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Hiking in Rondane Wild Reindeer Range: Human Trail Use and the Effect of Removing Trail Marks

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Preface

This thesis marks the end of my master's degree in Natural resource management at the Norwegian University of Life Sciences (NMBU). I want to thank my supervisors Professor Stein Ragnar Moe at NMBU and Vegard Gundersen at the Norwegian Institute for Nature Research (NINA) for giving me the possibility to write this thesis and guiding me through this whole project. Thanks for all helpful discussions, great text feedbacks and quick responses on e-mails. I want to give a special thanks to Stein Ragnar who helped me a great deal with the statistics. You have taught me a lot. Thanks to Vegard for sharing data from NINA and for giving me knowledge about the tourism and wild reindeer in Rondane wild reindeer range. I do also want to thank Sofie Kjendlie Selvaag for helping me with monitoring of counters, and to NINA for disposal of necessary equipment for my field work. Further I want to thank Finn Bjormyr, Erik Hagen, Espen Rusten and Per Erik Sannes from the Norwegian Nature Surveillance and Mountain Board for sharing their knowledge with me, and to all tourists I met for being interviewed. Finally, I want to thank my family and friends for lots of motivation and for supporting me from start to end!

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Abstract

Habitat loss caused by human disturbance is one of the largest threats to the wild reindeer (*Rangifer tarandus tarandus*) in Norway. Increasing infrastructure development and human use of marked trails and tourist cabins in wild reindeer areas are affecting the possibilities for wild reindeer to migrate and leads to separation between populations. Rondane wild reindeer range is probably the area with the most prominent conflicts between human and wild reindeer among the 24 ranges in Norway. To reduce human use in core wild reindeer areas in Rondane and elsewhere, the management have decided to remove problematic hiking trails, including signs, marks, as well as branding of them on maps and brochures. In this thesis I investigated the effect on the human use by removing of five hiking trails in Rondane wild reindeer range. The methods for sampling data of the human use were based on automatic counters, field observations and semi-structured interviews with experts and hikers during the summer of 2019. Two counters were installed on each trail, altogether ten counters, to record the number of hikers. The 2019 counter results were compared with similar pre-data to study if there is a change in human use before and after removal of trail marks. Observations were used to map hiker activity on and off trails, and interviews were used to get local knowledge of the former and today's use of the five trails. The current human use and effect of removal of hiking trail marks seems to be dependent of location, time since marking removal and user groups. Registrations from counters in 2019 showed relatively low and decreasing use over years. Still, there exist high variation in human use between the trails, and the trail with the highest use had four times as many hikers during the summer as the trail with the lowest use. Change in human use before and after removal of trail marks were tested at one of the trails, but no significant difference was identified. Removal of trail marks on this trail were done less than ten years ago, and it will be likely that it takes some time to see the effects. In addition, visitation to mountains may fluctuate natural from one year to another because of weather conditions etc. The main user group in this study were non-local Norwegian hikers on daytrips, who had visited the trails before. Hikers with knowledge to an area, in addition to local users, are not necessarily available of marked hiking trails and may be difficult to affect by removal of trail marks.

Table of contents

1 Introduction

A large proportion of wildlife worldwide is vulnerable to anthropogenic disturbances, and land degradation contribute to decline and great extinction risk for several species (IPBES, 2018; Yemshanov et al., 2019). Habitat loss and fragmentation is one of the largest threats towards biological diversity (IPBES, 2018). In Norway, wild reindeer *(Rangifer tarandus tarandus)* populations are particularly vulnerable because of large scale seasonal migrations for food and calving areas (Kjørstad et al., 2017). Fragmentation is affecting wild reindeer survival and reproduction by hampering their need to move, which is necessary to sustain gene flow and colonization of new areas where they can feed, rest, mate and raise newborns (Panzacchi et al., 2016). Disturbance effects may be divided in direct effects like flight reactions, regional effects like avoidance of certain areas and reduced survival and reproduction that ultimately have effects on population size (Flydal et al., 2019; Kjørstad et al., 2017). It is therefore important to identify ways to minimalize the consequences of these human disturbances on the wild reindeer.

To improve the work with management and conservation, it is important to understand the effect of anthropogenic activity, intensity and patterns on wild reindeer populations (Colman et al., 2017; Kaltenborn et al., 2014). While there are many studies of anthropogenic disturbance effects on wild reindeer, few have addressed spatial response to different disturbances, used before and after data when assessing effects of infrastructure development and research design are frequently inappropriate e.g. wrong scale, lack of before data, insufficient knowledge of confounding factors (Colman et al., 2017; Flydal et al., 2019; Panzacchi et al., 2013; Tsegaye et al., 2017). For example, many studies of indirect habitat loss due to avoidance of human disturbances rarely include data on the reindeer use of the whole range (Polfus et al., 2011). It has nevertheless been shown that avoidance of anthropogenic disturbances most likely will have long-term effects on wild reindeer, reducing carrying capacity that could affect population dynamics (Flydal et al., 2019; Kjørstad et al., 2017; Nellemann et al., 2000). Despite that there is limited knowledge about the effects of human disturbance on wild reindeer populations, especially when it comes to long-term effects on carrying capacity and population demography (survival and death rates), there is ample evidence that wild reindeer avoid humans and infrastructure (Kjørstad et al., 2017; Vistnes & Nellemann, 2008).

Wild reindeer will most often respond with decreased density with increasing infrastructure development, and the more fragmented and developed an area is, the greater is their avoidance (Gundersen et al., 2019; Vistnes et al., 2001). Once the density of infrastructure reaches a certain threshold, the reindeers may completely abandon these areas (Kjørstad et al., 2017; Vistnes et al., 2001), and this is most often the case in the fringe of the reindeer ranges where development of human infrastructure is most predominant. However, increasing recreational activities and tourism in the core areas of wild reindeer, including simple recreational infrastructure like T-marked trails, tourist cabins and bridges, will also affect the reindeer spatial use (Gundersen et al., 2019; Kjørstad et al., 2017). T-marked trails (hereafter called marked trails) are operated by DNT (The Norwegian Trekking Association), which manage several thousand kilometers of trails (recognized by red T's) across Norway (Den Norske Turistforening, n.d.).

A study done by Strand et al. (2014) from Rondane, Snøhetta and Nordfjella wild reindeer ranges, showed that if a trail is passed by more than 30 people per day in the tourist season, it may have negative effects on the reindeer's willingness to cross the trail. There is, however, large variation in the data material when it comes to context, and some trails are crossed with even quite high amount of tourists (e.g. 100 tourist per day) (Strand et al., 2014). Strand et al. (2014) never observed wild reindeer crossing trails with more than 220 tourists per day. Another study from Rondane wild reindeer range, mapping reindeer distribution from snowmobile, showed that maternal reindeer was avoiding tourist resorts and was hardly found within 10 km from a resort in winter (Nellemann et al., 2000). The same study also indicate a functional effect that overgrazing lichen mats in core winter areas was a result of avoidance from human infrastructure, the grazing pressure was considerably higher in areas 15-25 km away from the resort, and this was leading to reduced forage intake and further a lower productivity of the herd (Nellemann et al., 2000). The main way to deal with the overgrazing problem has been to manage wild reindeer population trough hunting, to maintain healthy populations adapted to the available resources (Kaltenborn et al., 2014). In the hunting season, between August 20th to September 10th , the wild reindeer may change their area use as a direct effect of hunters by using larger part of the range and use areas closer to roads and marked trails (Strand et al., 2014).

Panzacchi et al. (2013) found that presence of tourist cabins caused a complete abandonment by reindeers within one km radius from the cabin. They did also test the effects of hiking trails,

but found that they had highly variable impacts with no long-term effects on the probability of reindeer use (Panzacchi et al., 2013). However, these analyses were not including the human use of the trails and therefore did not consider effects of high variation in the use of the trail system. Contrary, in the study by Vistnes et al. (2001), the results showed that areas with ski trails had a negative impact of the reindeer distribution, compared to areas with no development. Therefore, the indirect habitat loss caused by development may have a greater importance than the direct habitat loss itself (Panzacchi et al., 2013). This may in the worst case prevent genetic exchange between reindeer populations, which already has been a problem in Norway for several years (Kjørstad et al., 2017; Røed et al., 2014). Recent researches are now focusing more on the wild reindeer spatiotemporal use of the whole range using GPS technology, and are thus better able to study effect of human use of infrastructure and development and how to minimize human-reindeer conflicts (Flydal et al., 2019; Gundersen et al., 2019; Panzacchi et al., 2016).

The last remaining populations of wild reindeer in Europe are located in Norway, where they are geographically split into at least 24 separate wild reindeer populations (Norwegian Environment Agency, 2018; Villrein.no, n.d.-b). In this study I focus on the Rondane wild reindeer range, which is defined as one of Norway's 10 national wild reindeer areas and also part of the European Dovre-Rondane wild reindeer region (Villrein.no, n.d.-b). Rondane wild reindeer range got its first regional plan for management of wild reindeer in 1992, with the twofold aim to achieve sustainable populations and area management by preserving important habitat and control the tourist traffic and development, in addition to preserve interests of other user group as for example local inhabitants and give grounds for further local development and entrepreneurship (Norwegian Environment Agency, 2018; *Regional plan for Rondane*, 2013). To reach all these often diverging and conflicting goals at the same time in the same area is demanding, and currently one of the main challenges for the management (Gundersen et al., 2019). Rondane National Park and Rondane wild reindeer range overlap to large extent in my study area, and the spectacular mountain area is a very popular destination for tourism. One of the main aim of the national park is to protect reindeer, but this is challenging because of intensive human use of the area (Strand et al., 2014). Nevertheless, management may adopt different tools and concrete measures to control tourism. For example simple informative and educational measure, towards concrete physical manipulation of the landscape (e.g. move, relocate, establish new infrastructure) and guiding the visitors to these arrangements, and

eventually regulations and prohibition by law that indeed are quite controversial in Norway (Gundersen et al., 2015; Hagen et al., 2019).

Many studies have focused on disturbance effects on wild reindeer in Norway, and a general result is that disturbance have several effects on the migration and area use of the species. In historical time, there seems to have been 3-4 large population of wild reindeer using most of the mountain areas in the Southern Norway, but today these have been fragmented to several isolated populations, and this fragmentation is still ongoing (Norwegian Environment Agency, 2018). At the same time the number of visitors to the mountain areas is increasing, and national parks and other larger protection areas should be more important for development of tourism and local economics (Norwegian Environment Agency, 2015). The national park management and policy authorities have thus implemented different programs to enhance the human use and at the same time protect the natural values. This include national tourist trails (e.g. Trolltunga, Kjerag, Besseggen), visitor strategies in all national parks that focus on local development in mountain communities, as well as branding strategies for the national parks (Norwegian Environment Agency, 2015). There is an urgent need for knowledge about disturbance effects on wild reindeer as a result of increased visitation, as well as research that documented the effects of management tools to handle the visitors in a way that they cause fewer negative effects on the wild reindeer populations (Gundersen et al., 2015).

More knowledge on how to minimize the negative effect on natural resources caused by human use in national parks are needed. With the aim to prioritize protection values before human use in the protection areas of Norway, the management authorities are strongly dependent on available tools to handle human use in a predictable way. Because restrictions and prohibition by law is a highly controversial measure in Norway due to the right of common access, concrete physical manipulation of the environment seems, together with information strategies, to be the most promising tool to redirect people to less vulnerable areas (Selvaag et al., 2020). To remove, relocate and establish new hiking trails and tourist cabins are examples of such concrete physical manipulation (Nellemann et al., 2010; Selvaag et al., 2020). My aim with this study was to improve our knowledge of the effects on the human use when trail marks have been removed (along with stop in marketing and removal of trail marks from maps etc.) in core wild reindeer areas.

Specifically, I asked:

1. What is the current human use of hiking trails?
2. Have the number of people using the trails decreased over time?
3. Are there any changes in use before and after removal of trail marks?
4. Who (i.e. local people, national or international hikers) is using the trails?

2 Materials and methods

2.1 Study area

The study was located in Rondane wild reindeer range in south-central Norway, in Innlandet county, and is placed between Gudbrandsdalen in the west and Østerdalen in the east (Figure 1). Rondane wild reindeer range consist of a total area of 3300 km^2, where the northernmost area is about 1200 km^2 and the southernmost 2100 km^2 (Villrein.no, n.d.-a). Rondane National Park is located in the northern part of Rondane wild reindeer range. Rondane was passed as a national park in 1962 and was the first national park to be established in Norway, covering an area of 963 km^2 (Miljødirektoratet, n.d.).

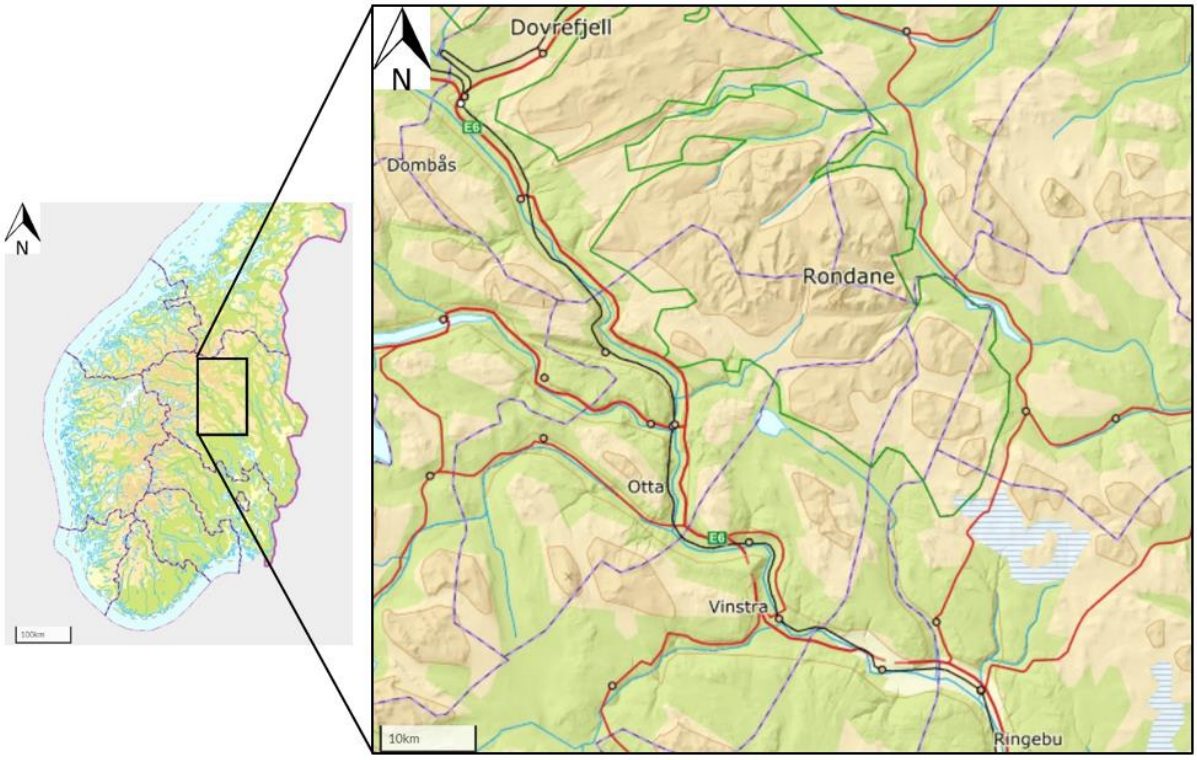

Figure 1 *Rondane wild reindeer range in Innlandet county, including the Rondane National Park (Norgeskart, 2019).*

The area is characterized by a continental climate regarding temperature, precipitation and other conditions (e.g. dry snow). The north and central parts of Rondane wild reindeer range consists of alpine landscape with ten peaks above 2000 meter and with several deep valleys located between the massifs. This part is suitable winter habitats for the wild reindeer because of easy access to tick lichens layers, with almost twice as much lichens available compared with the more oceanic climate at Hardangervidda, another important mountain plateau for reindeer in Norway (Kjørstad et al., 2017). The great deposits of lichens is caused by acidic and unproductive soil, which reflects the dominance of nutrient-poor vegetation (Schei et al., 2015). The southern part of Rondane consist of a more open and low-laying forest landscape, and are more well suited as summer grazing areas because of larger elements of mire, wetlands and boreal forests (Strand et al., 2014; Strand & Gundersen, 2019). Several old pitfalls are situated in the national park, showing that the wild reindeers had migration routes between southern and northwestern parts of Rondane, and even further west towards Dovrefjell (Jordhøy, 2008).

Rondane is a relatively small and an elongated mountain area. Main roads are laying close to the national park both on the western (E6) and on the eastern (Fv 27) side, according to the gravel road, Grimsdalsvegen, that cross over the reindeer range in the northern part which is in use during summer (Strand et al., 2014). Marked trails are used by a high numbers of hikers and the tourist traffic in Rondane are considerably larger compared to other protected areas in Norway (Strand et al., 2014; Strand & Gundersen, 2019). In total 48 883 cabins and holiday homes has been registered in Oppland (now part of Innlandet) in 2017, where almost 10 000 were placed in Rondane (Statistisk sentralbyrå, n.d.; Vorkinn et al., 2017). The numbers are still increasing, with 10 233 registered cabins within the area of the regional plan for Rondane-Sølnkletten per 1.1.2019 (Strand & Gundersen, 2019). All these factors make Rondane to one of the wild reindeer areas in Norway with the highest disturbance pressure from human recreational use (Kaltenborn et al., 2014).

The wild reindeer habitat use in Rondane and human use in these areas was studied in the period from 2009 – 2013, where several conflicts with use of marked trails by reindeers and humans were identified (Strand et al., 2014). It was then recommended that the management should monitor the future use of these trails, and that some trails should be closed or remarked in less vulnerable areas (Strand et al., 2014). Removal of trail marks to lead people away from reindeer core areas in Rondane was early implemented and are still ongoing (Strand & Gundersen, 2019). The tourists responding to such measures will probably vary among different user

groups, even though the general prediction is that the human use will be reduced following removal of trail marks (Gundersen et al., 2015; Hagen et al., 2019).

2.2 Study species

Wild reindeer are the most abundant large herbivore in tundra ecosystems and the herds migrate between seasonal resources like summer and winter grazing areas, calving areas, glaciers to avoid insects etc. (Kjørstad et al., 2017). They require large areas, and their area use in wintertime are mainly controlled by snow cover, lichens distribution and quality, and extent of human disturbances (Strand & Gundersen, 2019). In summer, they use the rich summer grazing areas and avoidance of insect on warm days is important. Reindeers have a great sense of smell and are especially sensitive for movements, which form the basis for their antipredator behavior (Kjørstad et al., 2017).

The total number of wild reindeer in Norway today are between 30 000 and 35 000 individuals (Norwegian Environment Agency, 2018). The management goal for the Rondane herd in wintertime is approximately 1600 individuals in the northern part and 2300 individuals in the southern part (Villrein.no, n.d.-a). Since 1950, the number of reindeer in Rondane has been surveyed, and GPS data from 2009 shows that the herds are restricted in the same areas in all seasons because of habitat fragmentation (Strand et al., 2014). In all 41 females have been GPS-collared in the period from 2008-2018 (Strand & Gundersen, 2019), and some radio-tracking have been done by Reimers et.al (unpublished) before that as well (Strand et al., 2014). Based on genetic analysis of archaeologic wild reindeer material, the todays wild reindeer stock in Rondane seems to represent the primary wild reindeer from this region (Kjørstad et al., 2017).

2.3 Study locations

The study was conducted in both the northern and southern part of Rondane wild reindeer range, in five case areas (Table 1) (Figure 2).

Table 1 *The case areas used in this study, and time of removal of trail markers.*

Case	Trail	Removal of trail markers
1	Fokstugu – Grimsdalshytta, through Foksådalen	2013
2	Rondvassbu – Dørålseter, through Langholet	1994 – 1995
3	Mysusæter – Bjørnhollia, through Musvorddalen	1994 – 1995
4	Mysusæter – Eldåbu, through Steinbudalen	1994 – 1995
5	Remdalsbua – Breitjønnbu	1995

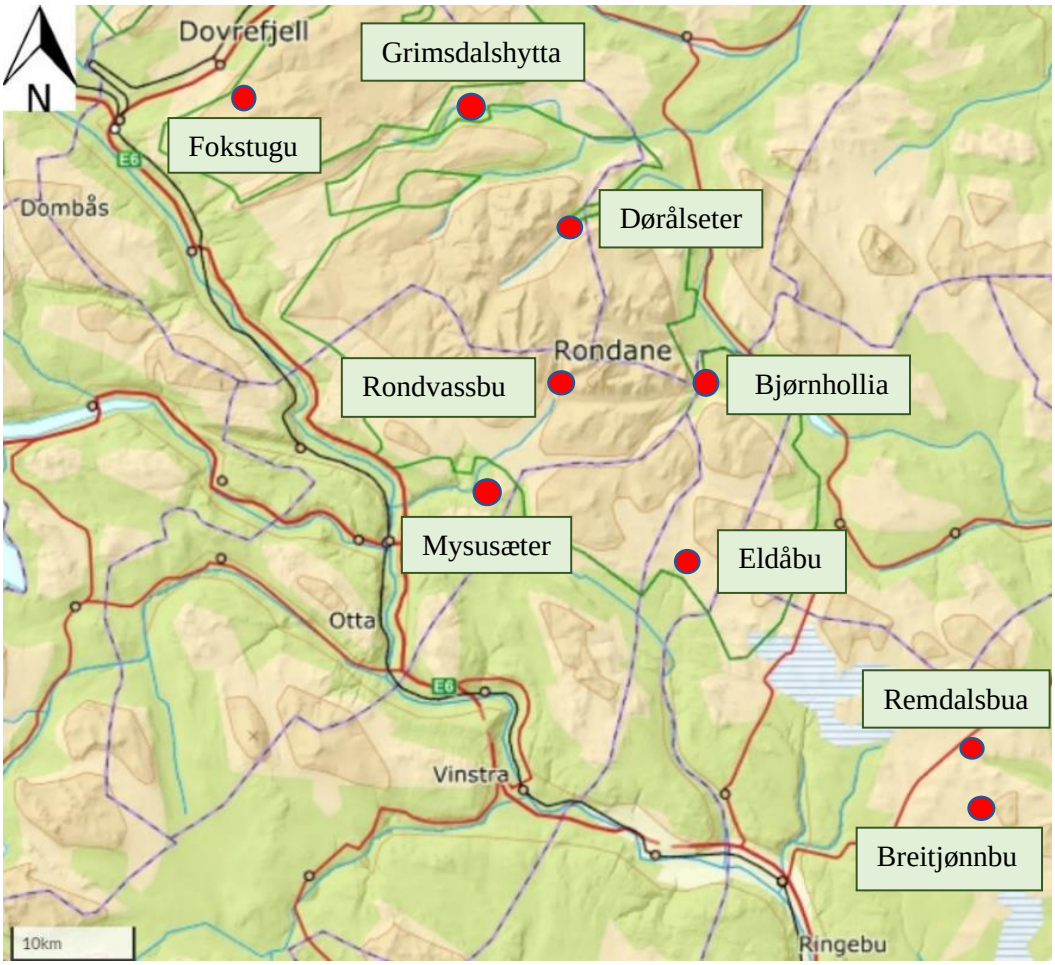

Figure 2 *Placement of the starting and ending point on the 5 study locations in Rondane wild reindeer range (Norgeskart 2019, paint).*

2.3.1 Fokstugu – Grimsdalshytta

From Fokstugu, the trail is part of The Pilgrim route towards Furuhaugli until they separate, and the trail to Grimsdalshytta continue to the east. The total length of the trail is approximately 20 kilometers (Figure 3).

Figure 3 *To the left: trail from Fokstugu in west to Grimsdalshytta in east, marked in red (Norgeskart 2019, paint). To the right: first part of the trail from Fokstugu in direction to Grimsdalshytta.*

The trail is clearly visible the first kilometers from Fokstugu, before it narrows and gets less visible further into Foksådalen. Some cairns are still preserved alongside the trail, indicating that this is an historical route. The trail is situated in an open landscape with soft mountain formations, which give good visual access (Figure 3).

Strand et.al (2014) predict future use of this trail after removal of marks in 2013: Questionnaires and studies about the tourist use of this area shows that local people most likely will continue to use the trail after removal of markings, but that the amount of international and several days tourists will be reduced, and by this way result in a net reduction in tourist traffic .

2.3.2 Rondvassbu – Dørålseter

From Rondvassbu, this trail is part of the new marked trail to Dørålseter in about 1.5 kilometers until they separate, and the previous trail to Dørålseter continue towards Storesmeden and Langholet. The total length of the trail is approximately 18 kilometers (Figure 4).

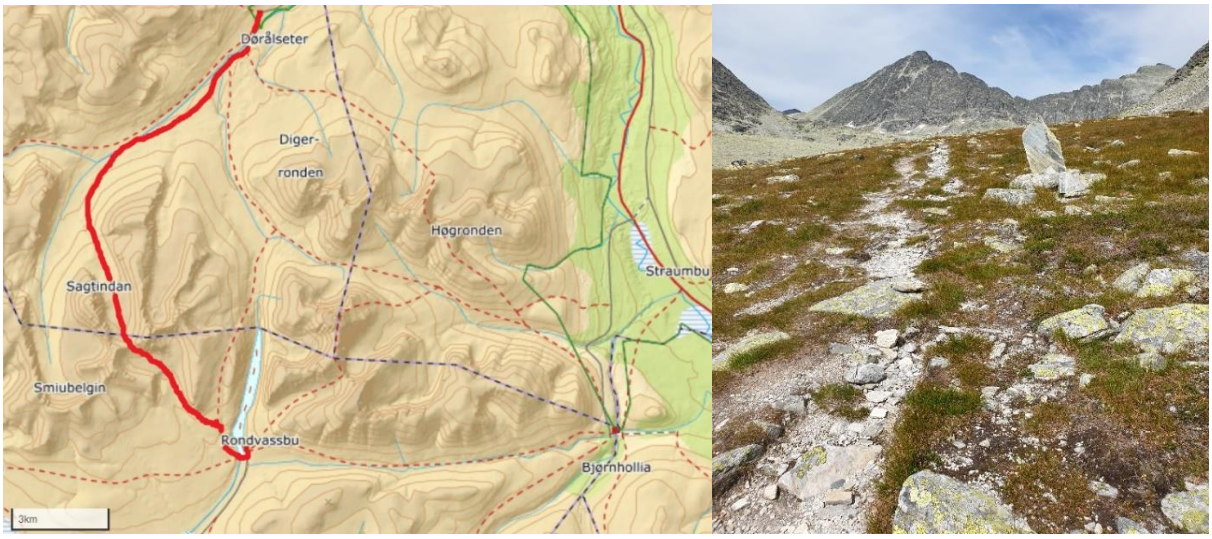

Figure 4 *To the left: trail from Rondvassbu in south to Dørålseter in north, marked in red (Norgeskart 2019, paint). To the right: the trail in direction from Rondvassbu to Dørålseter, with sight to Storesmeden.*

Several cairns are preserved along the trail, but the trail itself is not clearly visible and can be difficult to spot (Figure 4). The landscape is characterized by high mountains (the Rondane massifs) and deep valleys, and the terrain switch between steep and flat areas. Thus, the visual access is limited, and varies along the trail.

On printed maps, the trail is shown as marked from Rondvassbu to Storesmeden and further as unmarked towards Dørålseter (Kartverket, 2018). Rondvassbu was built in the beginning of the 1900s and is a popular tourist cabin with several thousand visitors every summer (Strand & Gundersen, 2019). The highest use in Rondane in 2019 was registered from Spranget to Rondvassbu, with 29278 registered hikers from 31th June to 1th October. Rondvassbu is often used as a starting point for several hiking routes to mountain summits in the area.

2.3.3 Mysusæter – Bjørnhollia

The trail starts at Mysusæter, more precisely by Indretjønne, and goes northeast towards Bjørnhollia. The total length of the trail is approximately 18 kilometers (Figure 5).

Figure 5 *To the left: trail from Mysusæter in west to Bjørnhollia in northeast, marked in red (Norgeskart 2019, paint). To the right: the trail in direction from Mysusæter towards Bjørnhollia, through Musvorddalen.*

The trail is wide and clearly visible the first two to three kilometers from Mysusæter before it crosses the river and narrows further into Musvorddalen (Figure 5). Some cairns are still preserved alongside the trail. The landscape is open, and mostly flat with element of small and soft mountain formations, which gives relatively good visual access.

Bjørnhollia is a popular tourist cabin in the northern part of Rondane. It is often used in summer by hikers from other tourist cabins as for example Rondvassbu, Dørålseter and Straumbu. Some tourists are also using the trail through Musvorddalen, most often local hikers and cabin owners on daytrips (Gundersen et al., 2016). The areas near Breitjønnbu offers important migration routes for the wild reindeer, especially in wintertime, and calving areas is also situated in this area (Strand et al., 2014). Management advice from earlier research stated that it is important to prevent new infrastructure establishment around Bjørnhollia to keep the tourist traffic at a low intensity level (Strand et al., 2014).

2.3.4 Mysusæter – Eldåbu

This trail has the same starting point as the trail to Bjørnhollia, and they are connected the first six kilometers before the trail to Eldåbu separate and continue southeast towards Steinbudalen. The total length of the trail is approximately 20 kilometers (Figure 6).

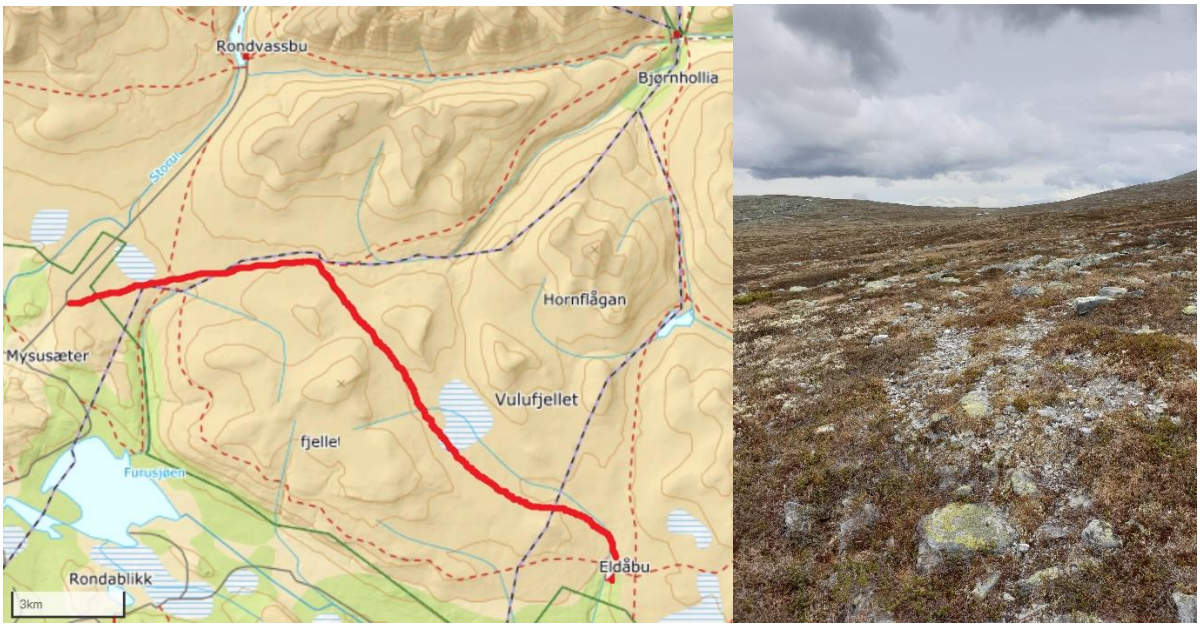

Figure 6 *To the left: trail from Mysusæter in west to Eldåbu in southeast, marked in red (Norgeskart 2019, paint). To the right: the trail in direction towards Eldåbu, through Steinbudalen.*

There are no or just a few cairns left on the trail in Steinbudalen, and it is difficult to spot after separation of the other trail (Figure 6). The landscape is open with slightly slopes, which gives great visual access.

Eldåbu is a self-service tourist cabin and is used in every season of the year, except in the reindeer calving season between 1st May to 10th June (Den Norske Turistforening, 2019a). There is minor information in the literature of the human and wild reindeer use in Steinbudalen.

2.3.5 Remdalsbua – Breitjønnbu

The old trail toward Breitjønnbu starts at Remdalsbua and goes further southeast towards Breitjønnhøgdene (Figure 7).

Figure 7 *To the left: trail from Remdalsbua in north to Breitjønnbu further southeast, marked in red (Norgeskart 2019, paint). To the right: first part of the rail from Remdalsbua.*

Breitjønnbu and the associated trail segment was located in the central part of the southern wild reindeer range and was removed and replaced by Jammerdalsbu in 1995, placed further southwest. Some cairns are still preserved on the previous trail to Breitjønnbu, especially from the start, and the trail is clearly visible (Figure 7). The landscape is wide and open, which gives good visual access.

Nellemann et al. (2010) analyzed the distribution of wild reindeer in wintertime before and after relocation of Breitjønnbu. The results showed that the human use was reduced in the previous location of Breitjønnbu and that reindeer moved into the restored areas, which indicate that removal of infrastructure to regulate human traffic and restore access to reindeer core areas are effective (Nellemann et al., 2010).

2.4 Data collection

The methods for sampling data of human use in the case areas was based on automatic counting, field observations and field interviews during the summer of 2019 (Table 2). Two automatic counters were placed out in each case area between 18th and 22nd of June and were collected between 24th and 25th September. They were used to register total number of passing hikers. The counters, of the type *EcoCounter*, are aggregating data every 15 minutes with a pyroelectric two-way sensor that contains a lens which is sensitive to heat radiation from human (or animals)

(Andersen et al., 2014). The sensors are capable to register direction (in or out) of hikers passing by (Andersen et al., 2014). The pyro-electric sensors were installed one meter above ground to prevent sheep, dogs and other smaller animals to be counted and the data storing unit were hidden as well as possible, either in stone cairns or in the ground (Figure 8). All data were loaded into the EcoVisio database. To avoid haphazard observations caused by different factors that interfered or disturb the counter regarding technical (e.g. sunlight, reflections) or field contextual errors (large animals, large arrangement) (Andersen et al., 2014), I decided to standardize the dataset. All counting's between 11.00 pm and 7.00 am have been removed (n=3166 removed), and mean numbers are used where both counters at the same trail showed passages between 0 and 60 (n=216 mean numbers). Further are all values showing more than 60 passages per day removed (n=44 removed).

In total, nine days with observations and interviews in the case areas were done in different periods between 11th July and 18th August, which includes the tourist season with highest intensity of use. I used two days in each case area, except in area three and four where I used three days, combining observations and interviews on both trails at the same time. Observations with binocular were used to map tourist activity, in form of position and direction, both on and off trails. Locations for observations were selected to areas with optimal visual access. Interviews of tourists passing by the trails, and phone interview with employee from SNO (Norwegian Nature Surveillance) and Mountain Board were used to get information of the current users, and previous and present use of the area. The interviews were semi-structured with possibility to add more questions depending on the respondent's answers.

Figure 8 *One of the counters used in this study, placed and hided in a stone cairn.*

Table 2 *Methods for sampling data of human use in the case areas.*

	Fokstugu – Grimsdalshytta	Rondvassbu – Dørålseter	Mysusæter – Bjørnhollia	Mysusæter – Eldåbu	Remdalsbua – Breitjønnbu
Distance covered in data collection	0 – 5 km	0 – 4 km	0 – 8 km	0 – 7 km	0 – 5 km
Counters (numbers)	2	2	2	2	2
Observations (hours/number of hiker observations)	8/12	9/12	11/11	11/0	7/2
Interviews (number of tourists)	3	11	9	0	0
Interviews (numbers of experts)	2	3	2	3	1

Document studies (x=yes)	x	x	x	-	x
Access to earlier counter data (x=yes)	x	-	x	-	-

Previous counting data from the Norwegian Institute for Nature Research (NINA) on marked and unmarked trails in Rondane wild reindeer range have been used as reference or as standard of comparison with my registrations on the particular trails studied. Especially, NINAs counting data on the trail from Fokstugu to Grimsdalshytta (back to 2011) and Mysusæter to Bjørnhollia (back to 2009) have been compared with my registrations to test for change in human use over time.

Counters at the trail from Remdalsbua to Breitjønnbu were not able to locate, and thus not collected, because the counters were hidden by deep early snow. Earlier counting data from marked and unmarked trails near the location of Breitjønnbu have been used as a reference to my results from the interviews and observation at this trail.

2.5 Data processing and statistics

All statistical analyses were conducted in RStudio version 3.5.2 (R Core Team., 2018).

The trail from Fokstugu to Grimsdalshytta and Mysusæter to Bjørnhollia were statistically tested for change in human use from 1st July to 23rd September between all year with earlier registrations. Generalized linear models (GLM) were used to test relation between the response variable "number of hikers" and the explanatory variables "year", "month" and "before vs after removal of trail marks". Differences between periods were considered to be significant at $P < 0.05$. Because of overdispersion in the poisson and quasipoisson model I used negative binomial regression analysis (R function *glm.nb*). I started model selection using a model with all explanatory variables, before I subsequently eliminated the least significant and ended up with the most parsimonious model. Reduced models were compared by using a likelihood ratio test.

3 Results

3.1 Current human use

The largest human use based on the counting's in 2019 was registered at the trail from Rondvassbu to Dørålseter, with more than four times as many hikers than at the trail from Mysusæter to Bjørnhollia, with the lowest registered use (Table 3). From the interviews, the experts argued that the trail from Rondvassbu to Dørålseter is still used by hikers mainly because of the attractive peaks in this area. The trail from Fokstugu to Grimsdalshytta had the second highest use, and experts from SNO argued that the use of this trail segment is highest at the first kilometers from Fokstugu where the counters were placed. Further towards Grimsdalshytta, the trail is less visible and partial overgrown, which indicate a lower use level. The current human use on the trail from Mysusæter to Eldåbu are according to the experts very low, and there are no attractions leading tourists to this location. Results from the counters did nevertheless show twice as much use at the trail from Mysusæter to Eldåbu than the trail from Mysusæter to Bjørnhollia.

Table 3 *Total number of hikers, registered from the counters, on each trail in different years from July 1th - September 23th. Recordings at the trail from Mysusæter to Bjørnhollia in 2009 are from July 15th, and in 2010 from July 18th.*

Year / Trail	2009	2010	2011	2012	2013	2014	2015	2016	2019
Fokstugu – Grimsdalshytta	-	-	1742	584	1225	1122	1305	720	939
Rondvassbu – Dørålseter	-	-	-	-	-	-	-	-	1047
Mysusæter – Bjørnhollia	1482	776	781	742	-	-	-	-	239
Mysusæter – Eldåbu	-	-	-	-	-	-	-	-	550
Remdalsbua – Bjørnhollia [1]	-	-	-	-	-	-	-	-	-

[1] No counting data at this trail.

The counters registration of human use during the summer of 2019 were overall highest in July, except on the trail from Mysusæter to Bjørnhollia were August had the highest use (Figure 9). The use on the trail from Rondvassbu to Dørålseter and Mysusæter to Eldåbu in July where about three times higher than in August. September had the lowest use in all case areas, with less than half of the use in August in all trail segments.

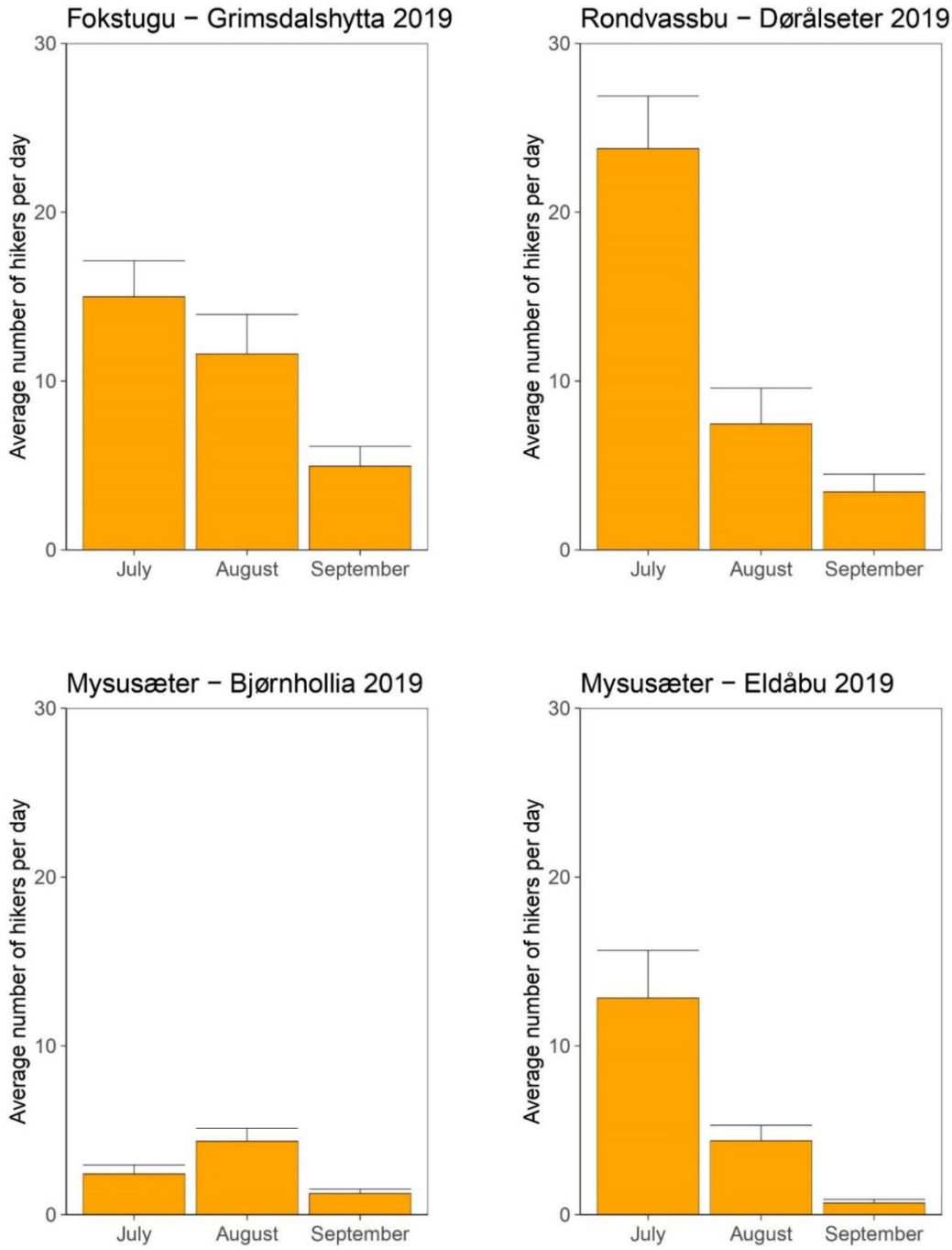

Figure 9 *Average number of hikers (±SE) per day in the study areas (except the trail from Remdalsbua to Breitjønnbu) from 1st July to 23rd September in 2019.*

3.2 Change in human use over time

The statistical analysis showed that it was a decreasing trend in human use over years on the trail from Fokstugu to Grimsdalshytta and Mysusæter to Bjørnhollia (Table 4) (Table 5). The human use on the trail from Fokstugu to Grimsdalshytta in 2019 were lower (177 hikers less) than the average use from the previous years (1116 hikers per year), but still higher than in 2012 and 2016 (Table 3). No significant change before and after removal of trail marks from Fokstugu to Grimsdalshytta were found (negative binomial regression: P = 0.124, SE=0.237), although the use from 2011 to 2013 (before removal) had an average of 161 hikers more per year than the year after removal of trail marks (Table 3) (Figure 10). The employees from SNO argued from the interviews that the human use of this trail has never been extremely high, but that the tourist traffic still had declined after removal of marking and stop in marketing.

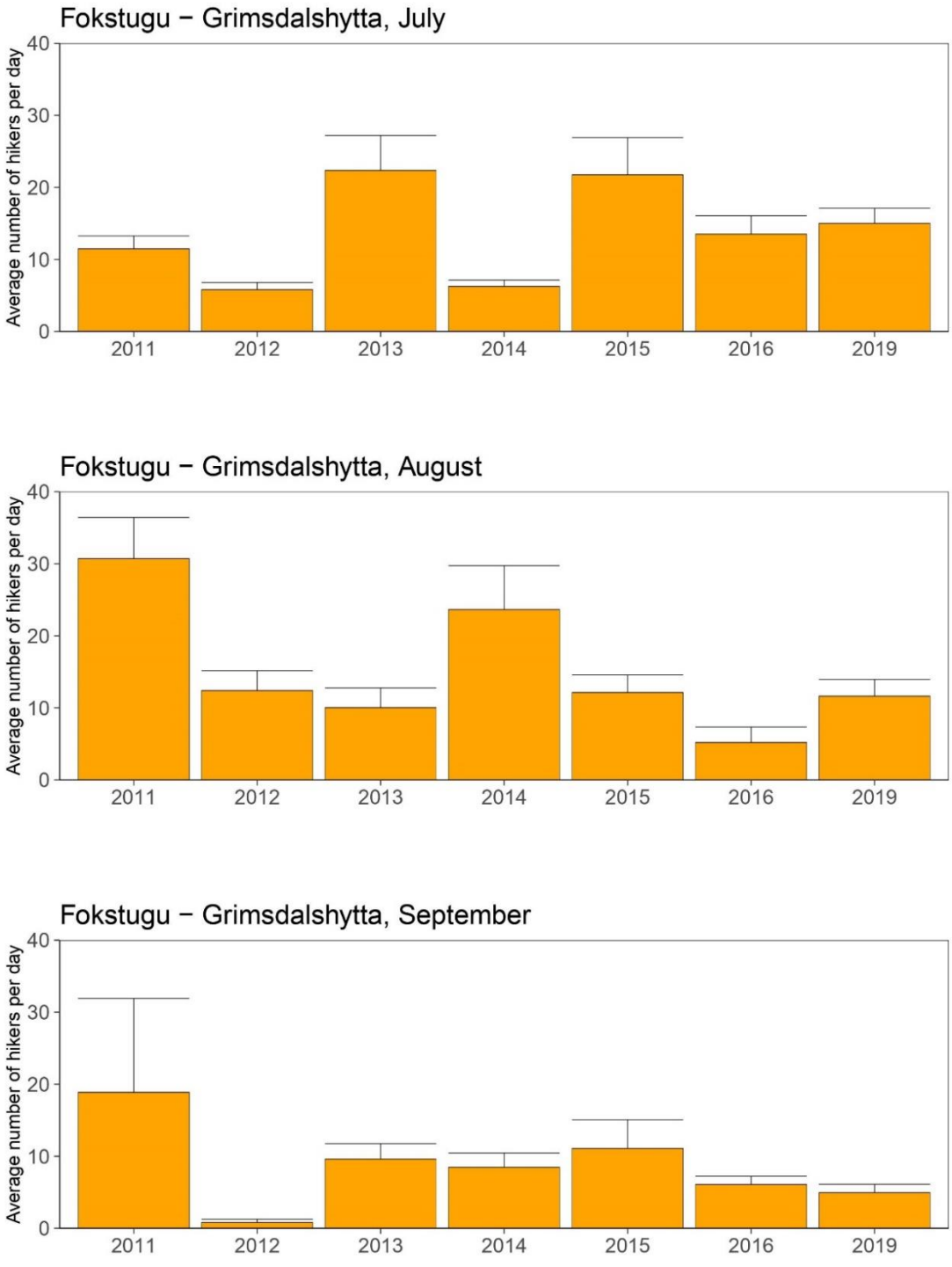

Figure 10 *Average number of hikers (±SE) per day on the trail from Fokstugu to Grimsdalshytta from 1st July to 23rd September in 2011-2016 and 2019. Markings were removed during summer of 2013. The year 2011-2013 are representing the before-data.*

There was a significant decrease in human use over years and the use is predicted to be largest in July and August (Table 4) (Figure 11).

Table 4 *Number of hikers (response variable) in relation to years and months on the trail from Fokstugu to Grimsdalshytta using a negative binomial regression model. The non-significant variable "before vs after" was not included in the most parsimonious model.*

	Estimate	SE	Z value	P value
Intercept	2.93	0.153	19.2	< 0.0001
Year	-0.0702	0.0295	-2.38	0.0172
August	0.0335	0.137	0.243	0.807
September	-0.523	0.15	-3.49	<0.001

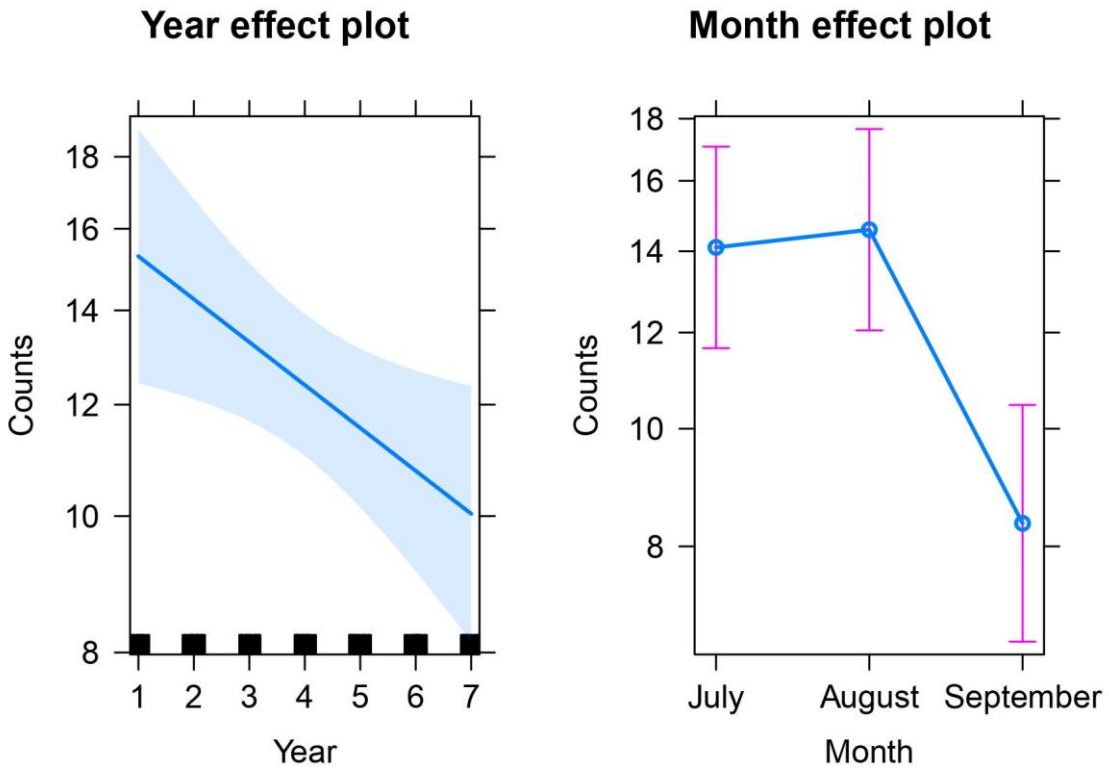

Figure 11 *Predicted human use ("counts") in different years (left graph) and months (right graph) at the trail from Fokstugu to Grimsdalshytta. The prediction was based on the model from Table 4.*

There was a significant decrease in human use over year on the trail from Mysusæter to Bjørnhollia (Figure 12) (Table 5). The human use in 2019 on this trail was the lowest registered in all years (Figure 12) (Table 3). The expert's impression is that this trail is still used by some hikers, with the main use concentrated at the first part of the trail segment, between Mysusæter and Fremre Gjetarbu.

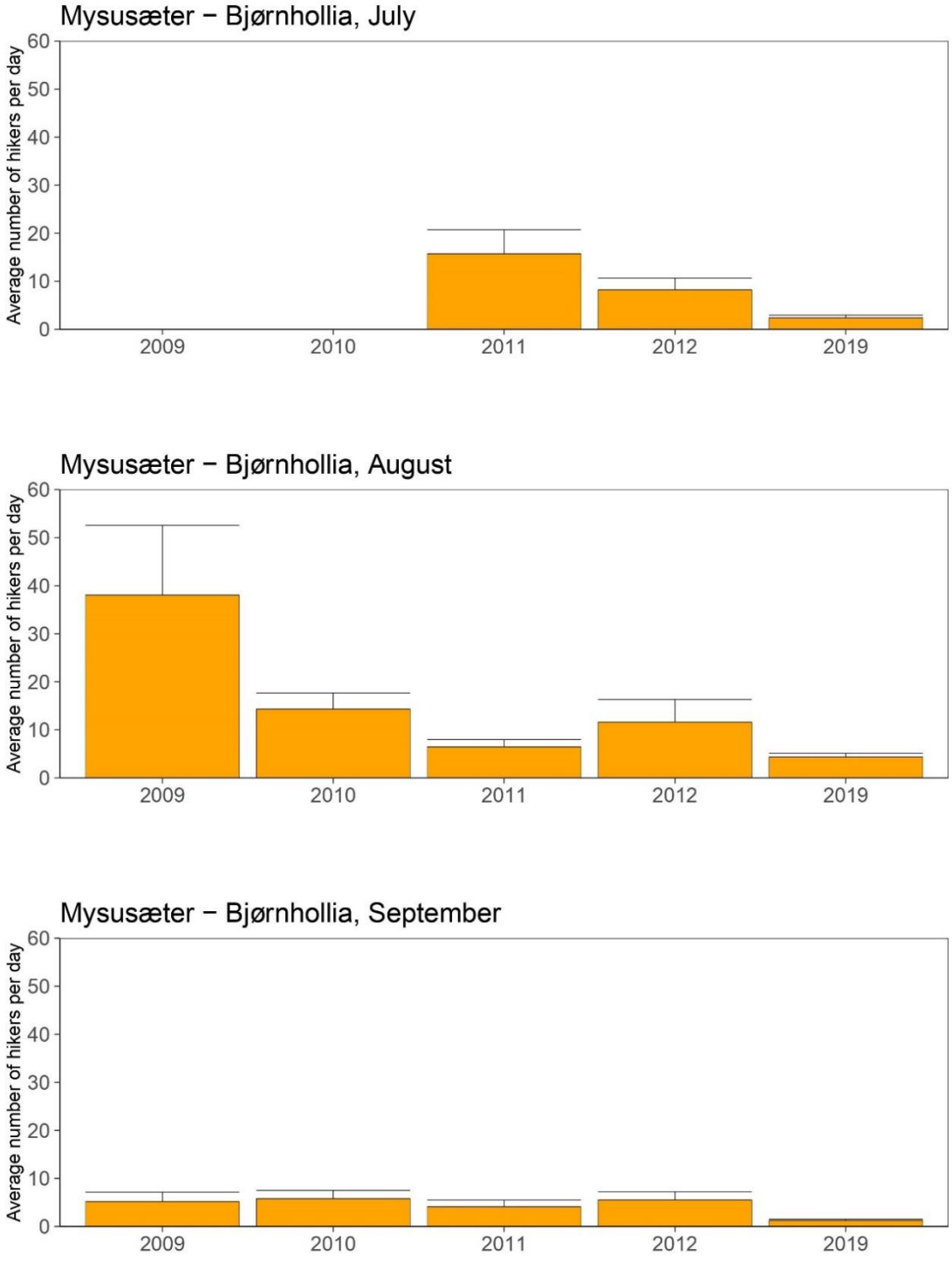

Figure 12 *Average number of hikers (±SE) per day on the trail from Mysusæter to Bjørnhollia from 1st July to 23rd September in 2009-2012 and 2019. Markings were removed in 1994-1995.*

Table 5 *Number of hikers (response variable) in relation to years and months on the trail from Mysusæter to Bjørnhollia using a negative binomial regression model.*

	Estimate	SE	Z value	P value
Intercept	3.48	0.233	14.9	<0.0001
Year	-0.389	0.056	-6.94	<0.0001
August	0.172	0.185	0.926	0.354
September	-0.877	0.203	-4.32	<0.0001

The human use on the three other trail segments have also decreased after removal of trail marks, according to the experts. The expert's impression is that there has been a shift in the hikers prioritizing of hiking trails, in which todays hikers are selecting shorter and faster hiking routs instead of hiking from cabin to cabin, which was more common in previous years. This can be illustrated by the trail from Rondvassbu to Dørålseter where the number of hikers going all the way Dørålseter have decreased, even if the trail segment is still used. Removal of trail marks on the trail from Mysusæter to Eldåbu is the most successful example in which this is an effective measure, according to SNO and Mountain Board. The great decline in human use have resulted in substantial revegetation on the trail segment, and one expert state that about 200 wild reindeer were observed in this area in the summer of 2019.

Experts argued that most of the tourist traffic from Remdalsbua to Breitjønnbu have been reduced and that the effect of moving Breitjønnbu have been positive. Some tourists may nevertheless visit the flight wreck located south from Breitjønna in addition to hike on the old traffic artery from Åsdalsætra and further southwest in direction of Jammerdalsbu. Counters on this trail segment registered 222 hikers from July 1st to September 23rd, 2016, which is lower than all my tourist registrations on the four other trails in 2019 (Table 3). The Mountain Board stated that most of the human use are concentrated in other areas adapted for tourism, especially trail segments connected with Jammerdalsbu. Counting's west and east of Friisvegen (Fv 2204) along the marked trails to Jammerdalsbu, showed an average number of 2227 (SD±759) hikers from July 1st to September 23rd, 2011. An average of 1980 (SD±62) hikers used the trail segment leading southeast from Jammerdalsbu in direction of Saubu and Vetåbua in the same period in 2010.

3.3 Who are the users

In total 37 tourists were observed, and 23 tourists were interviewed in this study. The largest user groups were Norwegian tourists, representing 74 % of all tourists interviewed (Table 6). Local and international tourists comprised 13 % each. The experts informed that the users of the trail from Fokstugu to Grimsdalshytta, Mysusæter to Eldåbu and Remdalsbua to Breitjønnbu are dominated by local hikers and hunters. Further they informed that Norwegian tourists are the main user group on the trail from Rondvassbu to Dørålseter and from Mysusæter to Bjørnhollia, in addition to some local hikers on the latter trail.

Table 6 *Number of tourists interview in all study areas, and distribution of user groups.*

	Locals	Norwegian tourists	International tourists
Fokstugu – Grimsdalshytta	2	1	0
Rondvassbu - Dørålseter	1	10	0
Mysusæter - Bjørnhollia	0	6	3
Mysusæter - Eldåbu	0	0	0
Remdalsbua – Breitjønnbu	0	0	0

In all, 74 % of the tourists interviewed were on daytrips. The other 26 % were going to stay for two or three days, all of them close to the trail from Mysusæter to Bjørnhollia. The frequent visitors were representing 87 % of all tourists interviewed, were all of them had been in or nearby the case areas one or more times before. Three of them had also a cabin at Mysusæter. The rest 13 % were first-time visitors, two of them hiking on the trail from Mysusæter to Bjørnhollia and one on the trail from Rondvassbu to Dørålseter.

In interviews with tourists I got the impression that the trail from Fokstugu to Grimsdalshytta and the trail from Rondvassbu to Dørålseter were most used in connection with mountain summit trips, especially for the latter trail were nine out of eleven tourists were going on peaks nearby higher than 2000 meter above sea level. This was also the expert's impression.

Many tourists were attracted to the case areas because of the nature and feeling of wild nature, and many did in addition describe the case areas as easily accessible and passable. Some tourists were preferring to hike on unmarked trails to avoid other hikers and feel quietness. In total 27 % of the hikers were observed off the trail in the study locations, while 73 % were observed on the trails (Table 7). All tourists observed off the trail in the study locations were following

another unmarked trail nearby, except from two tourists observed freely in the terrain nearby the trail from Rondvassbu to Dørålseter.

Table 7 *Total number of observed hikers in all study areas, both on and off trails.*

	On trail	Off trail
Fokstugu – Grimsdalshytta	8	4
Rondvassbu - Dørålseter	10	2
Mysusæter - Bjørnhollia	9	2
Mysusæter - Eldåbu	0	0
Breitjønnbu	0	2

4 Discussion

I found a significant decrease in human use on the trail from Fokstugu to Grimsdalshytta and from Mysusæter to Bjørnhollia, but no significant change before and after removal of trail marks from Fokstugu to Grimsdalshytta. The use was generally highest in July and lowest in September, except for the trail from Mysusæter to Bjørnhollia where August had the highest use. Most tourists were non-local Norwegians (74 %) and almost all tourists were observed on a trail (73 %).

The removal of the trail marks from Mysusæter to Bjørnhollia seems effective over time. Human use of this trail have changed from an average of one to three hikers per hour (Strand et al., 2014) to two to three hikers per day in my study. Non-local Norwegians and international hikers were the main user group of this trail segment. Former studies have shown that management restrictions like removal of trails tends to affect user groups differently, for example that non-local Norwegians and international hikers prefer to follow marked trails (Gundersen et al., 2015; Vistad & Vorkinn, 2012), in opposite of what is found by the local users. However, the Norwegian tourists at the trail from Mysusæter to Bjørnhollia were visitors who had visited the same areas before and the foreign hikers were all adventure seekers. These user groups have been shown to be more challenging to affect with management measure like removal of trail marks (Gundersen et al., 2015; Selvaag et al., 2020), and this may explain todays current human use of this trail.

The use of the trail from Fokstugu to Grimsdalshytta has been reduced over years, without showing any significant difference before and after removal of trail marks. My data indicate that the trail is used by an average of 0.6 persons per hour during the summer of 2019. This may be a few less compared with the data from Strand et al. (2014), collected before the trail marks on the trail from Fokstugu to Grimsdalshytta were removed, with a use close to one person per hour. This support my results in that I found a decrease over years but no difference in human use before and after removal of trail marks. According to the experts interviewed in this study it may take about ten years before the effect of trail mark removal can be measured, which is the case on the trail from Mysusæter to Bjørnhollia. The effect of trail mark removal on the trail from Fokstugu to Grimsdalshytta may therefore be more apparent in the coming years. In 2012 there was a low number of users at the Fokstugu trail due to several haphazard circumstances like bad weather in July and low hunting activity in September. This illustrates that it is also important to consider natural variation such as weather, arrangement etc., because such variations may complicate comparison of human use between years. This is especially the case on the trail from Fokstugu to Grimsdalshytta, where the time since removal of trail marks is relatively short (less than ten years). In addition, the users of this trail are, according to this study, mainly local hikers. This user group does often have a strong attachment to the place and culture (hunting, fishing, berry picking) and may be difficult to affect by management of trail segments (Gundersen et al., 2015; Muñoz et al., 2019; Selvaag et al., 2020).

I found that the trail from Rondvassbu to Dørålseter have the highest use of all trails in this study. The trail is passed by an average of 0.8 person per hour, which correspond with results from Strand et al. (2014), showing a use of about one person per hour. This indicate no or minimal reduction of the human use at this trail segment from 2014 to 2019. I found that the main users of the trail from Rondvassbu to Dørålseter are non-local Norwegian tourists on mountain summit trips. Gundersen et al. (2015) argued that this user group may adapt to new areas more easily than local hikers, but this seems not to be the case on this trail. The reason is most likely connected with the alpine landscape around the Rondane massifs, which is a popular attraction, with or without marked trails (Strand et al., 2014). It has been shown that trails containing attractions along the segments are more visited than trails without attractions (Svobodova et al., 2019). In a study from Jotunheimen National Park, where differences in spatial priorities among tourists were examined, they found that Norwegian and international tourists valued the mountain landscape and iconic peaks in the national park (Muñoz et al., 2019). This comply with my results from tourist interviews on the trail that passed high summits

from Rondvassbu to Dørålseter. Therefore, my results support Strand et al. (2014) who found that the human use on the first part of the trail from Rondvassbu to Dørålseter was quite high, and the areas nearby still will contribute to maintain a large use in the future because of the mountain summit attractions. In addition, the fact that the first part of the trail is still marked on some printed maps and that stone cairns are still preserved along the trail, is also contributing to sustain the tourist traffic in this area.

The human use of the trail from Mysusæter to Eldåbu are very low according to my results from interviews and observation, with local hikers and hunters as the main users. The trail was difficult to detect, only sporadically visible in the terrain, and no tourists were observed. This is supported by Strand et. al (2014), who state that the human use of this trail segment is at an absolute minimum. In addition, the observation of wild reindeers in this area during the summer of 2019 and the distribution of GPS observation along the trail (Strand et al., 2014) indicate that the disturbance ratio from humans have been reduced.

As opposed to the expert's opinions and my observations, the counters showed more than twice as high use on the trail to from Mysusæter to Eldåbu than on the trail from Mysusæter to Bjørnhollia. Some of these registrations may of course have been local users, which may often select to hike off trails because of their knowledge and attachment to the place (Gundersen et al., 2015). July is the month with most counts, and this may be a result of daytrips from the locals or cabin owners at snow free areas and herding activity early in the season. However, some "outlayer" number of counter registrations are likely associated with errors. For example, during one of my observation days on the trail from Mysusæter to Eldåbu (12th July) with no hikers observed, the two counters had registered 169 and 1628 hikers, respectively. Several domestic sheep were observed in this area and may have been registered by the counters. Direct sunlight, blowing vegetation and other animals passing by the sensor may also have caused such extreme registrations (Andersen et al., 2014; Pettebone et al., 2010).

Extreme observations and variations between counters were not only a single pass occurrence and were also detected at the other trail segments. This gives reasons to ask questions about the counter's reliability (Pettebone et al., 2010). Pettebone et al. (2010) state that use of automated counters is subject to several source of errors, that data from automated counters requires to be calibrated to generate reliable estimates of human use and emphasizing the importance of additional sampling like direct observations. In my study, I standardized the dataset by

excluding unlikely large numbers and using mean numbers between counters at each trail (see 2.4 Data collection). My direct observations were important to confirm some incorrect registrations from the counters. In my study, the two counters at each trail were placed at different places along the trail segment and may therefore have been exposed to different disturbances. The optimal solution had been to place them side by side, to make them more comparable. However, there is still a need for standardized methods to calibrate counters that gives a reliable estimate of the human use (Pettebone et al., 2010). This is challenging because of the large amount of errors that may affect the registrations, and that errors may be difficult to declare. Knowing which registrations comes from hikers and errors may therefore be a problem, which was the case in this study.

The current human use on the trail from Remdalsbua to Breitjønnbu are low according to my data from observations and interviews with experts. However, stone cairns and some markings along the trail make it relatively easy to follow, contrary to the trail from Mysusæter to Eldåbu. Markings at these two trails were removed at the same time for more than 20 years, but the trail from Remdalsbua to Breitjønnbu is still visible. This may indicate a greater human use on this trail than the trail from Mysusæter to Eldåbu (Hagen et al., 2019). The use of the traffic artery from Åsdalsætra are also indicating a very low human use in this area. In addition, counting's from marked trails connected with Jammerdalsbu are indicating intensively use of these segments and that the main tourist traffic is concentrated on the marked trail segments. This supports the expert impression that the tourist traffic now is concentrated in areas designated for hiking tourism.

It is likely from my data that relocation of Breitjønnbu to Jammerdalsbu have been effective to move the tourist traffic away from vulnerable areas for wild reindeers (see also Nellemann et al., 2010). A similar project has now been executed with the former tourist cabin Gråhøgdbu, placed between Jammerdalsbu and Eldåbu. Gråhøgdbu was closed in January 2020 and replaced by Veslefjellbua further west in the fringe area of the wild reindeer range (Den Norske Turistforening, 2019b; Strand & Gundersen, 2019). This project is also involving closing of long distances of marked trails previous connected with Gråhøgdbu (Strand & Gundersen, 2019). Nellemann et al. (2010) showed that wild reindeer responds rapidly to reduction in tourist traffic, which probably will be the outcome with removal of Gråhøgdbu.

Management restrictions in national parks, like removal of trail marks (Gundersen et al., 2015), and the feeling of locals to be monitored for example by automatic counting, may bring some conflicts (Haukeland et al., 2011). In my study, I discovered problems with illegal remarking's on the trail from Rondvassbu to Dørålseter and the trail from Remdalsbua to Breitjønnbu. During interviews with SNO and Mountain Board, they stated that there have been problems with illegal remarking at the trail from Rondvassbu to Dørålseter, Mysusæter to Bjørnhollia, Mysusæter to Eldåbu and Remdalsbua to Breitjønnbu. They argued that observation and control of tourist traffic on removed trails are important to diminish this problem, and that this must be followed up over several years. I did also discover human interruption of counters at the trail from Fokstugu to Grimsdalshytta and the trail from Remdalsbua to Breitjønnbu. Some counters were physically taken out of the stone cairns, and some sensors were blocked with stones. Most likely this is caused by humans. In Dovrefjell-Sunndalsfjella, Rondane and Jotunheimen National Park, scientists have detected conflicts within user groups and between users interests and the management (Haukeland et al., 2011; Strand et al., 2013) . Haukeland et al. (2011) found that several stakeholders felt a frustration over certain management measures and regulations of human use, mainly because they could not see the rationale behind such measures. In addition, the study found that locals often felt that their own knowledge about the areas was missed out when the management were making decisions (Haukeland et al., 2011). To interrupt counters may therefore be a way to express this frustration. However, this is increasing the chance of incorrect registrations on the counters used in this study.

The conflict of increasing tourism in Rondane wild reindeer area was already raised by hunters in 1967 that was worry about human disturbance and that reindeer will avoid important habitats (Dagningen, 1967). Measures like removal of trail marks and tourist cabins were gradually carried out to reduce human disturbance in core reindeer areas, including four of the trails in this study. I confirm in my study that these measurements have been effective. Although the human use of unmarked trails in my study indicates a relatively low and decreasing use, the general use of marked trails in Rondane have been increasing in the period of 2009-2019 (Strand & Gundersen, 2019). Most of the tourist use is concentrated on the trails leading to the main tourist cabin Grimsdalshytta, Bjørnhollia, Rondvassbu and Dørålseter (Strand et al., 2014). For example, the number of visitors to Rondvassbu have increased every year since DNT took over the cabin in 1927, and the number of overnight visitors are now more than 12 000 per summer (Strand & Gundersen, 2019). In a context of increased development of recreational infrastructure and visitation of mountain areas in Rondane and in protection areas elsewhere in

Norway, physical management intervention like removal of marked trails seems, with certain limitation discussed in this thesis, to be a reasonable and effective tool to protect natural resources in the most sensitive areas.

5 Conclusion

The current human use and effect of removal of hiking trail marks seems to be dependent of location, time since marking removal and user groups. Generally, the human use of studied unmarked hiking trails seems to be low and decreasing over years. This was especially shown at the trail from Mysusæter to Bjørnhollia, where counters showed that the use of this trail in 2019 was the lowest registered in all years. In addition, the trail from Mysusæter to Eldåbu and Remdalsbua to Breitjønnbu have very low use compared with marked trails in the same area. The trail from Fokstugu towards Grimsdalshytta have somewhat more use, and this is a historical route with longstanding local use that seem to be continued despite of removal of marks. The trail from Rondvassbu towards Dørålseter is the most used trail in my study, and this is caused by attractive mountain summits. My data indicate that counters may be inaccurate under certain circumstances, both derived from technical and field errors. An important result from my study is that mixed methods is necessary to test the before-after intervention of recreational infrastructure. Based on my results on the trail from Fokstugu to Grimsdalshytta, there is likely to presume that reduction of human use is a time-consuming process. The main user group of this unmarked trails were overall Norwegian tourists on daytrips, who had visited the same areas before.

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Appendix

I have considered NSD (Norwegian Centre for Research Data) for treatment of personal information, but I find no conflicts with my data collection, since automatic counters, observations on distance and anonymous interviews involve no identification of individuals.

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