

WINTER HABITAT USE BY BOREAL CHICKADEE FLOCKS IN A MANAGED FOREST

ADAM HADLEY¹ AND ANDRÉ DESROCHERS^{1,2}

ABSTRACT.—There are increasing conservation concerns associated with boreal regions, but little is known about winter habitat requirements of bird species inhabiting them. We examined flock size, winter habitat preference, and home range size of Boreal Chickadees (*Poecile hudsonica*) in a boreal forest harvested for timber near Quebec City, Quebec, Canada. We investigated whether and to what extent home range size was affected by clearcuts and regeneration forest stands. Flocks included an average of four individuals and occupied a mean winter home range of 14.7 ha. Flock membership and size were stable during the winter. Boreal Chickadees strongly preferred mature stands of commercial value (>7 m in height) and used regenerating stands (4–7 m in height) to a lesser extent. Younger stands (<4 m in height) and open areas were avoided. Home range size was not associated with landscape composition, but flocks with larger home ranges used them less evenly than those with smaller home ranges. This resident species prefers stands of commercial value and logging may contribute to apparent population declines of Boreal Chickadees. Received 23 September 2006. Accepted 31 March 2007.

Logging is considered the most important threat to birds inhabiting boreal forest regions (Imbeau et al. 2001) and is rapidly modifying North America's boreal forests. Approximately 300,000 ha of boreal forest in Quebec, Canada have been clearcut annually in recent years (Ministère des Ressources naturelles et de la Faune 2006). This logging practice is leading to a dramatic regional reduction in large tracts of mature forest and a subsequent increase in younger successional stages. The remaining forest patches are typically restricted to riparian buffer strips and buffers between adjacent clearcuts (Ministère des Ressources naturelles 1996).

Among birds, resident species are hypothesized to be most exposed to loss and fragmentation of boreal forests (Imbeau et al. 2001, Schmiegelow and Mönkkönen 2002). Population dynamics of resident species inhabiting northern latitudes appear to be strongly affected by events occurring during the non-breeding season (Matthysen 1990, Lahti et al. 1998, Doherty and Grubb 2002). Many resident species inhabiting boreal forests in Europe have undergone marked population declines hypothesized to result from forest harvesting (Imbeau et al. 2001). Despite increasing conservation concerns associated with boreal regions, little is known about win-

ter habitat requirements of bird species inhabiting them.

The Boreal Chickadee (*Poecile hudsonica*) is a boreal forest resident which exemplifies the lack of knowledge of wintering birds within these regions. The Breeding Bird Survey, despite its weak sampling effort for boreal species, reports an alarming decline of Boreal Chickadees (mean annual change 1966–2004 = -3.59% , $P = 0.0035$) in eastern North America (Sauer et al. 2005). This species is listed as highly vulnerable to changes induced by modern forestry (Imbeau et al. 2001). The Boreal Chickadee is often considered the North American ecological equivalent of the Grey-headed Chickadee (*P. cincta*); a species that has also undergone dramatic declines due to the effects of forestry practices (Imbeau et al. 2001).

Flocks of Boreal Chickadees form as soon as young fledge and persist throughout the non-breeding season (Sep–late Apr) (Ficken et al. 1996). Winter survival is thought to set population limits for Boreal Chickadees (Erskine 1977, 1992) and concern has been expressed about suitability of the remaining habitat in winter (Erskine 1992, Foss 1994, Cyr and Larivée 1995). Increasing the proportion of non-habitat and sub-optimal habitat within a landscape can increase the size of an animal's home range (Gjerde and Wegge 1989, Storch 1993, Siffczyk et al. 2003). However, winter home range characteristics and habitat use, despite their obvious implications for management, are virtually unknown for this species (Ficken et al. 1996).

¹ Centre d'étude de la forêt, Faculté de foresterie et de géomatique, Université Laval, Québec, Québec, G1K 7P4, Canada.

² Corresponding author; e-mail: andre.desrochers@sbf.laval.ca

Our objective was to measure the relative occurrence of Boreal Chickadees in mature and regenerating forest stands in a region managed for timber and recreational use. We tested whether flock size and interspecific composition were stable during winter months. We also tested whether size of Boreal Chickadee home ranges was associated with the area of clearcuts and regenerating stands. We predicted that flocks with large home ranges would occur predominantly in certain parts of their ranges (Carr and Macdonald 1986) and flocks with smaller home ranges would distribute their activities more evenly throughout their home range.

METHODS

Study Area.—We collected data during winters 2004–2005 and 2005–2006 at the Forêt Montmorency, Quebec, Canada (47° 20' N, 71° 10' W). The study area is a 66 km² boreal forest mosaic managed for timber exploitation and recreational use. Mature coniferous stands (>7 m in height) cover ~56% of the study area. Balsam fir (*Abies balsamea*) and occasionally black spruce (*Picea mariana*) dominate mature stands, interspersed with white birch (*Betula papyrifera*). Younger seral stages (4–7 m in height) were characterized by sapling balsam fir, black spruce and, to a lesser extent, mixed regeneration. These cover 24% of the study area. Open areas consisting of clearcuts, lakes, rivers, roads >7 m in width, and sapling stands <4 m in height cover 20% of the study area. An extensive road network (2.6 km/km²) crosses the research forest.

Use of Forest Stands.—We investigated habitat use from 85 unmarked Boreal Chickadee flocks. Seventy-two flocks were studied in the first winter (6 Jan–10 Mar 2004) and 13 flocks during the following winter (14 Feb–24 Mar 2005). We combined data from both years since no major differences in weather or food availability were observed. We located chickadee flocks each day using randomly selected points on a systematic 1-km spaced grid covering the study area. Grid points were visited only once during the study and we located flocks by snowshoeing a systematic search pattern. We started from the selected grid point and moved 500 m north, 500 m east, 1,000 m south, 500 m west,

and 500 m north to return to the point of origin. All flock detections were passive (no use of playback or “pishing”). Flocks members were unmarked and we assumed that a new flock was monitored each day, as flock composition differed in all but three cases of adjacent flocks (known to be separate due to simultaneous observations). We followed flocks on snowshoes and plotted their locations in real time at 1-min intervals using a hand held Trimble[®] GPS receiver (PDOP < 8). One-minute sampling intervals were used because serial correlation is irrelevant when using the proportion of an animal’s trajectory contained within each habitat type for compositional analysis (Aebischer et al. 1993). Frequent sampling more closely approximates the underlying trajectory and provides a more precise estimate of proportional habitat use (Aebischer et al. 1993, Barg et al. 2005). No positions were recorded during the first 2.5 min following discovery of a flock. We followed each flock for as long as possible not exceeding 3 hrs. Positions were recorded only when we were at the approximate center of the flock; data recording ceased immediately if observer position no longer represented that of the flock. The following period for a flock was also terminated if the observer lost contact. We then moved to another grid sampling point before recommencing the search for different flocks. The time we followed flocks ranged from 5 to 152 min (mean = 53 min) and path lengths ranged from 90 to 2,125 m (mean = 871 m). The total distance traveled following 85 flocks was 74 km in 75 hrs. We observed no discovery bias since there was no relationship ($R^2 = 0.001$, $F = 3.4$, $P = 0.06$) between stand type and time elapsed since initial discovery of a flock.

We divided the habitat within the study area into three categories: (1) mature forest (stand >7 m in height), (2) regeneration (4–7 m in height), and (3) open areas (stands <4 m in height or areas devoid of vegetation above snow). Stand seral stages were characterized using existing GIS coverage for the study area (validated *in situ*, delimited by GPS, and mapped with ArcView 3.3 [ESRI 2002]). We established a measure of available habitat representative of home range size (Jones 2001) by delineating a 200-m buffer surrounding the movement path for each flock. We generated

a 10-m spaced grid of points within each buffer. The resulting grid points were assumed to represent unbiased samples of the habitat due to the apparent lack of spatial periodicity in the stand types of the study area. We used compositional analysis (Aebischer et al. 1993) to examine if used habitat (observed locations) differed from available habitat within 200 m (grid points). We replaced missing values in log ratios (available but not used) with 0.001, at least one order of magnitude less than the smallest non-zero value for that habitat type, as suggested by Aebischer et al. (1993). We used SAS (SAS Institute Inc. 2004) and BYCOMPSAS macro (Ott and Hovey 1997) to compute the randomization procedure recommended by Aebischer et al. (1993). Only flocks having all three habitat types represented within the "available habitat" were used in the analysis. This constraint reduced the sample size to 79 flocks.

Home Range Estimation.—We calculated home range sizes using data collected from color-marked flocks of Boreal Chickadees during winter 2004–2005. Twenty-three members of seven flocks were captured from 6 December 2004 to 3 February 2005 using mist nets and playbacks of chickadees mobbing a stuffed owl. We marked birds with USGS numbered aluminum bands and unique color combinations. We fitted color bands with ~1 cm long flags of colored electrician's tape to enhance visibility for up to 10 m without use of binoculars (Desrochers et al. 1988).

Each marked flock received seven visits between 7 February and 24 March 2005. We randomized the order and time of visits among marked flocks, and successive visits were separated by 2–7 days. We located marked flocks using short (5 sec) bursts of Boreal Chickadee calls on a portable speaker audible to 70 m and by searching on snowshoes in concentric circles around the initial capture locations. Bursts of playback were short and restricted in frequency to limit effects on flock movements. We ceased playbacks if answering calls were heard and proceeded directly to where the birds were located. We identified flocks by band combinations and flock composition was recorded at the beginning of each visit. We followed flocks during each visit using the same procedure as with unmarked flocks. The time that we followed marked flocks during

each visit ranged from 5 to 165 min (mean = 43 min). We recorded successive locations when they were separated by at least 5-min intervals. Points were considered biologically independent as chickadees could easily move to any point within their home range during this time period (Barg et al. 2005). The number of locations per flock ranged from 48 to 83 (mean \pm SE = 69 ± 5 points).

We calculated home range size using both the minimum convex polygon (MCP) and 95% kernel methods. The MCP was used to allow comparison with other studies of parids (Harris et al. 1990). However, the MCP allows little insight into internal configuration of used spaces, is highly affected by peripheral locations, and can contain larger areas not used by the organism (Harris et al. 1990, Barg et al. 2005). We addressed these shortcomings by using a fixed kernel density estimator to study the density distribution of observations and to construct each flock's distribution of use (UD). We used the 95% fixed kernel to define the kernel home range size and the 50% fixed kernel area (containing 50% of the observations) to define the core area for each flock. Fixed kernel density estimations were performed using the Animal Movement extension in ArcView 3.3 (Hooge and Eichenlaub 1997). We used least squares cross validation (LSCV) for each flock to calculate the optimal smoothing parameter. Least squares cross validation provides the least biased estimates for smoothing parameters (Worton 1995, Seaman and Powell 1996).

Correlates of Home Range Size.—We compiled the proportion of different stand seral stages within MCP and kernel home ranges, and examined their association with home range sizes. We also calculated a variable (USE) representing the distribution of locations within the home range. USE was obtained by calculating the difference between the 95% and 50% (CORE) kernel estimations (Siffczyk et al. 2003). The USE variable provided information on whether flock locations were concentrated in distinct areas of the home range (high USE values) or evenly distributed throughout the home range (low USE values). Flocks with home ranges containing patchy, widely distributed, resources would be expected to have large USE values (concentrates use in select locations) and larger home

TABLE 1. Relationships among home range size, landscape composition, flock size, and use patterns within home ranges of seven marked Boreal Chickadee flocks. Correlation coefficients are shown with *P*-values in parentheses (Spearman rank correlation). Home range size = 100% minimum convex polygon (ha); USE = difference between the 95% and 50% kernels (ha). Habitat proportions represent proportions within MCP.

Variable	Home range size
Proportion of mature stands in home range	-0.57 (0.2)
Proportion of regeneration stands in home range	0.14 (0.8)
Proportion of open area in home range	0.39 (0.4)
Flock size	0.26 (0.6)
USE	0.89 (0.007)

range sizes. Flocks with evenly distributed resources would be expected to have lower USE values (more even use of home range) and smaller home ranges.

The association between landscape components and home range size was examined using Spearman rank correlations (SAS Institute Inc. 2004). Effects were considered significant at $\alpha = 0.05$.

RESULTS

Use of Forest Stands.—Boreal Chickadee flocks did not use mature forest, regenerating forest, and open areas at random (Wilks' Lambda = 0.22, $F = 134$, $P < 0.001$, $n = 79$). Mature forest was used more frequently than regenerating forest (mean log-ratio = 7.16, $P < 0.001$) or open areas (mean log-ratio = 16.44, $P < 0.001$), and regenerating forest was used more frequently than open areas (mean log-ratio = 3.60, $P < 0.001$).

Flock and Home Range Size.—We used data from all 85 flocks of Boreal Chickadees and found that mean (\pm SE) flock size was 4 ± 0.2 with a range of three to eight Boreal Chickadees. Sixteen of 85 flocks contained at least one Black-capped Chickadee (*Poecile atricapillus*) (4 ± 0.4 , range = 1–10 within these 16 flocks) and Red-breasted Nuthatches (*Sitta canadensis*) were present in 27 of 85 flocks (4 ± 0.3 , range = 2–8 within these 27 flocks). Nine flocks contained all three species. Black-capped Chickadees appeared to form cohesive flocks with Boreal Chickadees and remained in close contact with Boreal Chickadees throughout the entire following period. Red-breasted Nuthatches were associated with Boreal Chickadees only as loose foraging groups (they followed at a distance, often leaving and rejoining flocks). We used seven flocks of marked individuals to learn

that flock membership and size remained stable throughout winter months (Jan–Mar). We observed no apparent immigration, emigration, or mortality over a 6-week period in the seven marked flocks. No banded individuals disappeared or moved between flocks and the total number of individuals within flocks remained unchanged.

Boreal Chickadee flocks occupied a mean (\pm SE) home range size of 14.7 ± 3.2 ha (MCP, $n = 7$) with a range of 7.9 to 30.4 ha. Mean home range size using the 95% fixed kernel was actually larger, 16.9 ± 3.4 ha (95% kernel, $n = 7$) with a range of 7.6 to 33.9 ha. Flocks had a mean (\pm SE) core area of 2.3 ± 0.7 ha (50% kernel, $n = 7$) with a range of 1.0 to 5.8 ha.

Landscape Structure and Home Range Size.—Boreal Chickadee MCP home ranges contained $61 \pm 9\%$ mature forest (range = 21–94%), $23 \pm 10\%$ regeneration forest (range = 0–79%), and $15 \pm 6\%$ open area (range = 0–43%). We found no relationship between landscape components and MCP home range size (Table 1). However, we believe the trend of increasing MCP home range size with increasing proportion of open area (Fig. 1A) and decreasing home range size with increasing proportion of mature forest (Fig. 1B) has biological significance. Flocks with larger home ranges concentrated use in several distinct areas (large differences between 95% and 50% core areas) while flocks with smaller home ranges used their home range more evenly (Table 1). Home range size was not associated with flock size (Table 1).

DISCUSSION

Boreal Chickadee flocks are similar to wintering flocks of other northern parid species in size and member stability. Mean flock size (4

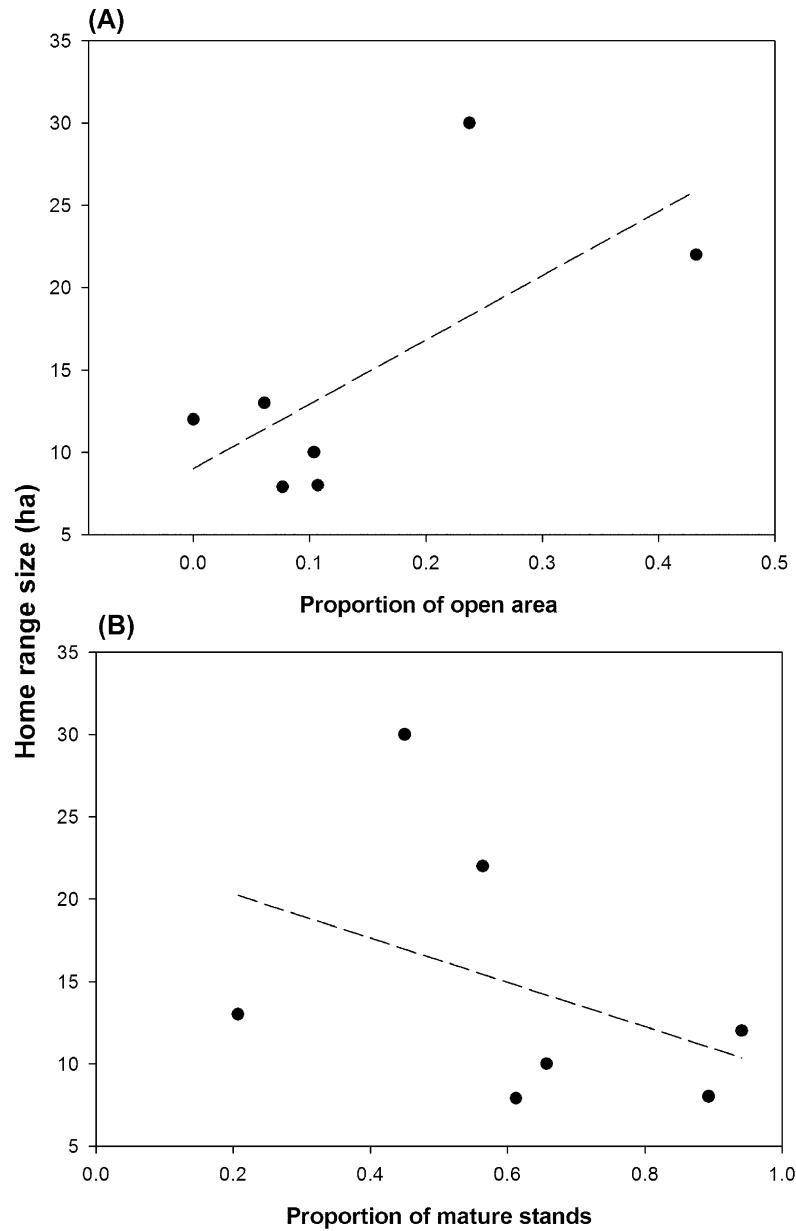


FIG. 1. Association between MCP home range size and (A) proportion of open area within home ranges, and (B) proportion of mature stands within home ranges of Boreal Chickadees, Quebec, Canada, 2004–2005. Trend lines are not significant.

± 0.2 individuals) was slightly larger than Grey-headed Chickadee winter flocks, which average between two and three individuals (Virkkala 1990). Willow tits (*Poecile montana*) form, on average, four-bird flocks (Ekman 1989, Siffczyk et al. 2003), while Black-

capped Chickadees usually form slightly larger flocks with six to eight individuals (Smith 1991). Our marked flocks showed member stability throughout the winter, as is thought to be the case with most parids (Desrochers and Hannon 1989, Ekman 1989). Boreal

Chickadees formed mixed species flocks similar to many wintering parids (Hogstad 1987, Smith 1991), but most often maintained flocks solely composed of conspecifics.

Boreal Chickadee flocks preferred mature forest stands and avoided young successional stages or open areas (Fig. 1, Table 1). Mature forest stands were strongly preferred to regeneration stands, but flocks frequently spent time in regenerating forest habitat. Boreal Chickadee flocks rarely spent time in open areas (when lone trees were available or when crossing gaps). These results are consistent with information on breeding habitat use by Boreal Chickadees. Whitaker and Montevecchi (1997) considered the Boreal Chickadee to be a forest generalist within coniferous wood-land areas. Erskine (1977) also showed Boreal Chickadees used both mature and young forest during the breeding season.

Our flocks had winter home range sizes of 14.7 ha, comparable to those of Black-capped Chickadees (9.5–14.6 ha [Smith 1991]; 22.4 ha [Desrochers and Fortin 2000]) and Willow Tits (12.6 ha [Siffczyk et al. 2003]) during the non-breeding season. Sizes of winter home ranges were not significantly associated with forest composition. However, our flocks had similar tendencies of increasing home range size with inclusion of a larger proportion of non-habitat to those demonstrated previously (Gjerde and Wegge 1989, Storch 1993, Siffczyk et al. 2003).

Differences in space use patterns depending on the size of winter home range likely reflect the patchiness of resources within large home ranges. Flocks with large home ranges focused their activity in distinct locations within their home range while flocks with smaller home ranges distributed their activities more evenly across space. These results agree with the resource dispersion hypothesis (RDH), which predicts that home ranges will be large when patches of resources are widely spaced (Carr and Macdonald 1986). Similar results have been shown for Willow Tits (Siffczyk et al. 2003).

Boreal forests in eastern North America are being subjected to intensive forest exploitation (Ministère des Ressources naturelles et de la Faune 2006). Extensive logging has resulted in a reduction in the proportion of mature forest with a subsequent increase in proportion

of young forest or open areas (Imbeau et al. 1999, Ministère des Ressources naturelles et de la Faune 2006). Consequently, forestry practices will result in substantial reduction of optimal Boreal Chickadee wintering habitat, at least over several decades. Our findings are consistent with the hypothesis that apparent population declines in this species result from loss of high-quality wintering habitat.

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