

# **Spatial segmentation of hikers and wild reindeer (*Rangifer tarandus tarandus*) at Hardangervidda National Park: Management implications**

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Recent years we have seen a paradigm-shift in – primarily – national park policy in Norway, but partly also in management and planning of Norwegian national parks: the role of nature-based tourism has clearly increased in attention and importance. A national branding strategy for national park tourism and a program for development of local visitor strategies for national parks in Norway was presented in April 2015 (Norwegian Environment Agency 2015). The ambition is to increase local economic and tourism development in and around the national parks, but not on the expense of the conservation interests. The focus is to increase visitation through some main entrances and other attractive areas, primarily in the fringe areas of the NPs. The immense disturbance potential of humans becomes clear in a Norwegian National park where wild reindeer (*Rangifer tarandus tarandus*) react to the presence of tourists by avoiding high-altitude infrastructure like resort areas, tourist roads, tourist cabins, marked trails etc. (Nellemann et al. 2010; Panzacchi et al. 2013 a, b; 2015). Thus, in many areas a much deeper understanding of the responses to anthropogenic disturbance is needed to support sustainable and more flexible management strategies (Kaltenborn et al. 2014). Hence, there is an urgent need in management to carefully study human-reindeer interactions and actual carrying capacities of national parks to fulfill their multiple goals. Especially it is important to try to identify conflict areas where tourists have great impact on wild reindeer, meaning acceptable number of visitors in critical periods or in important grazing, migratory areas etc. In this paper, our ambition is to estimate visitor use intensity and spatial pattern during summer and analyze the spatial overlap with wild reindeer in Hardangervidda National Park (3 422 km<sup>2</sup>), Southern Norway.

The human use of the area during summer was monitored in 2017 by surveys with short questionnaire and map in self-registration checkpoints on site along main entrances (n=33 sites, n=4055 respondents), and by automatic counters (n=75) at main entrances and in core area. Self-registration cards include questions of respondents demography, characteristics of the trip, accommodations, and their preferences for recreational facilities and management, and were available in Norwegian, English and German. In addition, each hiking route drawn by the respondents was digitized, and all routes were overlaid to calculate the tourist volume along each trail. Each trail was divided into shorter segments, separated at the intersection point with other trail branches. These trail segments became the basic unit through which we could link survey data with data from automatic counters and thereby obtain a proxy of the daily intensity of use of each trail segment in the study area, which we called Trail Use Index, TUI.

Equipped reindeer females by GPS devices obtained data on wild reindeer in the period of 2001-2018. For each individual we selected one GPS location every 3 h during the period June 15th –October 1st, as this is the period in Norway when tourists hike in high mountain.

In all, 148 individuals of wild reindeer were captured and GPS collared. The wild reindeer data are presented descriptive on maps including kernel density analyses.

The daily sum of TUI during summer peak between the end of July and the beginning of August. During the hunting period TUI is much lower compared to the high tourist season, and it is highest during the first week of the hunting period.

We identify large variation in the intensity of use of trails by the tourists. Some areas have a dense network of trails and that additional have high intensity of use by the tourists, and other areas have few trails and low intensity of use. In general, the most intensive used areas of Hardangervidda is in the western parts, at spectacular attractions in the fjord landscapes. In this area the attraction Trolltunga have almost an equal visitor volume as counts on all the other 74 counters at Hardangervidda. There is relatively low visitor volume in the core area of Hardangervidda, but here is the human – wild reindeer coexistence more pronounced.

The density of wild reindeer shows similar spatial use during the sampling period 2001-2018. The space use is very concentrated during the low and high tourist season, but more dispersed during the hunting period. In high tourist season wild reindeer are concentrated in the southeastern part of the area, covering only less than 20 % of the summer range at Hardangervidda. The comparison of space use data for humans and wild reindeer indicates seasonal large-scale segregation and suggest that reindeer move to areas with lower density of trails or areas including trails with low intensity of use during the whole tourist season.

During high season, we identified several trails that, based on findings from previous studies, are expected to function as barriers and hamper wild reindeer space use. For example, the core summer area for wild reindeer is surrounded by trails with more than 30 visitors / day (08:00-20:00), which seem difficult for wild reindeer to cross.

Our study suggests a strong potential for coexistence between wild reindeer and tourists in Hardangervidda National Park, at large spatial scale, and indicates that wild reindeer move to refuge areas with less tourist infrastructure and fewer hikers during the peak tourist season. More specifically, the study identifies popular hiking trails that are predicted to hamper the possibilities for wild reindeer to migrate and access important resources. We discuss overall management implications with the aim to reduce the impact of human activities on wild reindeer at Hardangervidda National Park.

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