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Range fidelity: The missing link between caribou decline and habitat alteration?

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ABSTRACT

Conservation of forest-dwelling caribou (*Rangifer tarandus caribou*) is of great concern across most of its range. Anthropogenic disturbances, primarily logging activities, have been identified as the most important cause of caribou decline, although the mechanisms underlying this decline are not fully understood. Caribou commonly display fidelity to calving sites or seasonal ranges, but the potential role of this life-history trait has been largely overlooked in research and conservation planning. This is surprising because sites and ranges with high inter-annual use should have high conservation value. We investigated the relationship between habitat disturbances and home-range fidelity of forest-dwelling caribou across three study sites in Québec, Canada, using a broad range of natural and anthropogenic disturbances. Between 2004 and 2007, we tracked 47 adult female caribou using GPS collars. Home-range fidelity varied between seasons, being higher during calving and summer, and lower during winter. Caribou reduced fidelity following natural and anthropogenic disturbances, the latter having a stronger negative influence. Anthropogenic disturbances had a strong negative impact on home-range fidelity during annual, summer and winter periods, whereas natural disturbance was the dominant factor during calving. Despite this negative influence on fidelity, caribou tended to demonstrate range fidelity even in study sites most impacted by human activities. Habitat disturbances could produce two possible outcomes for caribou conservation: (1) a trend for females to reduce home-range fidelity which could translate into lower calf and female caribou survival through reduced familiarity with food distribution, escape cover and predation risk and (2) a global tendency to maintain range fidelity even in a drastically modified landscape which could turn into an ecological trap, particularly for calves when predation risk increases due to increased black bear density in early successional forests. Taking range fidelity behavior into consideration during forest management planning could direct conservation efforts toward the best available sites and therefore facilitate caribou persistence in managed landscapes.

1. Introduction

Conservation ecologists have sought to identify factors threatening biodiversity for several decades, agreeing that loss and alteration of native habitats rank among the most important factors driving global species declines (Venter et al., 2006). In the boreal ecosystem, forest harvesting has profoundly modified the composition, structure, and dynamics of plant and animal communities over the last century (Lindenmayer and Franklin, 2003). Although some early-successional species may benefit from forest harvesting over the mid-term (e.g., moose (*Alces alces*), Courtois et al., 1998), the habitats of many species, such as old-growth associated and interior species, are often degraded (St-Laurent et al., 2008).

Across North America, it is widely accepted that conservation of woodland caribou (*Rangifer tarandus caribou*) is highly compromised by anthropogenic disturbances (Schaefer, 2003; Hins et al., 2009; Vors and Boyce, 2009). As an example, forest-dwelling caribou, an ecotype of woodland caribou, rely on large patches of mature coniferous forests where they can find the terrestrial lichens on which they feed in winter (Bergerud, 1972) and distance themselves from their predators and alternative prey (e.g., Rettie and Messier, 2001; O'Brien et al., 2006; Courtois and Ouellet, 2007). However, these mature coniferous stands are also a primary target of the logging industry. The range distribution and abundance of forest-dwelling caribou have declined throughout North America

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since the end of the 19th Century (Courtois et al., 2003; Schaefer, 2003), and this ecotype has been considered threatened across its entire Canadian distribution since 2000 (COSEWIC, 2006). Habitat alterations associated with human activities, primarily logging, have been identified as the most important cause of caribou decline (Schaefer, 2003; Vors et al., 2007), having negative impacts on caribou demography and behavior (Courtois and Ouellet, 2007; Courtois et al., 2007, 2008). For instance, in North America, caribou mortality (Courtois et al., 2007) and movement rates (Smith et al., 2000) on one hand, and caribou recruitment rate (Environment Canada, 2008a) on the other hand, have been found to be positively and negatively related to the proportion of early seral stands in managed landscapes, respectively. Several studies have also reported that caribou avoid areas that are actively harvested, recently logged or in regeneration (Smith et al., 2000; Courtois et al., 2007, 2008; Hins et al., 2009), as well as linear disturbances such as seismic lines and roads, and oilfield complexes (James and Stuart-Smith, 2000; Dyer et al., 2001).

There has been less focus, however, on the relationship between logging activities and caribou fidelity to a site or to a seasonal home range, a potentially important behavior for the species. Theoretically, site fidelity can be described as an area-restricted space-use behavior (Switzer, 1993; Borger et al., 2008) which could enhance survival and reproductive success through familiarity with food distribution, escape cover and predation risk (Greenwood, 1980). On an inter-annual basis, site fidelity can be presented as a cost–benefit balance between the benefits accrued from familiarity and the energy expended while traveling back to a previously occupied site (Part, 1991; Edwards et al., 2009). Within a year or a season, site fidelity in prey species also supports the hypothesis that reduced movements can minimize encounter rates with predators (Rettie and Messier, 2001). As an example, a study on birds observed increased reproductive success among individuals demonstrating strong site fidelity (Schieck and Hannon, 1989). Similarly, use of traditional calving grounds has been identified as a strategy favouring caribou calf survival in Prudhoe Bay through lower predation risk and improved foraging conditions (Cameron et al., 1992). Such philopatric behavior can be observed at different spatial and temporal scales, and literature often suffers from confusion among relevant scale definitions and methods. Many species were found to exhibit fidelity to a specific calving or foraging site (western barbastelle bat, *Barbastella barbastellus*: Hillen et al., 2009), to an annual or seasonal range (e.g., elk, *Cervus elaphus*: Van Dyke et al., 1998) or to migration routes (Yellowstone pronghorn, *Antilocapra americana*; White et al., 2007) and such conclusions were obtained using various metrics ranging from the distance between locations or range centroids to the overlap between successive home ranges.

Space-use patterns, such as site fidelity, have important consequences on ecological processes, such as the distribution and local abundance of individuals, habitat selection and predator–prey dynamics (Borger et al., 2008). Woodland and mountain caribou are known to demonstrate some site fidelity behavior, which can fluctuate seasonally and between populations (e.g., Schaefer et al., 2000; Gullickson and Manseau, 2000; Rettie and Messier, 2001; Ferguson and Elkie, 2004; Metsaranta and Mallory, 2007). Nevertheless, these studies did not highlight variations in fidelity behavior between individuals and did not try to discriminate among the potential causes of such variation (but see Wittmer et al. (2006) for snow accumulation influence on caribou fidelity and Dalerum et al. (2007) for wildlife effects on home-range size and range fidelity). Despite the potentially important influence of site fidelity on caribou conservation, there are gaps in our knowledge concerning the potential influence of anthropogenic disturbances on this behavior and the resulting implications for caribou conservation. Indeed, identifying factors influencing site fidelity of caribou could aid greatly in developing effective conservation plans. Although researchers commonly aim to describe the critical habitat of a threatened species through habitat selection analyses (e.g., Johnson et al., 2004), habitat selection is the result of a complex process involving multiple variables, some of which are not sufficiently evaluated in the models. Subtle differences in habitat-model structure may lead to quantitatively different conclusions and management decisions (Southwell et al., 2008); therefore the choice of appropriate variables is crucial and we argue that assessing range fidelity could improve our understanding of the selection process, wherein we observe individuals concentrating their activity in certain habitat patches. One could expect that the preservation of these habitat patches would be of significant value to the species under consideration. For caribou, Metsaranta (2008) showed that home-range selection could not be explained based on forest attributes alone, and suggested the protection of selected ranges as a conservation action. Alternatively, we propose that range fidelity could be the missing link between habitat alteration and caribou decline. Individuals might stay in landscapes where they had success in the past; where profitability has declined following disturbances, maladaptive habitat selection might occur (Switzer, 1993; Schlaepfer et al., 2002).

We investigated relationships between habitat disturbances and home-range fidelity of female forest-dwelling caribou. According to White and Garrott (1990) and Wittmer et al. (2006), we considered that small seasonal home ranges reflect high fidelity within a season, while the tendency to return to the same seasonal range year after year suggested high inter-annual range fidelity. To distinguish between the influences of natural and anthropogenic disturbances, we conducted this study at two sites heavily impacted by human activities and one site with few human activities. We predicted that range fidelity would be negatively influenced by habitat disturbances in general and that those modifications originating from human activities (e.g., logging and roads) would have greater influence than natural ones (e.g., forest fires, windthrows and insect outbreaks). We therefore expected to find a positive relationship between caribou home-range size and proportion of disturbed habitats, and also predicted caribou living in disturbed environments would exhibit lower inter-annual home-range fidelity. We also investigated whether range fidelity varied between seasons. Because predation is the most important limiting factor for caribou, we expected that female range fidelity would be highest during the calving and summer periods, when predation risk on calves is highest (Rettie and Messier, 1998; Wittmer et al., 2005).

2. Methods

2.1. Study area

We conducted our study in three different sites located in the boreal forest of Québec, Canada, namely Charlevoix, Saguenay-Lac-St-Jean, and Côte-Nord (Fig. 1). The Charlevoix study site (47°40′N, 71°10′W; 8000 km^2) was dominated by coniferous stands and tree species including balsam fir (*Abies balsamea*), black spruce (*Picea mariana*), white birch (*Betula papyrifera*) and trembling aspen (*Populus tremuloides*). Following local extirpation at the end of the 19th Century, approximately 80 forest-dwelling caribou were captured 700 km northeast of Québec City and reintroduced in the Charlevoix region in the early 1970s. The Saguenay-Lac-St-Jean study site (referred to as Saguenay; 11700 km^2) was located south of the Pipmuacan Reservoir (49°10′N, 70°20′W). The tree layer was dominated by black spruce together with balsam fir, white birch, trembling aspen, white spruce (*Picea glauca*) and jackpine (*Pinus banksiana*). The Côte-Nord study site (18500 km^2) was located south-west of the Manicouagan Reservoir (50°00′N,