

Embracing fragmentation to save reindeer from disease

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Abstract

Space demanding mammalian species, such as reindeer, are in decline worldwide due to habitat loss and fragmentation. Policy to restore connectivity of reindeer habitat is now put to an abrupt halt in several areas because of an outbreak of Chronic Wasting Disease in Norway, and replaced with deliberate fragmentation of the landscape by enhancing barrier effects of linear structures.

KEYWORDS

connectivity, fragmentation, reindeer, wildlife disease

1 | INTRODUCTION

Conservation biologists around the world are struggling to keep habitat well connected under the threat of human infrastructure development. Connectivity is vital to secure long-term gene flow and allow species migration under threat of climate change. Space demanding species in particular face severe limitations to movement with increasing human footprint on the planet (Tucker et al., 2018). Reindeer and caribou (*Rangifer tarandus*), with their extensive migratory and nomadic space use behavior, are in decline worldwide (Vors & Boyce, 2009). Wild alpine reindeer in Norway form a northern and a southern Conservation area of Europe with distinct genetics from different glacial recolonization history, but comprise today 24 population management units due to an ever increasing fragmentation due to roads, railroads and tourist trails. The vast majority of studies show adverse impacts of human activity on reindeer and caribou space use (Johnson, Ehlers, & Seip, 2015; Plante, Dussault, Richard, & Côté, 2018; Vistnes & Nellemann, 2008). Genetic diversity of reindeer are already lowered in management units with low population sizes, and an overarching aim of conservation genetics is to restore lost connectivity (Kvie, Heggnes,

Bårdsen, & Røed, 2019). To facilitate reindeer crossing and restore connectivity, the main road across the Hardangervidda mountains were from 2007 blocked for car traffic in sensitive periods when large herds (>1,000 animals) were within 3 km (Figure 1: site 1). In other areas, parking along road was banned (Figure 1: site 7 from 1992), and access roads to a tourist cabin were closed (Figure 1: site 3). In some areas roads are deliberately not cleaned for snow during winter to allow reindeer movements (Figure 1: site 5, 6, and 8), while another road was closed for private traffic only allowing shuttle busses to a large tourist cabin (Figure 1: site 9 since 2016). In one area, there are restrictions on seasonal opening times even for biking (Figure 1: site 2). In some areas heavy restrictions on development plans have been put in place by introduction of regional land management plans in 2013–2015 (e.g., in site 11, 12, and 13 in Figure 1).

2 | CHRONIC WASTING DISEASE OUTBREAK AMONG REINDEER

Promoting connectivity and studying the impact of human disturbance on reindeer and other wild ungulates has been a core focus of conservation biology in Norway

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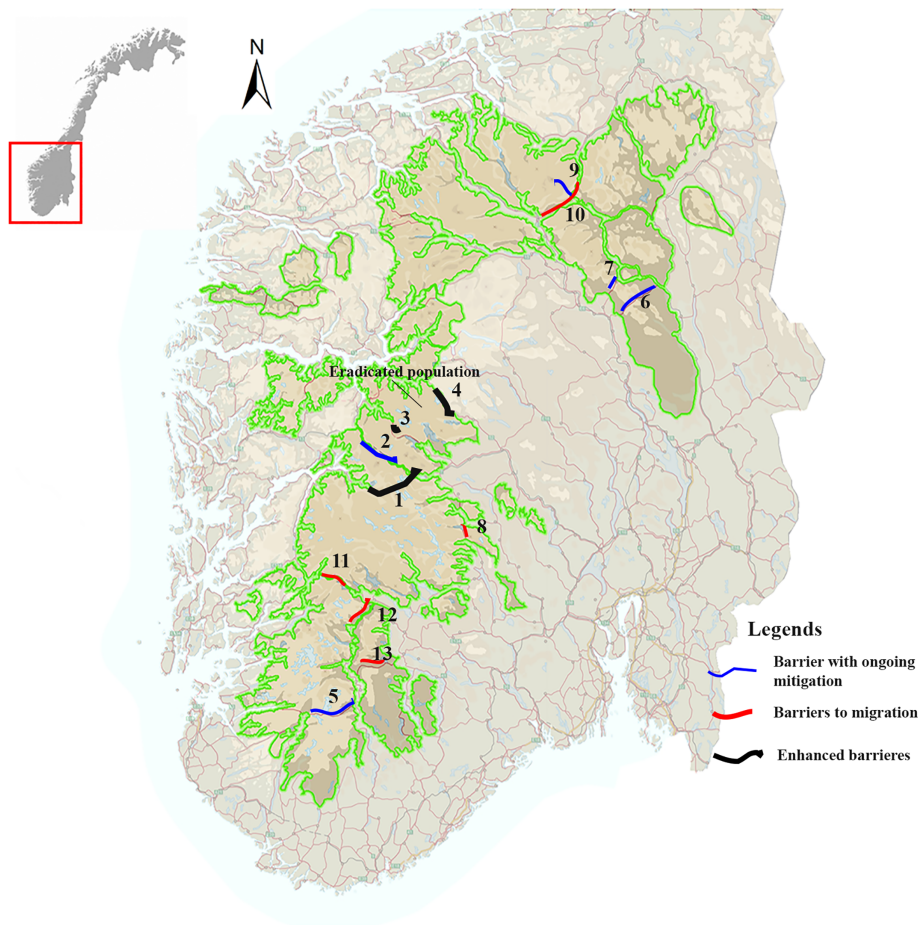


FIGURE 1 Wild, alpine reindeer populations in southern Norway constitute historically two well-connected metapopulations, but human infrastructure during the last century has severely fragmented previous contiguous habitat. Years of hard-won conservation efforts to restore connectivity is now put to an abrupt halt with the outbreak of Chronic Wasting Disease

(Panzacchi, Van Moorter, & Strand, 2013; Strand, Jordhøy, Panzacchi, & Van Moorter, 2015). This state-of-affairs changed abruptly with the first outbreak of chronic wasting disease (CWD) among reindeer detected in spring 2016 (Benestad, Mitchell, Simmons, Ytrehus, & Vikøren, 2016), with further cases detected with onset of surveillance fall 2016 (Mysterud et al., 2019). Facing CWD, we had to rethink our whole approach to conservation of reindeer in Norway, at least in the short-term. CWD is a contagious and lethal prion disease among cervids continuously spreading in USA and Canada since its emergence among wild deer in 1981 (Spraker et al., 1997). The infectious prions causing CWD are found in body fluids, and new individuals are infected through exposure via the oral route (Mathiason et al., 2009). CWD can transmit from animal to animal by direct contact, but over time environmental contamination of prions increases and becomes an important mode of transmission (Almberg, Cross, Johnson, Heisey, & Richards, 2011). The prions can persist in the environment for many years (Zabel & Ortega, 2017), and there are no effective management actions towards CWD once reaching an endemic stage (Uehlinger, Johnston, Bollinger, & Waldner, 2016). CWD has a slow epidemic growth, but has four decades later now come to the point

of reaching high prevalence and causing population declines among deer in USA (DeVivo et al., 2017; Edmunds et al., 2016). CWD therefore have huge cultural and economic consequences (Bishop, 2004; Rivera, Brandt, Novakofski, & Mateus-Pinilla, 2019), and spillover to semi-domestic reindeer in Norway would threaten the whole Sami-herding culture (Mysterud & Tranulis, 2017).

3 | MANAGEMENT ACTIONS TO COMBAT CWD

The Norwegian authorities' assessment was that the situation was so severe that they decided to eradicate the whole CWD-infected population with more than 2000 reindeer (Mysterud & Rolandsen, 2018; Mysterud, Strand, & Rolandsen, 2019), which was conducted from 10th of August 2017 to 1st of May 2018. After eradication, a minimum of 5 year following period with a goal to keep the area free of reindeer was initiated due to the persistence of prions in the environment. An important management aim was to limit risk of spatial spread to nearby population units, in what constituted historically one large southern metapopulation of reindeer (Figure 1). Due to uncertainty about spread of CWD and lack of

certainty regarding freedom-of-CWD in the adjacent population (Nordfjella zone 2), measures were taken also towards more distant populations. With CWD, the hard-won conservation efforts to restore connectivity were abandoned: restriction on the use of the road across the Hardangervidda mountains was lifted (Figure 1: site 1). Personnel from the Norwegian Environment Agency increased surveillance of approaching herds with instructions to use snowmobiles, helicopters or otherwise prevent animals from crossing the road. Wildlife fences were erected on shorter stretches of roads to further strengthen the barrier effect (Figure 1: site 3 and 4). Deliberately increasing fragmentation to save reindeer would be an unthinkable idea before the emergence of CWD.

4 | CONTAGION AND CONSERVATION OF METAPOPOPULATIONS

The SLOSS (single large or several small) debate provides insight into how biodiversity can best be conserved depending on spatial configuration: aggregated, contiguous, or connected (Diamond, 1975). A key insight point is how management decisions should include an assessment of whether the threats are spatially correlated, such as fires and emerging diseases (Albers, Busby, Hamaide, Ando, & Polasky, 2016). That well-connected metapopulations increase vulnerability to severe disease outbreaks was identified long time ago (Hess, 1996), but awareness to this fact has received little attention in practical conservation biology. The issue of deliberate fragmentation of landscape to limit disease spread is relevant for a wide range of wildlife diseases. Climate change weaken condition of many alpine species making them more vulnerable to disease outbreaks (Jones et al., 2008), and human-mediated movement of pathogens pose a considerable threat to wildlife populations and biodiversity more in general, especially when pathogens are introduced into naïve populations (Daszak, Cunningham, & Hyatt, 2000).

5 | ADAPTIVE BARRIERS AS CONSERVATION TOOLS

Several fences to limit spread of African swine-fever among wild boar in Europe are in place (Mysterud & Rolandsen, 2019). Currently, CWD is penetrating northwards in Alberta (Alberta, 2020) and Saskatchewan (Saskatchewan, 2020), Canada. Climate change further extend the northern distribution ranges of mule deer

and white-tailed deer (Dawe, Bayne, & Boutin, 2014), the species currently infected with CWD in Canada. This makes spillover of CWD from deer to boreal caribou an imminent threat, which may put the most iconic populations of migratory caribou at risk. In Wyoming, USA, there is a strong focus on retaining or restoring connectivity (Sawyer, Kauffman, Nielson, & Horne, 2009), but CWD is closing in also on these migratory populations. Deliberately fragmenting the landscape to enhance barrier effects of current linear structures appear as a painful question to be considered more often in conservation biology in years to come. This provide a delicate balance, as wildlife managers and local and regional stakeholders working to secure reindeer habitat are up against actors readily exploiting new arguments to build infrastructure with the long-term detriment to habitat (Hebblewhite, 2017). Adaptively adjusting barriers to current threats provide one possibility (Figure 1), though we lack a solid evidence-base for how reindeer respond to different kinds of barriers. We urge for innovative conservation tactics to solve the tradeoff between genetic and demographic costs of fragmentation on one side and emerging pathogens on the other.

ACKNOWLEDGMENTS

We acknowledge our institutions for support, University of Oslo (AM) and Norwegian institute for nature research (OS and CMR).

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Atle Mysterud drafted the article after idea and suggestion from Olav Strand and Christer Rolandsen. All authors contributed notably to further drafts and development of concepts. Olav Strand made the figure.

ETHICS STATEMENT

No animals were used in this study.

DATA AVAILABILITY STATEMENT

This article contains no data.

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How to cite this article: Mysterud A, Strand O, Rolandsen CM. Embracing fragmentation to save reindeer from disease. *Conservation Science and Practice*. 2020;2:e244. <https://doi.org/10.1111/csp2.244>