Human-wildlife interactions: The challenge of monitoring socio-ecological dimensions in Norwegian National Parks

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Habitat loss, fragmentation, and degradation are the principal threats to biodiversity worldwide. In addition to the direct changes to the habitat caused by human activity, the mere presence of humans can prevent wildlife from accessing otherwise intact patches of habitat. This is exemplified by a wide-ranging species, wild reindeer (*Rangifer tarandus tarandus)* in Norway. During winter, reindeer rely on lichens that are both vulnerable for wear and slow to regenerate. In summer months, the reindeer follow the retreating snowpack as they seek greener vegetation and insect-free calving pastures. The wild reindeer is a challenging species to manage. It is adapted to survive in a mountain environment with extremely variable foraging conditions that require extensive seasonal movements. Human development of different kind of infrastructure, combined with increased human presence in their environment, mainly for for recreational purposes, have created an ever-changing disturbance regime. To monitor the human use component in this context, include the metrics of visitors' spatial extent, temporal extent and variability, volume, type of activity and characteristics.

Marked trails between tourist cabins are the most common infrastructure within wild reindeer ranges, and trail systems often transect large remote areas in such a way that that wild reindeer herds are forced to cross marked trails frequently. The key question is: what level of human disturbance can reindeer herds tolerate, in terms of user numbers per unit of time, before the reindeer movements are either severely hampered or cease altogether? The human use of trails within a wild reindeer range inevitably varies considerably during the summer peak tourist season. Some trail segments see as few as 1 person/day, while other segments have more than 500 person/day. The intensity of use can also vary considerably between different types of trails or paths and the terrain they cross. NINA uses several different methods to collect data on the spatiotemporal pattern of human presence in large mountain areas where use is widely dispersed: automatic counters (TrafX, EcoCounter), GPS surveys (Trackstics), asking visitors to draw their trips on a map, systematic moment observations, mobility bigdata (e.g. the Strava training smartphone app), and different kinds of secondary data. This talk will address these methods and give examples of potential methodological biases.

Our findings from monitoring the effects of visitors in seven wild reindeer ranges revealed that the human footprint and the disturbance effects on reindeer is much larger in summertime than wintertime: a function of both the volume and patterns of human activity and inter-seasonal changes in reindeer behavior. We found a large-scale area segregation between humans and reindeer during the summer season when human activity is greatest, as wild reindeer move to areas less prone to disturbance by humans. We identified threshold values for animals' willingness to cross hiking trails in summer: herds started avoiding crossing hiking trails used by more than 10–15 persons per day and stopped crossing trails when visitor volumes exceeded 30–50 persons per day. During the hunting season in the fall, reindeer herds were more dispersed and animals were willing to cross hiking trails independent of visitor volume—indicating a collective flight response to hunters.

The intensity of human activities (e.g. tourist volume), and the density of infrastructure (e.g. density of trails and mountain cottages) are crucial to understand how reindeer movements respond to anthropogenic features in the landscape. Multiple sources of human disturbance interact to produce cumulative impacts, which manifest in both habitat loss and fragmentation. Our research team has developed a multi-step analytical framework to quantify cumulative impacts and guide sustainable land planning and management. We applied this approach to reindeer GPS data collected form more than a decade in the major herds across Norway to: 1) quantify reindeer habitat's functionality (i.e. areas that are simultaneously of high-quality and well-connected) and the movement corridors between

functional areas; 2) quantify the human footprint, or the cumulative impact of anthropogenic activities. The talk will provide examples of how data from human use can be used in such analyses.

Management of backcountry hiking areas primarily concerns trail use, since most visitors to national parks utilize the marked trails. Trail restrictions and manipulation of the trail infrastructure (i.e. re-routing trail corridors or removing mountain cabins) can have effects on the volume of cabin-to-cabin trekking, the number of foreign visitors, visitors' gender balance, and number of first-time visitors. Similarly, the kind of area use restrictions (which can vary in both space and time) can impact or potentially provoke visitors differently, depending on the characteristics of the visitors' demographics and the activities they pursue. For example, areas subject to restrictions might have consequences primarily for local users, such as farmers who are tending to grazing herds of domestic sheep and residents of adjacent municipalities who are pursuing substitute harvesting (i.e. hunting, fishing, berry-picking etc.). Alternatively, areas might also be visited by wilderness seekers who have travelled considerable distances to reach the park and mainly use the off-trail areas.

Understanding visitors' motives, experiences, preferences, and sensitivity to management-generated information about responsible behaviour in reindeer areas can help managers design information strategies that are better able to direct human activity in environmentally friendly directions. We used short questionnaires distributed at self-registration checkpoints (located in combination with automatic counters at parks' main entrances) or QR-code to collect information about user profiles and the purpose of their visit, as well as asking them to draw a map of their route. We also asked visitors for their email address so that we could send them a more comprehensive web-based questionnaire after the visit. Our results illustrate how visitors' characteristics can differ based on which park entrance they use and the activity they pursue, reflecting variation in demography, nationality, frequency of visiting the location, knowledge about the area, group-size, and presence of children—as well as their preferences for landscapes, facilities and management. It is crucial to take these dimensions of park visitors into account to project the possible effects and consequences of different kinds of direct and indirect management actions in the future.