of a highway as revealed by lichen measurements. *European Journal of Wildlife Research* 54: 27-35.

Dau, J.R. & Cameron, R.D. (1986). Effects of a road system on caribou distribution during calving. *Rangifer* 1: 95-101.

Dyer, S.J., O'Neill, J.P., Wasel, S.M. & Boutin, S. (2001). Avoidance of industrial development by woodland caribou. *Journal of Wildlife Management* 65: 531-542.

eKlima, Norwegian Meteorological Institute (2011). Avaiable at http://sharki.oslo.dnmi.no (accessed: 15.02.2011).

Flydal, K., Eftestøl, S., Reimers, E. & Colman, J. E. (2004). Effects of wind turbines on area use and behaviour of semi-domestic reindeer in enclosures. *Rangifer* 24 (2): 55-66.

Flydal, K., Korslund, L., Reimers, E., Johansen, F. & Colman, J. E. (2009). Effects of power lines on area use and behaviour of semi-domestic reindeer in enclosures. *International Journal of Ecology* Article ID 340953, 14 pp.

Frid, A. & Dill, L. (2002). Human-caused disturbance stimuli as a form of predation risk. *Conservation Ecology* 6:11

Gill, J.A., Norris, K. & Sutherland, W.J. (2001). Why behavioural responses may not reflect the population consequences of human disturbance. *Biological Conservation* 97: 265-268.

Helle, T. & Sarkela, M. (1993). The effects of outdoor recreation on range use by semi-domesticated reindeer. *Scandinavian Journal of Forest Research* 8: 123-133.

Johansen,B., Aarrestad, P.A. & Øien, D.I. (2009). Vegetasjonskart for Norge basert på satellittdata. Avaiable at http://www.norut.no/content/download/4551004/9246892/file/Norut_rapport_3_2009.pdf (accessed: 09.03.2011).

Neff, D. J. (1968). The pellet-group count technique for big game trend, census, and distribution: A review. *Journal of Wildlife Management* 32: 597–614.

Nellemann, C., Vistnes, I., Jordhoy, P. & Strand, O. (2001). Winter distribution of wild reindeer in relation to power lines, roads and resorts. *Biological Conservation* 101: 351-360.

Nellemann, C., Vistnes, I., Jordhoy, P., Strand, O. & Newton, A. (2003). Progressive impact of piecemeal infrastructure development on wild reindeer. *Biological Conservation* 113: 307-317.

Quayle, J. F. & Kershaw, G. (1996). Use of summer habitat by caribou on the north slope of a mountain near the Macmillan Pass, N.W.T. *Rangifer* 9: 311-317.

Reimers, E. & Colman J.E, (2006). Reindeer and caribou (*Rangifer tarandus*) response to human activities – a literature review. *Rangifer* 26: 55-71.

Reimers, E., Dahle, B., Eftestol, S., Colman, J.E. & Gaare, E. (2007). Effects of a power line on migration and range use of wild reindeer. *Biological Conservation* 134: 484-494.

Schwarz, C.J. (2011). Sampling, Regression, Experimental Design and Analysis for Environmental Scientists, Biologists, and Resource Managers. Chapter 16, Simon Fraser University. Available at: http://www.stat.sfu.ca/~cschwarz/Stat 650/Notes/PDF/Chapter16.pdf (accessed: 19.02.2011).

Skarin, A., Danell, Ö., Bergström , R. & Moen, J. (2004). Insect avoidance may override human disturbances in reindeer habitat selection. *Rangifer* 24: 95-103.

Skarin A. (2007). Habitat use by semi-domesticated reindeer, estimated with pellet-group counts. *Rangifer* 27: 121–132.

Skarin, A. (2008). Decay rate of reindeer pellet-groups. *Rangifer* 28: 47–52.

Skarin, A., Danell, O., Bergstrom, R. & Moen, J. (2008). Summer habitat preferences of GPS-collared reindeer *Rangifer tarandus tarandus*. *Wildlife Biology* 14: 1-15.

Skarin, A., Danell, O., Bergstrom, R. & Moen, J. (2010). Reindeer movement patterns in alpine summer ranges. *Polar Biology* 33: 1263-1275.

Skogland, T. (1984). Wild reindeer foraging niche organization. *Holarctic Ecology* 7: 345-379.

Skogland, T. (1990). Density dependence in a fluctuating wild reindeer herd; maternal vs. offspring effects. *Oecologia* 84: 442-450.

Skogland, T. (1994). Villrein – fra urinnvåner til miljøbarometer. Teknologisk forlag. 143 s

Statnett, (2011). Prosjekter / Nea – Järpströmmen. Avaiable at http://www.statnett.no/no/Prosjekter/Nea-Jarpstrommen/ (accessed: 09.03.2011).

Teterukovskiy, A. & Edenius, L. (2003). Effective field sampling for predicting the spatial distribution of reindeer (*Rangifer tarandus*) with help of the Gibbs sampler. *Ambio* 32, 568-572.

Vistnes, I. & Nellemann, C. (2001). Avoidance of cabins, roads, and power lines by reindeer during calving. *Journal of Wildlife Management* 65: 915-925.

Vistnes, I., Nellemann, C., Jordhoy, P. & Strand, O. (2001). Wild reindeer: impacts of progressive infrastructure development on distribution and range use. *Polar Biology* 24: 531-537.

Vistnes, I., Nellemann, C., Jordhøy, P & Strand, O. (2004). Effects of infrastructure on migration and range use of wild reindeer. *Journal of Wildlife Management* 68:101-108.

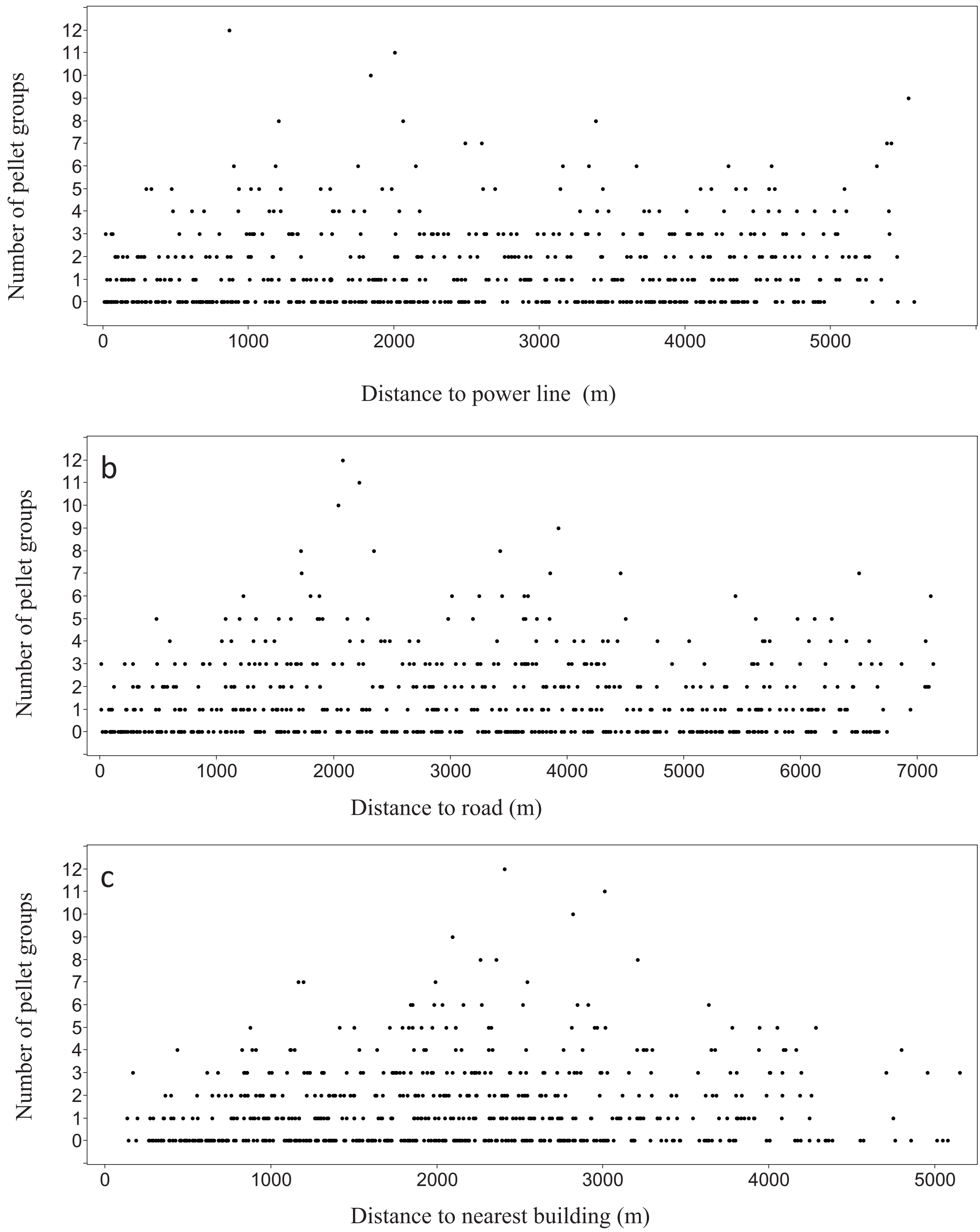
Wolfe, S.A., Griffith, B. & Wolfe, C.A.G. (2000). Response of reindeer and caribou to human activities. *Polar Research* 19: 63-73.

Appendix

Appendix 1.

Vetetati on type	*Vegetation class*	*Special charactheristics*	*Common plants*
Forest	(5) Deciduous forest	Vigorous and species-rich forest on nutrient-rich moist sunstrat.	Tall grassess, herbs, ferns
	(6) Birch forest type 1	Intermediate to moist sunstrate.	Blueberry plant, small ferns, grasses, herbs
	(7) Birch forest type 2	Dry and nutrient-poor sunstrat, species-poor.	Heather
Mire	(9) Mire type 1	Vegetasjon on peat that periodically becomes dry on surface.	Mosses, short graminoids, herbs
	(10) Mire type 2	Vegetasjon on peat with water level close to surface most of the growth season.	Tall graminoids
Wet mire	(11) Wet mire	Vegetasjon on peat with water at surface level throughout the growth season.	Sedges, rannoch-rush, graminoids
Rocky	(12) Bare rock and bedrock outcrops	Lack of, or scarcely vegetated.	Mosses, lichens
Ridge crest	(13) Grass and rush dominated ridge crests	Units of vegetation often formed as polygones.	Rushes, tufted grasses, dwarf willow, heather
	(14) Heath dominated ridge crests	Species poor, short vegetation in upper part of ridge crests.	Heather, dry grasses
Lee side	(15) Heath with lichens	Includes both heaths and ridge crests enriched with lichen.	Heather, lichens, dwarf birch
	(16) Lee side heaths and grass heaths	Closed vegetation cover on Lee side of ridge crests.	Heather, dwarf birch, grasses
	(17) Heaths and brush	Dence vegetation.	Dwarf birch, willows, juniper, heather, grasses and herbs
	(18) Grass and herb meadows	Vigorous vegetation, species-rich.	Grasses, herbs, ferns
Snow beds	(19) Moderate snow beds	Long-lasting snow-cover that melts late in summer.	Herbs, grasses, mosses
	(20) Extreme snow beds	Long-lasting snow-cover that melts very late in summer, scarce vegetation.	Mosses

Appendix 2.1 Number of reindeer pellet group counts (FSC method) at plots in relation to distance from (a) power line, (b) road and (c) nearest building**.**



Appendix 2.2 Number of pellet group counts (FAR method) at plots in relation to distance from (a) power line, (b) road and (c) nearest building.