Norwegian University of Life Sciences
Faculty of Environmental Science and Technology
Department of Ecology and Natural Resource Management

Master Thesis 2014
30 credits

Wild Reindeer (*Rangifer tarandus tarandus*) and Mountain Hiking

A study of human activity and potential reindeer avoidance in Setesdal-Ryfylke

Villrein (*Rangifer tarandus tarandus*) og ferdsel på tursti: Et studie på menneskelig ferdsel og reinens unnvikelse i Setesdal-Ryfylke

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PREFACE

This study is the final work of my Master degree in Natural Resource Management and was written at the department of Ecology and Natural Resource Management at the Norwegian University of Life Sciences. The thesis provides 30 credits and is based on field studies in a wild reindeer area in Southern Norway, summer 2014.

First, I would like to send a special thanks to my supervisors Associate Professor Jonathan E. Colman and Professor Stein R. Moe for introducing me to this topic and for their great efforts during the entire process of working on this thesis. I would also like to thank Kjetil Flydal and Ole T. Rannestad for help in preparations for fieldwork and methods; Aleksander L. Pedersen for keeping company with me during data collection and Sindre Eftestøl and Diress T. Alemu for invaluable help with data processing and statistical analysis.

Last, but not at least, I would like to thank my friends for a great time at the Norwegian University of Life Sciences and my family for support during educational studies towards a Master of Sciences degree.

Norwegian University of Life Sciences
Ås, Norway 12th December 2014

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ABSTRACT

The studied effects of human activities on wildlife provide necessary knowledge for management authorities to better understand and predict the consequences of increased wildlife habitat fragmentation. Human outdoor activities can negatively influence wild reindeer (*Rangifer tarandus tarandus*) populations through reoccurring disturbances. Previous studies indicate that frequently used hiking trails lead to reindeer avoidance or other behavioural changes. I conducted a study on the possible avoidance of wild reindeer in relation to a hiking trail in Setesdal-Ryfylke, Southern Norway, during July 2014. The reindeer area use was estimated by a faecal pellet count method and registration of habitat variables, including vegetation distribution and elevation. Faecal counts were done by a strip-transect method where all transects had a length of 2 km. Eight transects were located in proximity to the trail (<2 km) and additional eight transects were randomly distributed in the terrain (>2 km) to obtain a random density of pellets for the entire study area. Significant lower faeces density per km^2 was found for areas in proximity to the trail (<2 km) compared to areas beyond 2 km, indicating avoidance by reindeer. Additionally, a significant difference in faeces density was shown among vegetation types, but the vegetation distribution pattern did not explain the increased faeces density in areas beyond 2 km from the hiking trail. Furthermore, elevation was correlated to the location of the trail in the terrain and increased with increasing distance to the trail. Thus, it was not possible to conclude whether the observed faecal pattern in relation to the hiking trail reflects natural conditions (in elevation) or if it is caused by reindeer avoidance as predicted.

Keywords*: Rangifer tarandus tarandus, wild reindeer, Setesdal-Ryfylke, avoidance, disturbance, hiking trail, habitat selection, habitat variables, faecal pellet count method.*

SAMMENDRAG

Studier av antropogene aktiviteters effekt på natur og dyreliv bidrar med viktig kunnskap til forvaltningens konsekvensanalyse av habitatødeleggelse og fragmentering. Friluftsliv-aktiviteter kan ha negativ effekt på populasjoner av villrein (*Rangifer tarandus tarandus*) gjennom gjentakende forstyrrelse. Studier i villreinområder har vist at stor ferdsel på turstier medfører fravær av villrein på nærliggende arealer, i tillegg til andre atferdsendringer. Jeg gjennomførte et studie på villreinens potensielle unnvikelse i områder tilknyttet en tursti i Setesdal-Ryfylke, Sør-Norge, juli 2014. Kartlegging av villreinens områdebruk ble gjort ved registrering av feces, samt topografi- og vegetasjonskartlegging. Registrering av feces ble gjennomført ved bruk av transekter plassert i terrenget, henholdsvis 2 km lange. Totalt åtte transekter ble plassert vinkelrett ut fra turstien (<2 km) og ytterligere åtte transekter ble tilfeldig plassert i terrenget (>2 km) for å oppnå en tilfeldig tetthet av feces for hele området. Det ble påvist en signifikant lavere tetthet av feces per km^2 i nærheten av turstien (<2 km) sammenlignet med resten av området hvilket indikerer at villreinen unnviker turstien. I tillegg ble det funnet signifikant forskjell i tetthet av feces mellom ulike vegetasjonstyper, men vegetasjonsfordelingen var ikke en forklarende faktor for den signifikante forskjellen i tetthet av feces mellom området i nærheten av turstien (<2 km) og området lenger unna (>2 km). Høyde over havet var korrelert med turstiens plassering i terrenget og økte med økende avstand fra sti. Dermed var det ikke mulig å konkludere hvorvidt villreinens kartlagte områdebruk reflekterer naturlige habitatvariabler (som høyde over havet), eller om det skyldes reinens unnvikelse av turstien som følge av menneskelig forstyrrelse som først antatt.

Nøkkelord: *Rangifer tarandus tarandus, villrein, Setesdal-Ryfylke, unnvikelse, forstyrrelse, tursti, habitatpreferanser, habitat variable, feces registrering.*

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1. INTRODUCTION

An understanding of the possible negative effects of anthropogenic activities on different habitats and wildlife populations are required for the proper conservation and use of remaining wildlife areas. Local human disturbances are sometimes difficult to comprehend on a national scale and hence, landscapes are gradually fragmented (Berntsen & Hågvar 2010). Since the 1900s, Norway has suffered a nearly 90 % reduction in areas located more than 5 kilometres away from anthropogenic footprints (Berntsen & Hågvar 2010). The potential negative influence of wind-power plants, roads, power lines and resorts on surrounding wildlife has been focused on in earlier studies (Vistnes et al. 2001; Everaert & Stienen 2007; Stankowich 2008; Colman et al. 2012a). Particular focus has been related to animals with large range use, like reindeer (*Rangifer tarandus tarandus*) (Nellemann et al. 2001).

Norway is the only remaining country with populations of wild reindeer, and these are distributed in 23 separate national areas (Norsk-Villreinsenter 2014a). Consequently, Norway has the responsibility to maintain and protect, not only the populations of this species, but also the key seasonal pastures, calving grounds and insect relief habitats required for sustainable reindeer populations over time (Punsvik & Jaren 2006). The available pastures are not homogenous throughout the range, and large areas serve as important habitats for migration and grazing, which are often in conflicts with anthropogenic area use (Nellemann et al. 2001; Punsvik & Jaren 2006; Reimers & Colman 2006; Hongslo & Lundberg 2012).

Avoidance of roads, power lines and other infrastructure has earlier been reported for semi-domestic and wild reindeer populations (Nellemann et al. 2001; Vistnes & Nellemann 2001; Vistnes et al. 2001; Skarin & Åhman 2014). In contrast, other studies report of less negative effect of human infrastructure on reindeer (Flydal et al. 2004; Reimers et al. 2007; Flydal et al. 2009; Colman et al. 2012a; Colman et al. 2013), and reindeer avoidance to human infrastructure may be limited by herd traditions and motivation to follow established migration corridors between pastures (Dahle et al. 2008). However, the use of different methods among studies has been suggested to partly explain the observed differences between studies (Reimers & Colman 2006).

In addition to the already studied effects of human infrastructure in wild reindeer areas, some focus has been given to traditional recreational activities like hiking and skiing, in combination with more modern activities such as snowmobiling and snow kiting (Reimers et al. 2003; Reimers et al. 2010; Colman et al. 2012b). In connection with the construction of cabins and resorts, recreational activities and nature experience has been increasingly popular during the last decades (Bischoff & Odden 2000). The number of members in the Norwegian trekking association (DNT) exceeded 240 000 people in 2014 (DNT 2014). The possible interaction between wild reindeer and hiking along marked trails is unique in Norway, and relatively few studies have been conducted on this topic compared to studies of other anthropogenic disturbances in the same areas. The most remote and undisturbed areas are also popular areas for recreational use because of the desire for some people to search for quietness and relaxation in a natural environment. Thus, many of the human activities take place in management areas of wild animal populations, including wild reindeer (Andersen & Hustad 2004; Strand et al. 2013).

Questions are addressed on whether the increase in recreational activities in wild reindeer areas affect the reindeer populations negatively through reoccurring disturbance (Stankowich 2008). Most marked trails do not represent large and visible impacts in nature, but a trekking route in connection with DNT cabins increase human traffic and might consequently pose a greater disturbance to wildlife compared to, for example, a power line. Arguably, the intensity of human presence varies significantly between different areas and between seasons (Gundersen et al. 2013a). The total number of visitors to remote areas increases with increased tourist facilities like marked trails, access roads and the establishment of information centres, companies that offer outdoor activities and associated accommodation. Despite a higher visitor intensity, facilitation also causes a more predictable spatial distribution of visitors and likely reduces the overall hiking in the terrain and off marked trails (Strand et al. 2013; Gundersen et al. 2013b).

Hunting is prevalent in all reindeer areas and likely influences how reindeer perceive and react towards humans on foot, since humans are their main predator (Reimers et al. 2008). According to a meta-study by Stankowich (2008), ungulates respond to the behaviour of humans approaching the animals, and the perception of risk is greater when a herd is located in open habitats, which often is the case in wild reindeer areas. Human activities can have a direct effect on reindeer behaviour through smell, hearing and sight. Short-term indirect responses include sensitisation, avoidance and displacement, developed through associations in terms of reindeer's ability to experience, learn and remember (Reimers & Colman 2006). Avoidance behaviour occurs when animals reduce their utilization of an area they otherwise would have used more frequently if the disturbance factor was not present. In a long-term perspective, human activities may lead to limitations on established migration patterns and loss or reduction of pasture, either through reduced utilization of existing pasture (avoidance or barriers), or through physical destruction (pasture destruction or fragmentation) (Vistnes &

Nellemann 2001; Flydal et al. 2002; Punsvik & Jaren 2006).

Any factor that reduces optimal time spent feeding and ruminating, either through increased movement rates over time or through avoidance behaviour, may exert a negative effect on the herbivore's energy budget (Reimers et al. 2013). The loss of grazing time reduces reindeer's ability to gain weight, and prolonged or reoccurring disturbances may have negative impact on reindeer's activity pattern, nutrition and at the same time become a limiting factor on survival and productivity (Colman et al. 2003; Colman et al. 2012b). In contrast, studies in other Norwegian wild reindeer areas where reindeer were encountered by a person on foot, skis or snowmobile have not been able to identify escape distances or displacement durations that would entail substantial energy costs (Reimers et al. 2003; Reimers et al. 2006).

A continuous network of hiking trails may contribute to reduce the actual range use significantly, even though the potential habitat persists. Recent studies have been conducted on the possible negative effect of hiking in three of Norway's national wild reindeer areas: Rondane, Nordfjella and Snøhetta (Gundersen et al. 2013a; Gundersen et al. 2013b; Strand et al. Unpublished). The observed avoidance behaviour was related to the density of the trail network, the visitor intensity and the total distance between trails and important reindeer habitats. Comparative studies have also been done on snow-kiters and skiers during wintertime, indicating a difference in reindeer response distance dependent on the activity (Colman et al. 2012b).

Although cumulative effects from human activities are likely, testing reindeer avoidance is very difficult because of interacting factors and natural variations in pasture quality and demography, making interpreting causation and correlation challenging (Reimers & Colman 2006). The area use of reindeer is expected to change during the year, regulated by natural interacting factors like feeding conditions, insect harassment and preferred calving grounds, in addition to migration routes between preferred habitats. Hence, it is complex to study the possible disturbance caused by hiking and other recreational activities, but nevertheless important for future planning and optimal reindeer management.

I tested the spatial variability of reindeer habitat use towards a marked DNT trail in Setesdal-Ryfylke in relation to avoidance effects. By the use of a faecal pellet count method, reindeer habitat selection was estimated in relation to the trail in a landscape of alpine heath. Based on the theoretical framework, my main hypothesis is that the density of faeces increases in relation to increased distance from the trail (avoidance-hypotheses). Based on previous studies (Nelleman et al. 2000; Nellemann et al. 2010; Reimers et al. 2010;

Gundersen et al. 2013a), I predict that reindeer will avoid the DNT trail because the animals associate the trails with humans.

An indication of reindeer avoidance in the study area is further an indication of hiking trails contributing to fragment the continuous allocated area and thereby reduce the range use significantly. The aim of this study is to provide additional knowledge on the human-reindeer interaction as a tool for managers to improve the prediction of hiking and other recreational activities on wild reindeer, including disturbance levels and potential population level consequences.

2. METHODS

2.1 Study species: Wild reindeer

Based on the genetic history and origin, three different populations of wild reindeer are found on mainland Norway (Flagstad & Røed 2003; Andersen & Hustad 2004): (1) the original wild reindeer with little influence from domestic reindeer herding during the last century (Snøhetta, Rondane and Sølnkletten), (2) wild reindeer with influx of domesticated animals from local reindeer herding (Nordfjella, Hardangervidda and Setesdal-Ryfylke) and (3) feral reindeer with a domesticated origin through escape or release from reindeer husbandry units (for example, Forollhogna, Ottadalen North, Ottadalen South and Norefjell- Reinssjøfjell).

The estimated winter population is approximately 25 000 individuals in total (Norsk-Villreinsenter 2014a). In spring, the animals forage mostly on blueberry heather (*Vaccinium coria*), dwarf birch (*Betula pumilio*) and various grass-like plants. During summer, preferred diet includes easy digestible protein rich grass, and 5-10 % lichens. Reindeer are one of few animals that can forage lichens when alternative pastures are less available in winter (Punsvik & Jaren 2006).

2.2 Study area

The fieldwork was conducted in July 2014 and lasted for 8 days from the 18th of July to the 25th. The study area was located in Setesdal-Ryfylke, Norway's second largest wild reindeer area (6154 km^2) and Europe's southernmost wild reindeer area (Norsk-Villreinsenter 2014b). As unproductive land is estimated to exceed 40 % of the total allocated area, Setesdal-Ryfylke is the most marginal habitat if compared to the other 22 national wild reindeer areas. The region is characterized by a hilly terrain, several large lakes and rivers, and a coastal climate with high precipitation, frequent icing of pasture and limited available pasture during winter (Norsk-Villreinsenter 2014b).

The study area was situated on the border between the two counties Rogaland and Aust-Agder, on the east side of Blåsjø in Bykle Municipality (65° 88´N, 38° 29´E) (Fig. 1). Due to the high elevation (1100-1300 meters above sea level), vegetation height was only 2-30 cm in general and exposed bedrock was a substantial part of the landscape, in addition to snow beds. Lichens, crowberry (*Empetrum nigrum*), alpine bearberry (*Arctostaphylos alpinus*) and several low grass plants dominated the vegetation. The study area represents an important part of the reindeer population's migration route between the northern and southern parts of Setesdal-Ryfylke (Strand et al. 2011), and during the winter season of 2008/2009, estimations of population size exceeded 1500 individuals (Norsk-Villreinsenter 2014b).

Blåsjø is a 80 km^2 hydroelectric dam and among the ten largest lakes in Norway (NVE 2009). A marked trail is found along the east side of the lake, maintained by the DNT as a part of the trail network in the area. The trail is used for hiking in the summer season and skiing during winter, and connects a longer DNT route between the Krossvatn-cabin and the Vassdalstjørn-cabin (17 km) and further to the Hovatn-cabin (16 km). My fieldwork was conducted along a limited part of this marked trail, including a range located approximately 10 km south of the Krossvatn-cabin and 2 km north of the Vassdalstjørn-cabin (Fig. 2). There is no other human infrastructure near my study area. A 420 kV power line is located in the southern end of Blåsjø, while access roads are located on the western side.

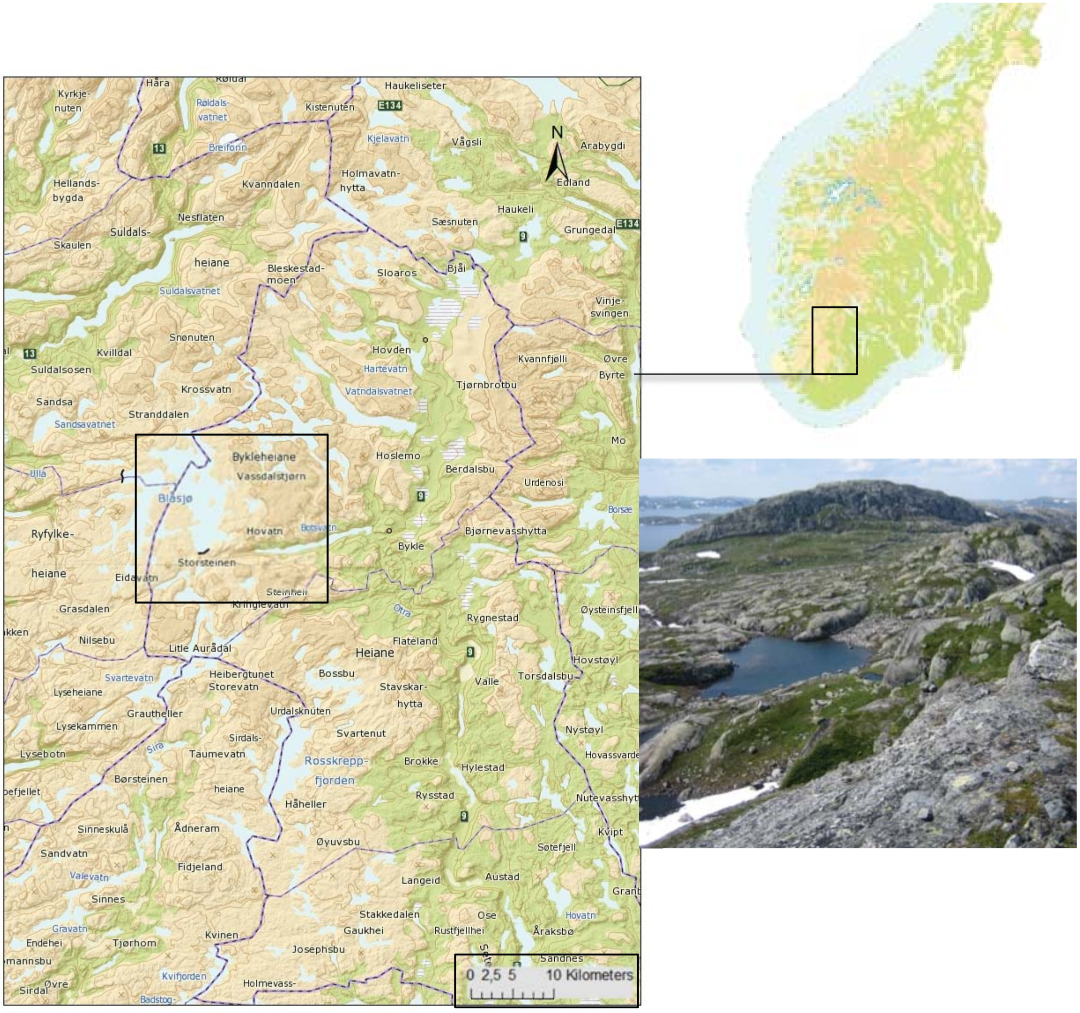

Figure 1: The fieldwork area in Setesdal-Ryfylke, Southern Norway. The study was conducted along the east side of Blåsjø where the hiking trail is located. The picture shows a limited part of the study area.

2.3 Study design and data collection

A faecal pellet count method was conducted to estimate the area use of wild reindeer in relation to the DNT trail (referred to as pellet count method, but include both single pellets and droppings). Direct observations of animals are extremely time-consuming and thereby difficult to conduct in a one-season study. In a landscape of alpine heath (*i.e.* vegetation types with a low decay rate), a pellet count method is useful because it provides an estimate of general habitat selection (Wahlstrøm & Kjellander 1995; Skarin 2007; Trôger 2012; Alves et al. 2013) and may also cover area use over several years (Skarin 2008).

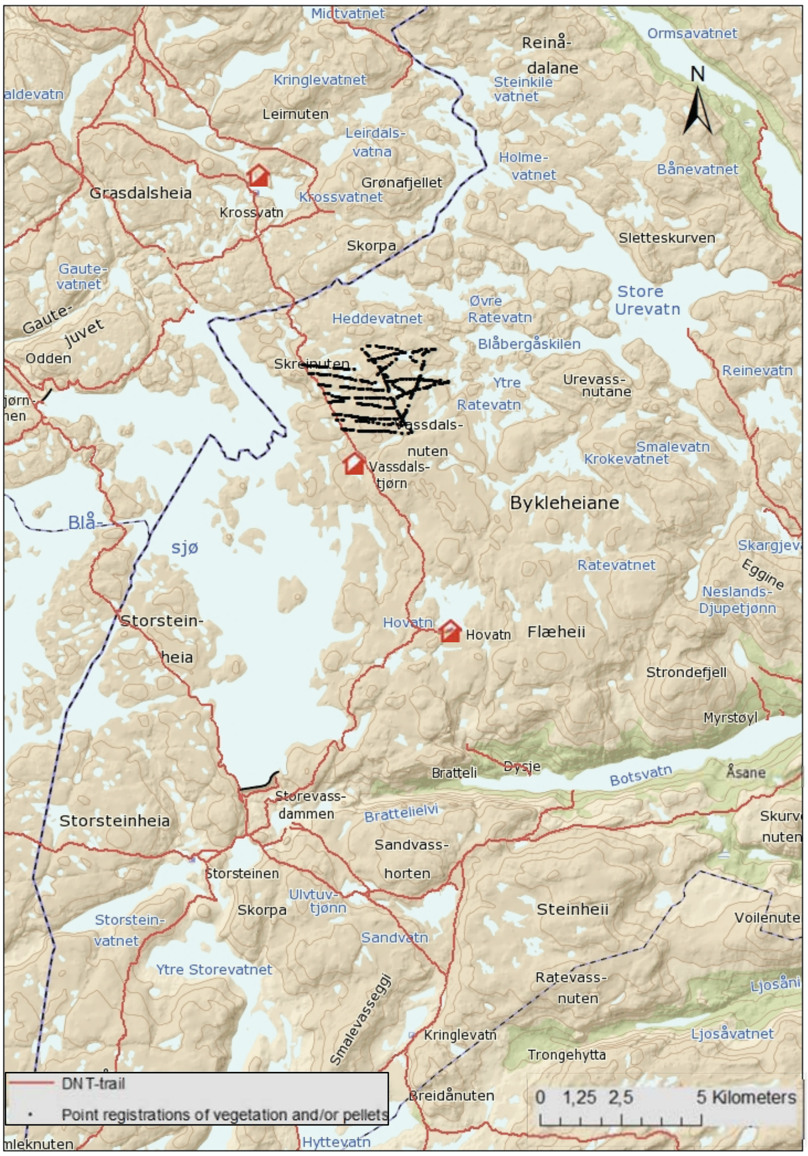

Figure 2: The study area along the east side of Blåsjø with marked black lines representing the walked transects. The marked red lines represent the DNT *(The Norwegian Trekking Association)* hiking trails in the study area and the surroundings, and DNT cabins are marked by a red cabin-symbol.

By the use of Global Positioning System (GPS), habitat variables like vegetation type and cover can be registered simultaneously and at the same spatial scale as the pellet count (Bergmo 2011). It is important not to mix the registrations of reindeer pellets with faecal counts of sheep, which arguably can affect the results. Grazing of sheep is a relevant issue in

Setesdal-Ryfylke, but no sheep were present in the surroundings of my study area (Skog-og-landskap 2013) (Pers. obs.).

Transect lines of different lengths distributed in the terrain is a useful method to determine the faecal distribution of animal populations (Bergmo 2011; Trôger 2012; Colman et al. 2013). I used the strip transect method, which is a modification of quadrate sampling, where in my case the quadrates are long narrow stripes. The method includes a continuous registration of faecal counts and is not dependent on plots like the plot survey method (Skarin 2007; Trôger 2012). Faeces are expected to vary in their distribution, both in relation to the season and the available pasture (Skarin 2007).

In relation to the DNT trail, I used a grid of transects (n=8) to cover parts of the reindeer area, approximately 3.514 km^2. Transects had a length of 2 km and were orientated in eastern direction perpendicular to the DNT trail with a distance of 250 m between each of them (Fig. 3a). The length of 2 km was chosen based on the assessment of earlier studies and on the location of the trail in the terrain (Härkönen & Heikkilä 1999; Bergmo 2011; Trôger 2012). A zone of half a meter on each side of the transect line was included when faecal counts were conducted (Fig. 3b), and every faecal finding within this one-meter width was included regardless of quantity or age, as the counted pellets could be older than the current season (Skarin 2008). Continuously along transects, faecal counts were registered manually with GPS coordinates on a field sheet.

Previously studies have indicated that reindeer avoid human activities even beyond 2 km (Nellemann et al. 2001; Vistnes & Nellemann 2001; Skarin & Åhman 2014). Consequently, I also placed transects beyond 2 km from the hiking trail to obtain a random density of pellets for the entire reindeer area and to compare the obtained data with the area in proximity to the hiking trail. The area beyond 2 km (65° 88´N, 38° 29´E) was chosen as a representative area for registration of vegetation distribution and reindeer pasture preferences and it had no infrastructure or other anthropogenic disturbance factors. I used the same pellet count method as described above, and transects (n=8) were distributed based on a random distribution pattern permitted by the terrain.

In total, transects in the study area combined (n=16), made up a length of 32 km. Due to several physical barriers along the transects, including lakes and cliffs, the actual walked transects differ to some extent from the plotted GPS lines (Fig. 4). However, this deviation should not be of significance to my results since the faecal distribution was counted on a relatively large and defined part of the total reindeer area, and hence, represent the faeces distribution on a general basis. Thus, covering an area of several km^2, the accuracy of transect lines is not essential to obtain a general distribution pattern of pellets.

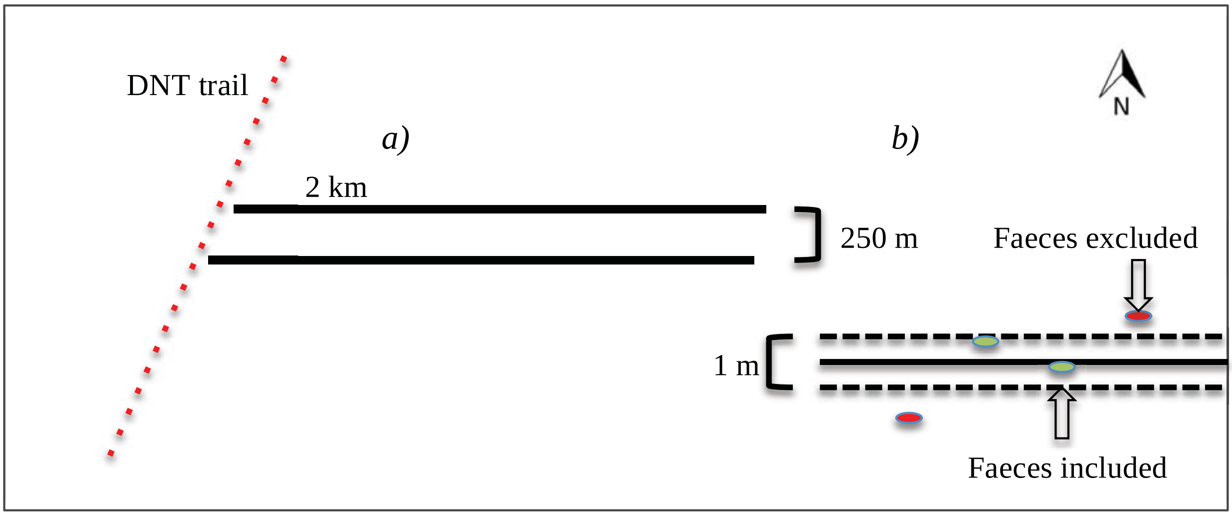

Figure 3: a) The continuous transect survey design with transect length in proximity to the trail (n=8). The transects located beyond 2 km (n=8) were randomly distributed in the terrain, but had the same length of 2 km. **b)** The strip transect method with faeces (dots) that will only be counted for when inside the one-meter path (the green dots).

2.4 Habitat variables

During fieldwork, I did registrations of habitat for each faecal finding. In addition, vegetation distribution in the study area was mapped by registrations of every change in vegetation type along each transect. Topographic features (elevation) and distance to the DNT trail were obtained based on field GPS recordings and subsequent analysis in the Geographical Information System.

Vegetation

Following Bergmo (2011) and the vegetation classification used by the Norwegian Forest and Landscape Institute, seven different vegetation types were developed for use during fieldwork (Table 1) (Skog-og-landskap 2011). The coverage of exposed bedrock became an important factor for vegetation classification because of the significant amount of exposed rock in the area. Inaccessible areas were categorized as “Cliff” or “Water”, and three out of seven vegetation types were potential reindeer pastures. Due to homogeneous habitats, the same vegetation classification was used for observations in areas related to the hiking trail and along the randomly distributed transects beyond 2 km.

2.5 Data analysis

The total number of faecal counts and the faeces density per km^2 were calculated prior to the statistical analysis. The total number of faecal counts is the sum of faeces, both pellets and droppings, found at the same sampling point (GPS coordinate) along each transect. The faeces density per km^2 was obtained by dividing the total number of faecal counts by the unit area between each GPS coordinate. The area equals the lengths of each transect since the faeces were counted within a one-meter width.

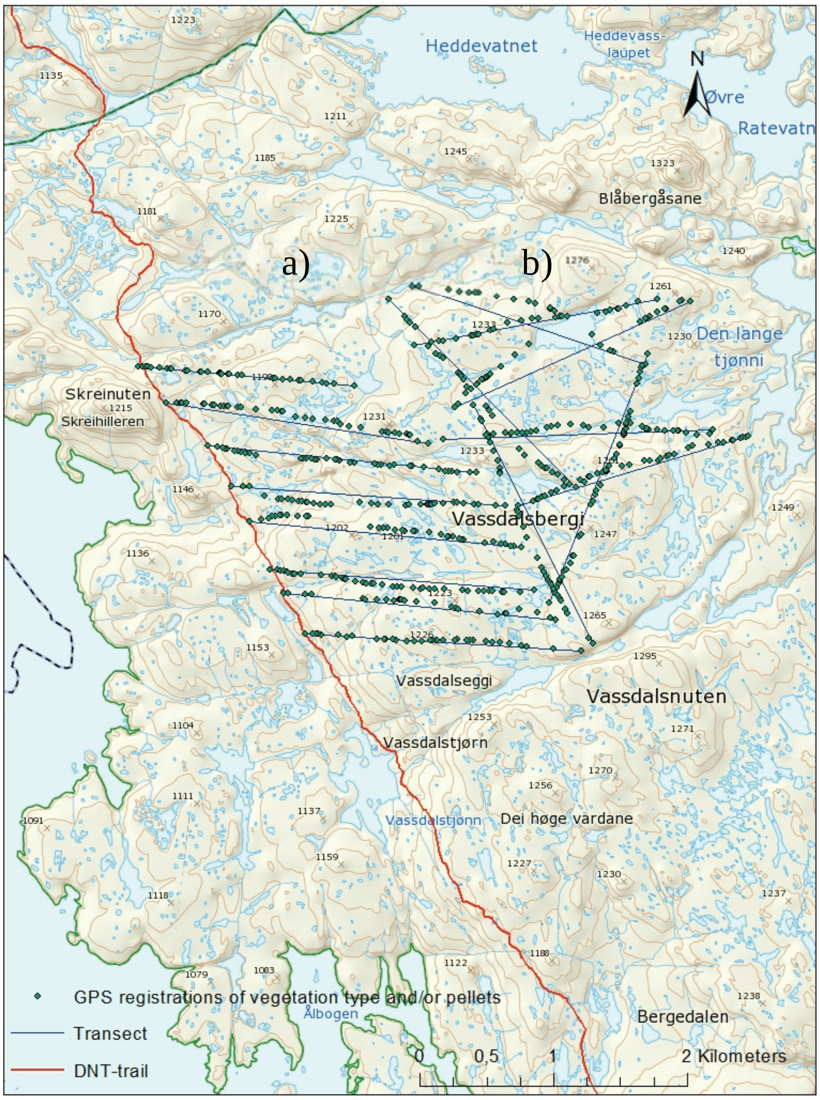

Figure 4: The ideally plotted transect lines and the GPS plots from the actually walked transect during fieldwork **a)** along the trail (areas within 2 km) and **b)** randomly distributed in the terrain (beyond 2 km). GPS plots (green dots on the map) include every registration of faeces and vegetation type. Inaccessible areas along transects are included in the plots on the map, but were removed prior to the statistical analysis.

The inaccessible areas during fieldwork, categorized as “Cliff” or “Water”, were removed from the dataset prior to the statistical analysis. Registrations of mire (R4; n=9) were also removed from the dataset because registrations of faeces in mires were assumed not likely.

Table 1: Vegetation types designed in advance of fieldwork (n=7). Each categorization is accompanied by a detailed description and a label for use in field and during data analysis. Three vegetation types were potential reindeer pasture, while additionally two types were assessed as inaccessible areas.

Vegetation types		
Vegetation categorization	Vegetation label	Vegetation type description
Mountain vegetation	R1a	**No vegetation.** No proportion of plants or lichens, only exposed rock or snow beds.
	R1b	**Exposed rocky areas.** Occasional cover of vegetation (<25 %) between rocks. The vegetation consist of lichens, alpine bearberry and small grassplants. Potential reindeer pasture.
	R2	**Alpine ridge vegetation**. Vegetation with occurance of herbs (mostly crowberry) and tiny dwarft birch (*Pumilio Betulis*) in addition to dens areas with lichens. Vegetation height is several centimeters. Mostly found at the top of the alpine ridges. Exposed rock covers less than 50 % of the area. Potential reindeer pasture.
	R3	**Grass-like vegetation.** Green vegetation that is not heather or herbs, often at the lowest part of a hill-side. Contain moist, but still less than marsh or wetland. Potential reindeer pasture.
Mire and swamp vegetation	R4	**Mire.** Wet-lands with grass, mosses and cottongrass *(Eriophorum*). Often slow snow-melting. The surface of these areas dry out periodically.
Other vegetation	W	**Water.** Inaccessible.
	C	**Cliff.** Inaccessible.

2.5.1 Analysis in Geographical Information System (GIS)

Measurements of distances between each GPS plot, as well as the total distance to the DNT hiking trail were obtained after fieldwork by the use of GIS, ArcMap (version 10.2.2). Measurements of topographical data (elevation) were obtained from a digital elevation model in the same software. ArcMap was also used for the establishment of maps of the study area.

2.5.2 Statistical analysis

Prior to model selection, I excluded the fieldwork data of grass-like vegetation (R3; n=4) because the registrations were rare compared to the other vegetation types. Hence, the vegetation types included in further analysis were “no vegetation” (R1a), “exposed rocky areas” (R1b) and “alpine ridge vegetation” (R2).

Several models were tested in order to estimate reindeer habitat use and the relationship between faeces density per km^2 (response variable) and the explanatory variables, including vegetation type, elevation and distance to trail. In addition, I included transect as a random variable for all models to account for variations between transect locations. All statistical analyses were performed in the statistical software R 3.1.0. (R-Development-Core-Team 2013).

First, I fitted density of pellets per km^2 (ln transformed) to a linear mixed-effect model (Pinheiro & Bates 2000), using the nlme package in R to test the difference in faeces density between the area in proximity to the trail, and the area located beyond 2 km. Secondly, I fitted the same model as above, including all explanatory variables. Several interaction terms were modelled and plotted in co-plots. Correlation was tested and found between elevation and distance to trail, which could not be assessed in the same model. For model selection, the least significant variable was removed using a backward elimination procedure until only the statistically significant terms were left in the model. Each removal was tested with an Analysis of variance test (ANOVA), and the new model was accepted or rejected according to Akaike´s information Criteria (AIC). In all cases, p-values ≤ 0.05 was considered statistically significant.

3. RESULTS

In total, 406 plots of vegetation distribution were made, including registrations of areas with no vegetation, exposed rocky areas and alpine ridge vegetation (Fig. 5). Out of the total number of vegetation plots, 217 plots were made along transects within 2 km from the hiking trail and 189 plots were made along transects beyond 2 km. Faeces (pellets and droppings) were found in 12.8 % of the total 406 vegetation plots (n= 52) (Fig. 6).

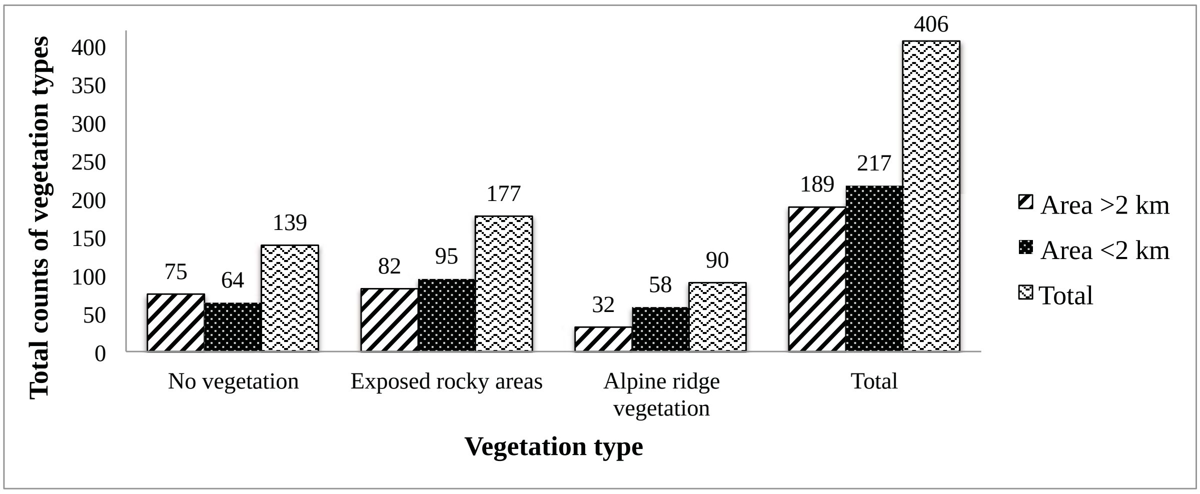

Figure 5: The total counts of different vegetation types (n=406), including areas with no vegetation, exposed rocky areas and alpine ridge vegetation, distributed in the area in proximity to the hiking trail (<2 km) and the area beyond (>2 km).

3.1 Avoidance behaviour

Faeces density per km^2 increased in relation to the distance from the DNT trail (Table 2; p=0.01), in correspondence to the increase of faecal counts (Fig. 7). In addition, the area located beyond 2 km from the hiking trail had significantly higher faeces density per km^2 compared to the area within 2 km from the hiking trail (Table 3; p=0.03) (Fig. 8a). There were no interaction between vegetation and distance to trail, or vegetation and elevation (p>0.05).

Table 2: Linear mixed-effect model for predicting faeces density per km^2 (ln transformed) in relation to vegetation and distance to the trail in Setesdal-Ryfylke wild reindeer area. Registrations of vegetation include areas with no vegetation (R1a), exposed rocky areas (R1b) and alpine ridge vegetation (R2). The model includes collated data from the entire study area.

Variable	Estimate	SE	df	*t-value*	*P-value*
Intercept	− 22.230	1.141	387	− 19.488	< 0.001
Distance to trail	0.001	< 0.001	387	2.608	**0.010**
Vegetation R1b vs R1a	− 2.435	1.074	387	− 2.266	**0.024**
Vegetation R2 vs R1a	− 1.576	1.292	387	− 1.220	0.223

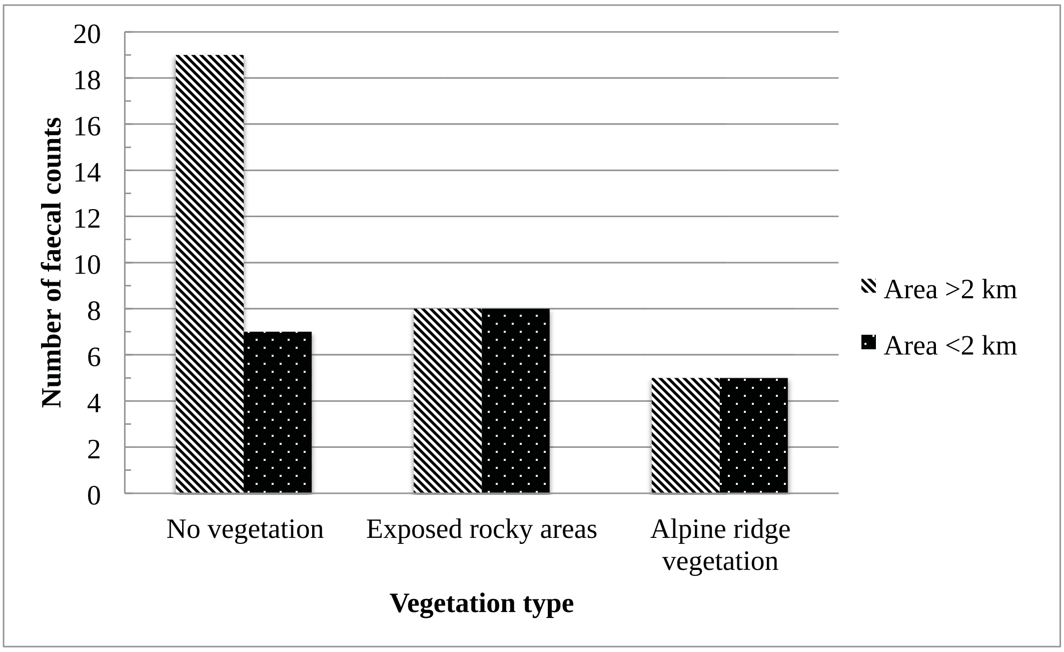

Figure 6: The number of faecal counts (n=52), both for areas in proximity to the hiking trail (<2 km) and areas beyond 2 km distributed on vegetation types, including areas with no vegetation, exposed rocky areas and alpine ridge vegetation.

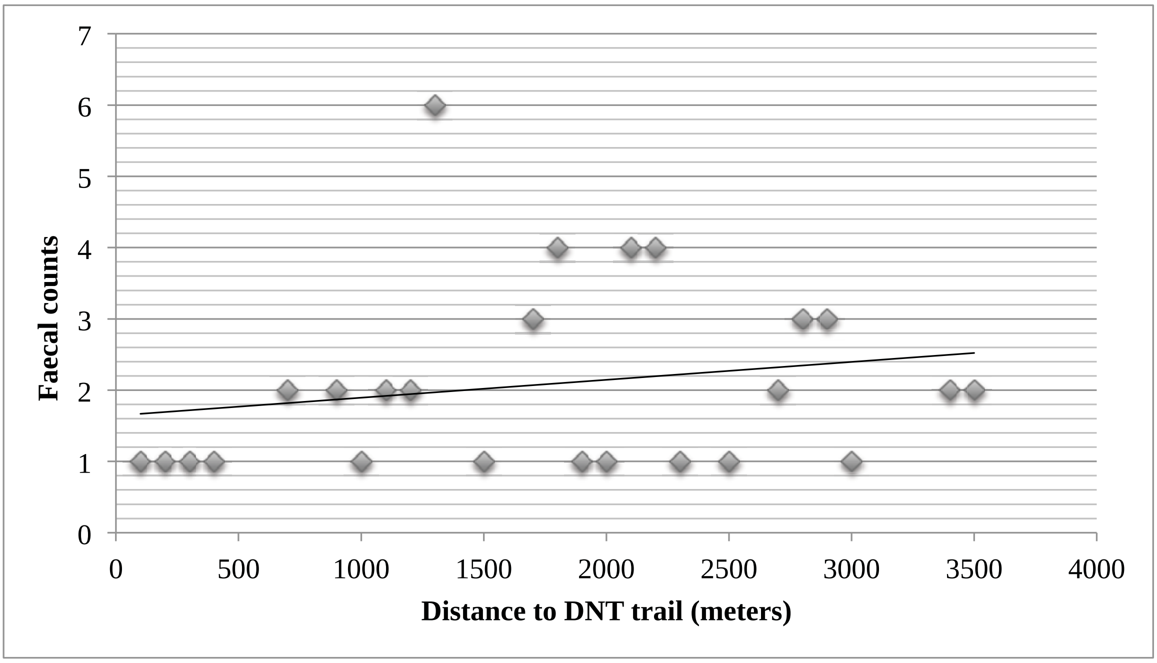

Figure 7: The total number of faecal counts (n=52) in relation to distance from the DNT trail in meters. Plot of raw data by a simple linear regression.

Table 3: Linear mixed-effect model for comparison of faeces density per km^2 (ln transformed) between the area in proximity to the hiking trail (<2 km) and the area located beyond 2 km in Setesdal-Ryfylke wild reindeer area. Transects located beyond 2 km had significantly higher density of faeces compared to transects within a 2 km range from the trail.

Variable	Estimate	SE	df	*t-value*	*P-value*
Intercept	− 14.706	0.527	390	− 27.923	< 0.001
Area	− 1.794	0.720	14	− 2.491	**0.026**

3.2 Habitat selection: Vegetation distribution and elevation

Exposed rocky areas were the most abundant vegetation type (177 registrations in total; 43.6 %), while alpine ridge vegetation was the least abundant vegetation type (90 registrations in total; 22.2 %) (Fig. 5). Areas with no vegetation had a total of 139 registrations (34.2 %). Significantly more reindeer faeces were found in areas with no vegetation compared to exposed rocky areas (Table 2; p=0.02, Table 4; p=0.02) (Fig. 8b). No significant difference was found in faeces density between any of the other vegetation types.

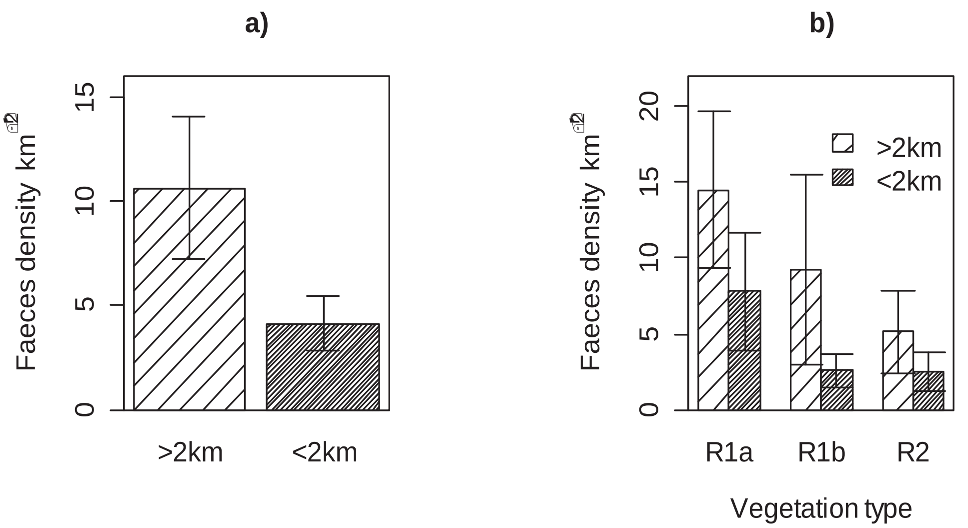

Figure 8: **(a)** Overall mean (±SE) faeces density in the study area, both for areas in proximity to the hiking trail (<2 km) and areas beyond 2 km. **(b)** Overall mean (±SD) faeces density for each vegetation type, including areas with no vegetation (R1a), exposed rocky areas (R1b) and alpine ridge vegetation (R2) both for areas in proximity to the hiking trail (<2 km) and areas beyond 2 km.

Elevation and distance to trail could not be included in the same model since they were correlated. Elevation had a significant effect on the observed faecal pattern in the study area (Table 4; p=0.03).

Table 4: Linear mixed-effect model for predicting faeces density per km^2 (ln transformed) in relation to vegetation and elevation in Setesdal-Ryfylke wild reindeer area. Registrations of vegetation include areas with no vegetation (R1a), exposed rocky areas (R1b) and alpine ridge vegetation (R2). The model includes collated data from the entire study area. Non-significant interactions-terms were removed from the model.

Variable	**Estimate**	**SE**	**df**	***t-value***	***P-value***
Intercept	− 62.480	19.380	387	− 3.224	< 0.001
Elevation	0.035	0.016	387	2.188	**0.029**
Vegetation R1b vs R1a	− 2.593	1.075	387	− 2.413	**0.016**
Vegetation R2 vs R1a	− 1.675	1.294	387	− 1.294	0.196

4. DISCUSSION

The faeces density increased in relation to the distance from the DNT trail (Table 2), and faeces density per km^2 was significantly higher in areas located beyond 2 km compared to areas in proximity to the trail (Table 3), both indicating reindeer avoidance towards the DNT trail. This corresponds with other findings where reindeer avoided areas with high human activity (Nelleman et al. 2000; Nellemann et al. 2010; Strand et al. 2013; Gundersen et al. 2013a). Hence, my avoidance-hypothesis is retained, but my prediction on reindeer avoidance caused by associations of humans may not be valid, as several natural factors determine reindeer habitat use.

A review study done by Vistnes and Nellemann (2008) concluded that the reindeer response towards disturbance differs substantially depending on the spatial and temporal scale. Studies performed on a local scale (up to 2 km from the human activity), were only able to detect effects on reindeer that were vague and short-lived. In contrast, studies done on a regional scale (criteria was to include at least a whole seasonal grazing range and an area further away than 2 km from the disturbance source) found that reindeer avoided disturbances several kilometres away (Vistnes & Nelleman 2008). In comparison to this review, my study is conducted on an expanded local spatial scale, but is still expected to cover a significant temporal scale and reindeer area use up to several years because of low decay rates of faeces in alpine environments (Skarin 2008).

4.1 Avoidance behaviour

It is challenging to exclude interacting and confounding biological factors and draw conclusions on observed faecal pattern as a direct result of human presence. When studying avoidance behaviour like in my study, it is desirable to obtain data from pre-establishment of hiking trails, since the long-term negative effects and possible avoidance will depend on the trail-characteristics (Gundersen et al. 2013b). Based on studies from Rondane-, Snøhetta- and Nordfjella wild reindeer areas (2009-2012), three main factors were found to influence the observed effect of hiking activities and avoidance by wild reindeer. A significant density of trail network, a high visitor intensity (people per day), as well as short distance between hiking trails and important reindeer habitats contributed to increased avoidance behaviour (Gundersen et al. 2013b). These factors are expected to differ substantially among wild reindeer areas in Norway (Strand et al. 2013), and based on these observations, a hiking trail is not a constant variable independent of area and relation to peripheral areas. Additionally, the number of hikers differs between seasons and within parts of a single reindeer area, influencing the potential disturbance frequency among animals. Some reindeer areas possess rather few trails and few visitors, while other areas consist of an expansive network of hiking trails, a significant number of visitors and have a substantial impact on the landscape through cabins and development of infrastructure in relation to recreational activities. For example, 70 % of the total number of visitors in the Dovrefjell-Sundalsfjella National park (Snøhetta wild reindeer area) make use of only 10 % of the total allocated area (Gundersen et al. 2013b).

Some reindeer areas (i.e. Nordfjella) have an apparent distinction between areas with few and unmarked trails used by hunters and local people, and areas with marked DNT trails used by most other visitors (Gundersen et al. 2013a). During the last ten years, an increased amount of hikers follow the marked trails and make use of the DNT cabins (Strand et al. 2013; Gundersen et al. 2013b). Hence, marked trails, skitrails and DNT cabins represent the most predictable hiking routes and the most predictable presence of humans. Thus, it might be possible to reduce the disturbance of reindeer by obtaining prediction in temporal and spatial scale through facilitation (Strand et al. Unpublished).

My study area in Setesdal-Ryfylke is less visited during summer if compared to popular hiking areas in Rondane and Snøhetta, and observance of avoidance may be challenging due to few visitors and unpredictable presence. During high season in Rondane, trail segments vary a lot in visitor-intensity, ranging from less than 1 person per day to 32 persons per hour, in contrast to my study area where the use is less documented and few trails exceed this wide spread number of visitors (Strand et al. 2011; Strand et al. 2013; Strand et al. Unpublished). The estimated number of hikers in my study area during summer season (1. June to 30. September) is 400-450 people, which equals an average of less than 4 visitors per day (Arnstein Salthammer Eide, personal communication, August 20, 2014). The negative effect on reindeer, however, is not necessarily less even if visitors are few. Unpredictable and random stimuli through few visitors in my study area may trigger more avoidance, flight and fright responses compared to trail-segments of extensive use and use on a regular basis. Reindeer and other ungulates are well known for their ability to habituate towards many types of stimuli and increased tolerance towards human activities can occur through constant and predictable stimuli (Reimers & Colman 2006; Reimers et al. 2010), which in this case involves many visitors at a predictable basis. Reindeer that are frequently exposed to human activity might get less stressed by it, compared to individuals exposed to low visitor intensity (Colman et al. 2001; Reimers et al. 2010).

It seems likely that over a period of several years since the DNT trails were established, reindeer in Setesdal-Ryfylke would enter the habituation process towards hiking trails. However, hunting is an essential part of Norwegian reindeer management, and represents an important source of disturbance caused by the hunters unpredictable movements in the landscape and the act of shooting and removing an animal from a herd (Reimers et al. 2008). I assume that reindeer in Setesdal-Ryfylke have been free ranging and hunted for several decades, and the general assumption is that hunting shapes fright behaviour in ungulates towards all human activities (Stankowich 2008). This, in addition to relatively few visitors and unpredictable movement may reduce the habituation process in Setesdal-Ryfylke. However, habituation processes have been proved for reindeer in hunted areas and for shorter time frames in relation to anthropogenic activities, both during a few years (Reimers et al. 2010) and within one single day (Flydal et al. 2004; Reimers et al. 2008).

4.2 Habitat selection: Vegetation distribution and elevation

It was not possible to control for the separate effects of explanatory variables in my study. Even though my hypothesis of avoidance is supported by my results, distinguishing the effect of human presence from the effect of other habitat variables is difficult.

There was significantly higher density of faeces in non-vegetated areas, including exposed rock and snow beds, even though exposed rocky areas with some vegetation was the most abundant vegetation type. Questions are addressed on whether the high faecal density in non-vegetated areas is caused by the reindeer's preferences to these areas, or simply by the fact that faeces are easier to register on non-vegetated ground compared to heather and grass where the faeces are more hidden. The difference among vegetation types may predict the reindeer habitat preferences within the study area, but does not necessarily explain the difference in faeces in relation to the distance from the hiking trail. A few more registrations of non-vegetated areas were done beyond 2 km compared to areas in proximity to the trail, but the number is not expected to be of significance (Fig. 5). Hence, the hypothesis of reindeer avoidance in relation to human presence is still supported.

Along each transect of 2 km, I registered changes in vegetation distribution (i.e. changes among the three vegetation types) more than 20 times, which means that reindeer cannot easily leave traces like pellets exclusively in the preferred vegetation type, and avoid the others. Vegetation distribution is undoubtedly an important factor for reindeer area use, however, in an area of such homogeneous habitat characteristics and proximity among different feeding options, we cannot assume that the observed faecal pattern in this study solely reflects the reindeer feeding preference during summertime. It may reflect the area use of short temporal scales or during special environmental conditions because of animal's trade-offs between quality foraging areas and areas in proximity to water, snow and shade, which are rarely included in studies.

Moreover, elevation had a significant impact on the observed faecal pattern, despite the limited variance in registrations, ranging from 1100 to 1300 meters above sea level. During statistical analysis, correlation was revealed between elevation and the distance to trail, likely caused by the hiking trail´s location in the terrain. Trails are commonly located in easy accessible areas where hiking is feasible, as in my study area where the location of the hiking trail at lower elevations and in proximity to Blåsjø is a good option to obtain an easy hiking route and hence, it is not located randomly. This cause difficulty in interpreting the observed relation between elevation, faecal pattern and distance to trail. Questions should therefore be addressed on whether the observed avoidance actually is a result of reindeer preference for areas with higher elevations. During summertime, reindeer prefer snow beds, as earlier shown, and high altitudes to avoid insect harassments and escape heat (Anderson & Nilssen 1998; Hagemoen & Reimers 2002; Skarin et al. 2004). In a study on semi-domesticated reindeer done by Skarin et al. (2004), the pellet group densities tended to be higher near a tourist trail that was located in higher altitudes, indicating an increase in reindeer tolerance towards humans in periods when insect harassment was severe. Skarin et al. (2007) confirmed that reindeer have a strong preference for rather high altitudes in the low-middle alpine region throughout the snow-free season, if in relation to high quality forage. As the hiking trail in my study area is located in proximity to a lake of significant size, this is expected to lead to comprehensive insect harassment during summer time. Hence, through preferences for higher elevation, in combination to snow beds, reindeer escape insect harassment and obtain easy access to wind for cooling.

5. GENERAL CONCLUSION AND MANAGEMENT IMPLICATIONS

This study found differences in faeces density that indicated reindeer avoidance in relation to a hiking trail in Setesdal-Ryfylke. However, the faecal pattern may reflect reindeer's preferences for higher altitudes and the trail's location at lower elevations, as correlation was revealed between elevation and distance to trail. Insect harassments are known to be an important factor determining animal's trade-offs between quality foraging areas and escaping plagues. Hence, the current indication of avoidance may not be related to the hiking trail itself or to reindeer's association of humans, but to elevation or other non-measured variables.

Since other studies have found negative effect of human disturbance on reindeer in relation to hiking trails, future studies should include extra robust study design to control the numerous environmental variables influencing reindeer behaviour, movement and area use over time. Pasture measurements and variation in topography alone are not sufficient to conclude whether reindeer area use has been influenced by human activity, and registrations of snow conditions, climate, insect harassment, natural barriers and fragmentation of the ranges should be included. Additionally, pellet count data should be corrected for possible differences in decay rate in different vegetation types (Skarin 2008). For future studies, it can be beneficial to include direct observations (i.e. GPS registrations), since a combination of direct and indirect measurements represents a good basis for interpreting reindeer area use over time.

For future development and the management of reindeer areas, stakeholders and management authorities would find it beneficial to obtain a set of data on the possible effect of human presence on reindeer populations, and the potential change in habitat use for decision-making. The outcome of this study can be used as predictions on reindeer responses towards human hiking activities and provide reliable guidelines regarding the planning and usage of new and existing DNT trails in several reindeer areas in Norway. Alternative management options include directing visitors to parts of wild reindeer areas that are known to be of less importance to the animals, and change the location of marked trails that currently fragment large continuously reindeer habitat.

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