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The use of coniferous forests and cutovers by Newfoundland woodland caribou

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ABSTRACT

Habitat selection and preferences are driven by population limiting factors which can vary across spatial and temporal scales. For example, woodland caribou prefer coniferous forests to avoid predation at the coarse-scale and at finer scales select for forage within forests. Forestry reduces the benefits of forests and prevents the regeneration of adequate caribou habitat. We described Newfoundland woodland caribou habitat preferences across coarse and fine spatial scales and assessed whether cutovers regenerate into forests of similar value to those preferred by the caribou. We determined if caribou preferred coniferous forests at the coarse-scale and which stand characteristics were selected within coniferous stands at the fine-scale. Linear regression was used to determine which stand characteristics predicted the intensity of use of the coniferous forests by the caribou. The same stand characteristics were used to compare cutovers of various ages to coniferous forests using principal component analyses to determine if they share similar characteristics. We found at the coarse-scale that coniferous forests were most preferred but did not differ from cutovers, and at the fine-scale caribou used coniferous forests with more forage. Cutovers did not develop into forests with similar stand characteristics as the coniferous forests selected by the caribou; the canopy of the cutovers was more closed and supported less forage than the coniferous forests. Old cutovers (>40 years) foster less forage for caribou and may act as a refuge from predation. This may cause caribou to seek forage in more risky landscapes in order to meet dietary requirements.

1. Introduction

Understanding an animal's habitat requirements and the mechanisms driving the selection patterns is necessary for effective management and conservation because they provide insight on interactions with conspecifics, other species, the environment and both natural and disturbed landscapes (Samuel and Green, 1988). This information can be obtained through habitat selection studies allowing managers to identify important habitat requirements. Several spatial and temporal scales in habitat selection studies have been recommended in order to better capture habitat selection (Mayor et al., 2009). Indeed, the choices an animal makes when selecting habitats is a hierarchal process and can vary both spatially and temporally (Johnson, 1980; Mayor et al., 2009). The selection preferences are driven by population limiting factors which can vary across both spatial and temporal scales (Mayor et al., 2009; Rettie and Messier, 2000). For instance, habitat selection pattern at coarse-scale aims at reducing the influence of the most important limiting factors, while less important factors are dealt with at finer scales (Rettie and Messier, 1998).

Predation is the most important limiting factor for woodland caribou and is the accepted cause for their major decline and threatened status in North America (COSEWIC, 2011; Vors and Boyce, 2009; Wittmer et al., 2005). Wolf (*Canis lupus*) predation has the largest impact on caribou and caribou respond to the wolf predation risk by finding asylum in coniferous forests and naturally open areas (Apps et al., 2001; Hins et al., 2009; Rettie and Messier, 2000; Wittmer et al., 2007). Nutritional requirements can also be considered limiting factor for woodland caribou (Bergerud, 1996) however, this factor does not limit populations as much as predation and thus is reflected only at smaller scales. Accordingly, caribou distinguish between coniferous forests preferring those with higher amounts of forage (Briand et al., 2009; Hins et al., 2009; Serrouya et al., 2007).

The majority of habitat selection studies for woodland caribou are conducted at coarse-scales using broad habitat categories (Chubbs et al., 1993; Hins et al., 2009; Mahoney and Virgl, 2003). Fine-scale habitat studies for caribou are few and the majority of those were conducted in winter on mountain caribou (Apps et al., 2001; Johnson et al., 2000, 2001; Mosnier et al., 2003; Serrouya et al., 2007; Terry et al., 2000) and most demonstrate that selection is driven by dietary requirements. However, woodland caribou may be more limited by forage availability during snow free periods (Bergerud, 1996) despite their broad food preference

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(Russell et al., 1993). Therefore, snow free periods may better illustrate the selection pressures at finer scales.

In addition, forest harvesting, the most prevalent method of habitat alteration in the boreal forest (Gagnon and Morin, 2001; Niemela, 1999), drastically alters the level of predation risk and forage potential (Bergerud, 1996; Festa-Bianchet et al., 2011; Vors and Boyce, 2009; Wittmer et al., 2005) influencing caribou habitat preferences. Forestry can increase predation risk directly by attracting other ungulates along with their predators (Boisjoly et al., 2010; Courtois et al., 2004; Mosnier et al., 2008; Vors and Boyce, 2009; Wittmer et al., 2005); increasing access for predators and hunters to caribou through logging roads (James and Stuart-Smith, 2000; Sorensen et al., 2008); and by removing refuges from predators (Courtois et al., 2008; Wittmer et al., 2007). The increase in predation risk often causes caribou to flee from harvested areas (Chubbs et al., 1993; James and Stuart-Smith, 2000; Schaefer and Mahoney, 2007; Vors et al., 2007). However, the combination of strong site fidelity (Faille et al., 2010) and the loss of quality habitat providing both forage and refuge may cause caribou to seek resources in harvested landscapes (Briand et al., 2009; Hins et al., 2009). Hence, the understanding of habitat requirements within coniferous forests may allow managers to strategically harvest less favorable forests, reducing the need for caribou to seek harvested areas to satiate their dietary needs. Moreover, caribou may show differential use between successional stages of harvested forests since cutovers may reduce the quality of caribou habitat as it develops (Hins et al., 2009).

In this study, our objective is to determine (1) if coniferous forests are selected at the coarse-scale during the summer; (2) if caribou select for stand characteristics within these forests; and (3) if cutovers regenerate into forests of similar stand characteristics as those preferred by the caribou. We predict that at the coarse-scale, coniferous forests will be the habitat most preferred by caribou in comparison to eight other habitat types because these forests are a refuge from predation despite their main predator, the wolf, being absent from the island. At the fine-scale, we predict that caribou will select for forage within coniferous forests because these forests are already preferred to avoid predation. We also predict that older cutovers will be most similar to un-harvested coniferous forests though they will not share the same stand characteristics as the coniferous forests preferred by the caribou.

2. Study area

The caribou in this study were located within the forestry management zone 5 (49°N, 56°W) in central Newfoundland. The northern part was bisected by the Trans-Canada Highway and contains the towns of Bishop's Falls at the East and Millertown to the West (Fig. 1). The topography of the area is characterized by flat to gently rolling landscape with many wet lowlands.

The major forest type was dense coniferous stands of mainly black spruce (*Picea mariana*) and some balsam fir (*Abies balsamea*) with sparse deciduous patches of trembling aspen (*Populus tremuloides*) and white birch (*Betula papyrifera*). Nonforested areas were also common such as bogs and shrublands. The summers are mild and wet (16 °C) and the winters are cool (−7 °C) with an average snow accumulation exceeding 4 m per year (Chubbs et al., 1993; Mahoney and Virgl, 2003). Logging operations, mainly clear cutting, have been ongoing since the 1920s focusing primarily on conifers for pulp and paper (Mahoney and Virgl, 2003).

The woodland caribou in the study area are sedentary ecotypes that perform only small seasonal migrations to wintering grounds (Bergerud, 1971). Much of the area is limited to human access, although some caribou home ranges can be accessed by public and logging roads. Besides man, the predators of the woodland caribou include lynx (*Lynx canadensis*), black bear (*Ursus americanus*) and the introduced coyote (*Canis latrans*) (Bergerud, 1971; Schaefer and Mahoney, 2007). Wolves were historically the major predator of the woodland caribou on the island however, they were extirpated in the 1920s (Bergerud, 1971; Chubbs et al., 1993). The only other wild ungulate on the island is the introduced moose (*Alces alces)*. This study was conducted during the post-calving season (July 1–August 30) because of the availability of green forage during this season which comprises an important part of woodland caribou diets (Russell et al., 1993).

3. Methods

3.1. Delineation of use intensity levels

Woodland caribou have high site fidelity allowing for the quantifying of use intensity levels to demonstrate their relative use patterns (North and Reynolds, 1996). We used fixed-kernel density in the animal movement v-2.04 BETA package in ArcView v-3.2 with cell size of 100 m to construct the use intensity levels using the location data (one location every 2 hours) of 12 GPS (Lotek 4400, Lotek Wireless Inc., Newmarket, Canada) collared adult female caribou for the post-calving season of 2008. The caribou were captured in prior years by the crew members of the wildlife department of Newfoundland using stratified random sampling to allow collars to be more evenly distributed across the landscape and herds; each collared caribou represented a small herd of 5–30 individuals. We found least squares cross validation for bandwidth selection inappropriate in this case because the core areas produced were conservative and fragmented. Therefore, in order to determine the bandwidth appropriate to construct the cores, we tested several bandwidths ranging from 400 to 1200 m. We concluded the 1000 m bandwidth produced the best cores for our purpose because it obscured the fine detail while highlighting the most prominent features of the range for most individuals. The density contours used to create the use intensity levels included the 95% for low use, 75% for medium use and 50% contour for high use. The home range was defined as the area within the 95% density contour as suggested by Laver and Kelly (2008) and the core areas were defined as the area within 75% density contour using the objective Area Independent method for each caribou (Powell, 2000; Seaman and Powell, 1990). Fig. 1 illustrates the density contours used to create the cores and the use intensity levels for each caribou within the study area.

3.2. Coarse-scale habitat selection

We obtained digital vegetation coverage from Newfoundland's Forest Service inventory database and classified the information into nine general habitat categories (Table 1). The information on the vegetation coverage was obtained from aerial photointerpretation by the forestry department mainly during the years 2002, 2003, and 2004 and projected in MTM 2 (North American datum 1983) in a Geographic Information System. The land covered by municipalities and agricultural fields were omitted from the map since they covered less than 1.0% of core areas.

We tested the accuracy of the habitat map by photointerpretation of 225 random points on aerial photographs from 2003 to 2004 distributed throughout the study area (Boitani and Fuller, 2000; Hansen et al., 2001). The map accuracy was 78.9% (Table 1). The accuracy would increase to 87.8% if the disturbed habitat type was omitted. The disturbed habitat type was difficult to distinguish from other habitats because it represented areas disturbed by natural phenomenon and thus resembled other habitat categories. However, considering the accuracy of the other habitat categories, we trust that the disturbed habitats were correctly defined and are reliable indicators of recent and historical natural disturbances.