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Thresholds in nesting habitat requirements of an old forest specialist, the Brown Creeper (*Certhia americana*), as conservation targets

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ABSTRACT

Many bird species respond to forestry, even at moderate intensities. In New Brunswick, Canada, the Brown Creeper exhibits a negative, threshold response to harvesting intensity. This study aimed to determine whether (a) the threshold found in Brown Creeper occurrence is lower than eventual thresholds in its nesting requirements, and whether (b) the conservation of this species could be achieved through moderate-intensity harvest systems. Creepers are particularly sensitive to forestry because they nest on snags with peeling bark and they mainly forage on large-diameter trees. In northern hardwood stands, we compared habitat structure at local- ($r = 80$ m) and neighbourhood-scales ($r = 250$ m) around nest sites and sites not used by creepers. Over two years, we found 76 nests, 66 of which were paired with unused sites for comparison. At the local scale, densities of trees $\geqslant$30 cm dbh and snags $\geqslant$10 cm dbh, and the probability of presence of potential nest sites were significantly higher near nests than at sites where no creepers were detected. At the neighbourhood scale, the area of untreated mature forest was significantly higher around nests. Variance decomposition indicated that habitat variables at the local scale accounted for the majority of explained variation in nest site selection. We also found significant thresholds in the densities of large trees (127/ha) and snags (56/ha), and in the area of mature forest (10.4 ha). The conservation of breeding populations of Brown Creepers may thus require densities of large trees nearly twice as high as those associated with its probability of presence. Such a target seems to be incompatible even with moderate-intensity harvesting.

1. Introduction

Forest management creates complex landscape mosaics composed of stands varying in floristic composition, age and disturbance history (Lindenmayer and Franklin, 2002). Although low-intensity forestry may maintain habitat for some species, others are sensitive to reductions in specific forest stand structures (Vance and Nol, 2003; Fisher and Wilkinson, 2005;

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Guénette and Villard, 2005) or to overall loss and fragmentation of their habitat at the landscape scale (Villard et al., 1999; Lichstein et al., 2002; Cushman, 2006). Determining the ranges in forest management intensity over which species exhibit strong "threshold" responses may provide critical guidance for the development of biodiversity conservation targets (Fahrig, 2001; Bütler et al., 2004a; Guénette and Villard, 2005).

Research on threshold responses and the ecological processes underlying such thresholds is still in its infancy. A threshold can be defined as a sharp change in an ecological response corresponding to a small alteration in ecosystem conditions (Guénette and Villard, 2004; Huggett, 2005). A threshold may be breached when ecosystem conditions shift through time at a given location. Alternatively, threshold responses may be observed by measuring an ecological response variable (e.g. probability of species presence) along a gradient in ecosystem conditions (Bütler et al., 2004a; Homan et al., 2004; Guénette and Villard, 2005). For example, Guénette and Villard (2005) sampled forest birds in stands varying in structure and floristic composition and related those stand characteristics to the probability of species presence. In northern hardwood stands, they found a threshold of 66 large trees ($\geqslant$30 cm diameter at breast height) per hectare, above which Brown Creepers (*Certhia americana*) were significantly more likely to be detected. Although this number represents a useful initial target for conservation and management, it still begs the question of whether meeting this target would be sufficient to expect reproduction and, ultimately, population persistence for this and ecologically-similar species. Authors who have addressed this issue have concluded that habitat requirements for reproduction may be substantially higher than those required for the mere presence of a species (Angelstam, 2004; Bütler et al., 2004b; Roberge et al., 2008).

Our study aims to determine whether the Brown Creeper exhibits threshold responses to stand structure variables when selecting nesting sites and if so, to compare these threshold values to those found by Guénette and Villard (2005) for the probability of presence at the local scale. Creepers (*Certhia* spp.) nest underneath pieces of bark peeling off from snags or declining trees (Cramp, 1993; Hejl et al., 2002). Therefore, they require a continuous supply of dying trees. They also require large surfaces of rough bark in order to find their food (invertebrates on bark surface and in crevices) (Mariani and Manuwal, 1990; Adams and Morrison, 1993). Both in Eurasia and North America, creepers have attracted the attention of conservation biologists owing to their potential value as indicators of sustainable forest management (Kuitunen and Helle, 1988; Kuitunen and Mäkinen, 1993; Bani et al., 2005; Suorsa et al., 2005; Wintle et al., 2005). However, Brown Creeper's life history remains surprisingly poorly known and so do the mechanisms underlying its sensitivity to forest management.

In northwestern New Brunswick, Canada, the Brown Creeper was among eight species of forest birds positively linked to the density of large-diameter trees and snags (Guénette and Villard, 2005). Current harvest practices in conifer-dominated stands make it unlikely that the structural requirements of these species can be met outside reserves. Mature stands are managed through clearcutting with retention patches generally much smaller than 1 ha. In shade-tolerant deciduous stands, however, forest management systems include selection, shelterwood, and patch cutting, which might be compatible with the conservation of sensitive species such as the Brown Creeper. Single-tree selection harvesting attempts to emulate small scale natural disturbance by removing approximately one third of the basal area in each diameter class every 20 to 25 years (Nyland, 1998; Guillemette and Bédard, 2006). In the northern hardwoods and Acadian forests [typically mixedwood stands dominated by yellow birch (*Betula alleghaniensis*), sugar maple (*Acer saccharum*), red spruce (*Picea rubens*) and balsam fir (*Abies balsamea*)], the most frequent natural disturbance is windthrow, which usually alters approximately 1% of a particular area annually (Runkle, 2000; Mosseler et al., 2003).

Selection harvesting allows manipulating the residual density of large trees and snags and, thus, the value of post-harvest stands as habitat for species associated with these structures. Hence, a broader objective of this project was to determine whether the conservation of the Brown Creeper in deciduous forests can be achieved through adjustments in harvest systems or whether forest patches must be left untreated or managed through extended harvest rotations. Based on its ecological requirements, we expected that the Brown Creeper would represent an efficient umbrella for other species requiring a continuous supply of snags, a high density of large-diameter trees, and associated habitat features.

2. Methods

2.1. Study area

The study was conducted in the Black Brook and West Tobique districts (47°05′–47°50′ N; 67°00′–67°50′ W), two privately-owned managed forests adjacent to each other in northwestern New Brunswick, Canada. We searched for nests in 2005 and 2006 in scattered sites over a 5,000 km^2 area comprising ~25% of mature deciduous stands. In deciduous stands, the dominant species are sugar maple, American beech (*Fagus grandifolia*) and yellow birch. In these stands, the dominant silvicultural treatment is single-tree selection harvesting. See Bourque and Villard (2001) and Guénette and Villard (2005) for further details on the West Tobique and Black Brook districts, respectively.

2.2. Nest searching and monitoring

In 2005 and 2006, we intensively searched for Brown Creeper nests in mature and old ($\geqslant$75 years) northern hardwood stands ($\geqslant$75% of deciduous trees), irrespective of their harvest history. Because we did not mark individuals, we searched for nests in different locations and any nest found in 2006 within 500 m of a 2005 nest was excluded from the analyses. We chose a distance of 500 m in order to minimise the risk of resampling the same individual and especially the same habitat. In our study area, the area of creeper territories appeared to range between ~5 and 10 ha (J.-F. Poulin and M.-A. Villard, unpublished data). For comparison, we sampled vegetation in sites without creepers, which were located *a priori* on forest