

# Distribution Patterns of Birds Associated with Snags in Natural and Managed Eastern Boreal Forests<sup>1</sup>

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## Abstract

In boreal forests, several bird species use standing dead trees for feeding or nesting and depend on them for their survival. Studies on wildlife use of snags have shown that their availability is greatly influenced by the age of the forest and the type of perturbation (natural versus anthropogenic). Accordingly, cavity-nesting birds seem largely affected by these changes in availability of snags. In North American boreal forests, relationships between birds and dead wood availability have predominantly been documented in western forests. The dynamics of dead wood and the distribution patterns of birds associated with this habitat feature remain largely unknown in eastern black spruce forests. Distribution patterns of birds associated with dead wood were documented in the eastern black spruce forest of northwestern Quebec, Canada. Study areas were composed of four forest landscapes (50-100 km<sup>2</sup>) that were naturally disturbed by different fire events (1 year, 20 years, 100 years and > 200 years) and two logged landscapes (20 years, 80 years). Birds were surveyed by point counts. Overall, 348 point counts were distributed over the six forest landscapes. Vegetation plots centered at each point count were used to sample live trees and dead wood. In naturally disturbed forest landscapes, species richness and abundance cavity-nesting birds reached a peak in early post-fire and in mature forest landscapes. Standing dead wood availability and abundance patterns of cavity-nesting birds were significantly less in 20-year-old managed forests landscapes than in those of naturally disturbed forests landscapes. This pattern was persistent in mature forests comparisons between 80-year-old horse-logged second-growth forests and mature forests of post-fire origin. Our results suggest that old-growth forests in this portion of the eastern black-spruce forest ecosystem do not play a key role for cavity-nesting birds. Mature and over-mature stands are, however, key habitats for many species of secondary cavity nesters, whereas early post-fire stands are key habitats for primary cavity-nesting birds and represent the main source of recruitment for standing dead wood in this ecosystem. Changes in silvicultural practices designed to maintain specific structure of over-mature stands (increased partial cutting) may provide a means for maintaining cavity-nesting birds at the landscape scale. Intensification of salvage cutting in early post-fire landscapes is another serious concern in black spruce forests. Reduction in the overall availability of dead wood through such forest practice may affect populations of some primary cavity nesters that are restricted to this specific forest type.

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## Introduction

In the boreal forest ecosystem, large-scale natural disturbances, especially fires, have historically played a major role in determining the structure of boreal forest landscapes (Anglestam 1996, Bergeron 1991, Johnson 1992, Van Wagner 1978). In the last 40 years, however, commercial timber management has become the prevalent perturbation in many parts of the boreal forest (Anglestam 1996, Enoksson and others 1995, Franklin and Forman 1987, Spies and others 1994). Although forest management may show some similarities with natural disturbances (fire and insect outbreaks) to which organisms are adapted, there are important differences between these two types of disturbances. Cutting rates are generally shorter than natural disturbance cycles (Gauthier and others 1996, Spies and others 1994) and more severe in terms of live trees and coarse woody debris that remain after logging (Spies and others 1994). Hence, in industrial forest landscapes, concerns regarding the issue of biodiversity have identified two important aspects: changes in the age structure of forests, and whether managed forests successfully substitute for unmanaged forests for maintaining biodiversity (Franklin 1993, Hansen and others 1991, Hejl and others 1995)—particularly in their capacity to maintain key environmental attributes such as coarse woody debris.

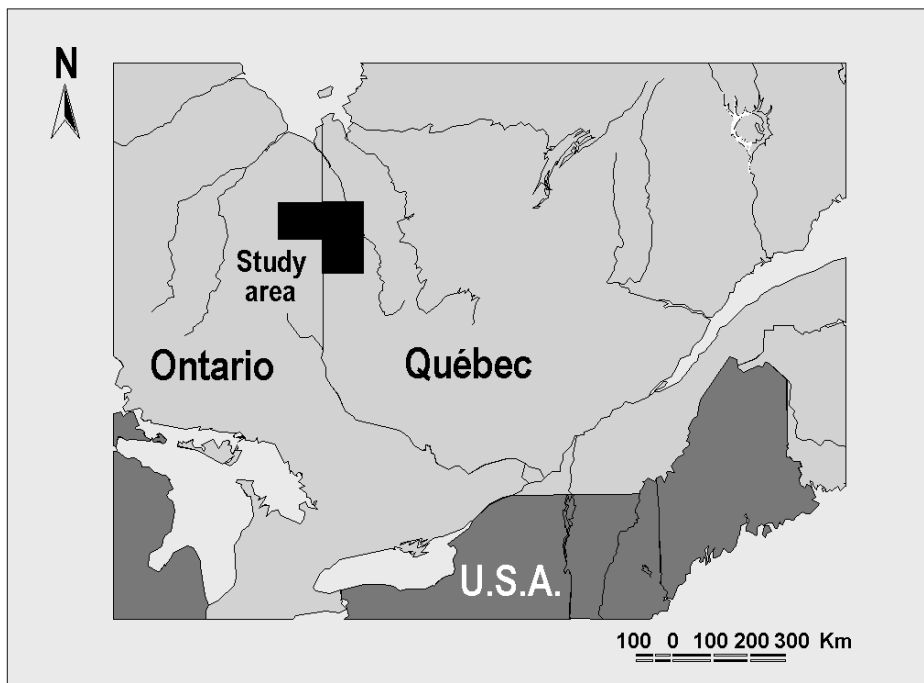
Until now, most knowledge on forest ecosystems biodiversity and how it relates to key habitats such as over-mature and old-growth stand types or key stand attributes such as density and quality of standing dead wood and fallen logs has mainly come from studies conducted in the Pacific Northwest forest (Hansen and others 1991, 1995a,b; Lamberson and others 1992; McGarrigle and McComb 1995; Spies and others 1988). Recommendations and management guidelines for sustainable forestry in this biome are not necessarily applicable in the eastern boreal forest. Moreover, as noticed by Freedman and others (1994), the status of forest types (by age-class) in eastern Canada and their contribution to biodiversity across landscapes remains poorly documented. Comprehensive efforts to assess the state of forest types and their contribution to biodiversity in the eastern boreal forest are critical. Coincident with these efforts, the question of how well managed forests substitute for natural forests is linked to quantitative field investigations that focus on whether key differences exist in biodiversity patterns between managed forests and naturally disturbed forests, and on how critical these differences are to the maintenance of regional biodiversity. For instance, in the eastern boreal black spruce forest, comparatively little information exists on responses of birds associated with dead wood. Does the general pattern of increased structural complexity of the forest as it is aging still hold for landscapes dominated by black spruce stands? Do the quantity and quality of dead wood show the same patterns of variation with forest age that has been documented in western coniferous forests? How do birds respond to changes in dead wood availability across time? Even though it is well recognized that standing dead wood is far less abundant in forests that were logged than they are in forests that regenerate from fire, what is the magnitude of differences in density of snags and in bird species' abundance? To tackle these issues, ecological investigations must incorporate both stand and landscape level approaches (Freedman and others 1994, Hejl and others 1995, Thompson and others 1995).

In this paper, we document distribution patterns of birds associated with snags in the eastern black spruce forest of northwestern Quebec, Canada. We examine abundance patterns across broad gradients in forest age and management history in four forest landscapes (50-100 km<sup>2</sup>) that were naturally disturbed by different fire

events (1 year, 20 years, 100 years and > 200 years) and in two timber harvested landscapes (20 years, 80 years). The first objective of this study is to document and explain the distribution patterns of birds associated with standing dead wood in naturally disturbed forest landscapes. The second objective is to evaluate some of the effects of forest management on this avian guild by comparing bird patterns and standing dead wood availability between natural and managed forest landscapes.

## Study Area

The study was undertaken in the eastern black spruce forest in the northwestern part of the Abitibi region in Québec (49°13'17" to 49°51'05"; 78°38'35" to 79°23'13") and in the Abitibi Lake Model Forest (49°03'33" to 49°42'20"; 80°09'03" to 80°38'35") in Ontario (fig. 1). These regions are part of the northern Clay Belt, a broad physiographic unit characterized by lacustrine deposits from the proglacial lakes Barlow and Ojibway (Vincent and Hardy 1977). Clay soils are predominant in the region, the topography is relatively flat, and the forest mosaic is dominated by stands of black spruce (*Picea mariana*). Jack pine (*Pinus banksiana*) is dominant on drier sites such as outwash deposits, old beaches, and eskers (Rowe 1972).



**Figure 1**—Location of the study area in the Quebec-Ontario eastern boreal black spruce forest.

Even though industrial forestry is increasingly shaping the present forest landscape, a large proportion of the forest cover is under a natural disturbance regime. Dendrochronological reconstructions of fire events indicate that natural fire frequency has decreased in the last 150 years (Bergeron and others 1998, 1999b). This decrease is responsible for the presence of large tracks of over-mature and old-growth forests in the study region. For the Quebec section of our study area,

industrial timber harvesting was initiated in the early 1970s, whereas even-aged management is the dominant silvicultural system with clearcutting as the main forestry practice. In Ontario, some areas have been horse-logged in the 1920s. As in many other regions of the Canadian boreal forest, clearcutting is followed by planting and seeding in 20 percent of the area, whereas 80 percent of logged areas are under natural regeneration (Haddon 1997).

## **Methods**

### ***Study Design***

Our study sites were within an area where a large (25,000 km<sup>2</sup>) fire history reconstruction project has been ongoing between the 48th and the 50th degrees of latitude along a south-north transect (Bergeron and others 1999b). A stand initiation map at the scale of 1:250,000 was constructed using either archives and aerial photographs (some dating from the 1930s) to delineate fires during the 20th century, or dendrochronology records of cored trees for older fires. We used forest cover maps and the fire history reconstruction map by Bergeron and others (2001) to delineate six forest landscapes (100 to 250 km<sup>2</sup>) that originated from different fire events (1 year, 20 years, 100 years and > 200 years) or logging events (20 years clear-cut and 80 years horse-logged). The forest cover maps and aerial photographs (for horse-logged forests) allowed us to identify the location of timber harvested areas, the time when they were harvested, and the location of access roads.

In each landscape, sampling stations were grouped by line transects to maximize time spent sampling, minimize time traveling between sites, and include inter-stand heterogeneity of forest mosaics. Four to six stations were located along line transects 1.2 to 2.5 km long. Line transects were separated by at least 1 km. Distance between stations varied from 350 to 450 m ensuring independence between stations (Bibby and others 1992). Each station was within a relatively homogeneous black spruce forest type. Overall, 348 sampling stations along 80 line transects provided extensive coverage of the study area.

### ***Bird Sampling***

The point count method was used to sample bird populations at each sampling station (Blondel and others 1970, 1981, Ralph and others 1995). Sampling was initiated at dawn and was conducted until 9:00 (EST). Data on bird species occurrence and abundance were recorded within a fixed radius of 75 m and over an unlimited distance around each station. Sampling stations were visited twice during the breeding season of 1997 and 1998: once in the first half and once in the second half of June. On each visit, birds (seen or heard) were recorded at 5-min intervals for a 20-min period. The sampling sequence varied so that each station was visited once at dawn and once later in the morning to maximize detection probabilities of each species present.

Sampling procedure adopted in this study with regard to the number of visits, the spacing of visits during the breeding season, the hourly periods appropriate for sampling, and count duration were based on a methodological study on the efficiency of the point count method in characterizing bird communities (Drapeau and others 1999a). The maximum count on either one of the two visits was used to estimate the relative abundance of each species at each station. Bird censuses were conducted in

comparable weather conditions, under clear and partly cloudy sky, and when wind speed generally did not exceed 8 km per hour. Counts were interrupted when wind speed exceeded 16 km per hour and when raining. Each sampling station was visited in only 1 of the 2 years.

### **Habitat Variables**

Habitat measurements were centered on the bird sampling station. From mid-July to mid-August of each year, features of vegetation structure and composition of live trees and dead wood were measured at each sampling station within a single triangular plot of 40 m per side covering a sampled area of 700 m<sup>2</sup>. For dead wood, measures of both standing dead wood and fallen logs were recorded in each plot. In this paper, emphasis is put on relationships between birds and standing dead wood. Hence, only methods for snags are presented.

Diameter at breast height (DBH) was recorded for all standing dead trees (snags) > 1.3 m tall in all plots. For each snag, decay stage was recorded using three variables: crown condition, bark, and wood condition. Crown condition was estimated by using the following classes: (1) all foliage, twigs and branches present; (2) some or all foliage lost, possibly some twigs lost, all branches usually present, possible broken top; (3) no foliage, up to 50 percent of twigs lost, most branches present, possible broken top; (4) no foliage, up to 50 percent of branches lost, top usually broken; (5) most branches gone, some sound branch stubs remain, top broken; (6) no branches, some sound and rotting branch stubs, top broken; and (7) no branches, minimum of rotting branch stubs, top broken.

Bark retention was determined using the following classes: (1) all bark present, (2) 1-5 percent bark lost, (3) 5-25 percent bark lost, (4) 26-50 percent bark lost, (5) 51-75 percent bark lost, and (6) >76 percent bark lost. Wood condition was assessed as follows: (1) no decay, (2) probable limited internal decay and wood essentially hard, limited decay, (3) wood mostly hard but decay spreading, soft wood present (4) balance of hard and soft wood (5) more soft wood than hard wood, (6) no more hard wood, and (7) hollow shell. Wildlife tree use, i.e., feeding activities (small holes and/or bark flaking) and nesting activities (nesting cavities) were also recorded for each of snag. These marks were identified to the bird species when possible.

### **Data Analyses**

To assess the overall stage of decay of standing dead wood, we used principal components analysis (PCA) (Legendre and Legendre 1998) to derive a single component variable that best describes the decomposition stage of each snag and that can provide a quantitative value of the mean stage of decay of snags in each sampling station. The first principal component accounted for 69 percent of the variance of the set of decay variables. PCA1 was partitioned into three equidistant classes of decay that will be used in further analyses.

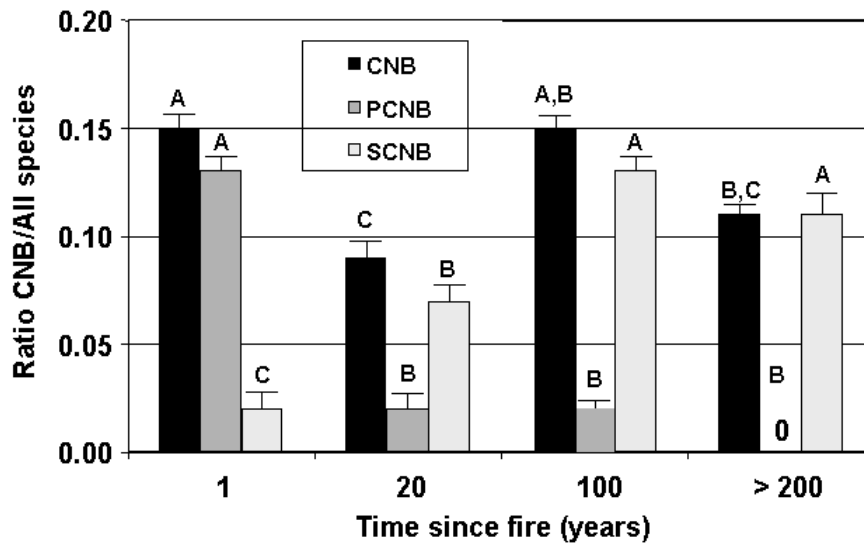
Comparisons among landscapes were conducted for species groups, such as (1) all cavity-nesting birds, (2) primary, and (3) secondary cavity-nesters. Species were grouped on the basis of their ability to excavate trees or to use holes excavated by other species. Relationships between these species groups and forest landscape types were determined using Kruskal-Wallis tests (Sokal and Rohlf 1981).

Differences between forest landscapes in mean availability (basal area) and decay stages of snags were evaluated using Kruskal-Wallis tests. For all significant Kruskal-Wallis tests, a Student-Newman-Keuls's (SNK) pairwise comparison procedure was used *a posteriori* to determine which landscapes showed significant differences. All analysis were performed using SAS (SAS Institute Inc. 1990). The significance level of each test was 0.05. Even though we counted birds with both limited (75 m radius) and unlimited distance (> 75 m) count points, data analyses were performed only with birds registered within 75 m of sampling stations centers.

## Results

### *Habitat Distribution of Birds at the Guild Level*

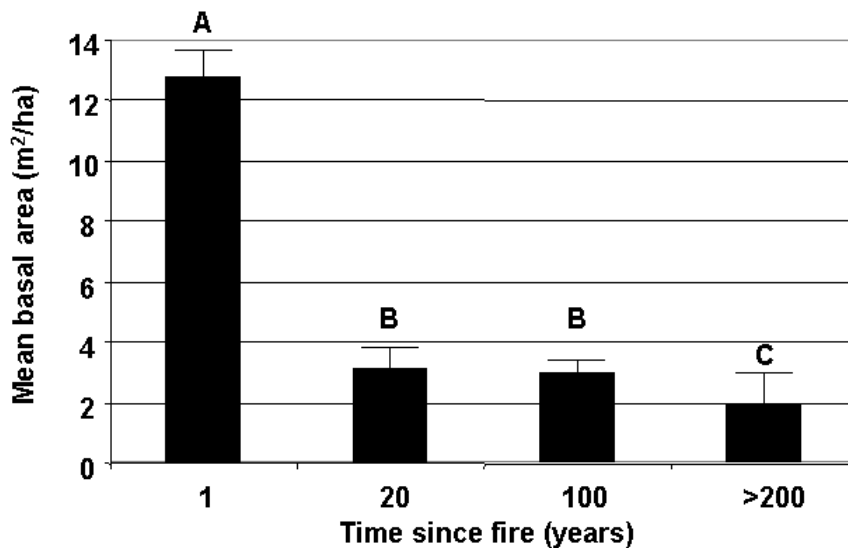
Overall, 94 species were detected across the 348 sampling stations. Half of these species were uncommon; 52 were detected in more than 5 percent of the sampling stations. Across landscapes the ratio of species associated with standing dead wood for nesting and feeding (hereafter cavity-nesting birds, CNB) peaked at 15 percent. Along the gradient of time since fire, CNB's reached a peak in early post-fire forests and in the mature forest landscape (*fig. 2*). The ratio of primary cavity nesters (PCNB) was highest in the early post-fire landscape, whereas the ratio of secondary cavity nesters (SCNB) peaked in the mature forest landscape, but was also important in old-growth forests. PCNB birds were absent in the old-growth forest landscape.



**Figure 2**—Distribution of cavity-nesting birds (CNB), primary cavity nesters (PCNB) and secondary cavity nesters (SCNB) in four natural landscapes that cover a time since fire gradient from early post-fire to old-growth forest types in the eastern boreal black spruce forest in Abitibi, Québec. For each category of birds, significant differences ( $P < 0.05$ ) for mean values ( $\pm 1$  SE) between landscapes are indicated by different letters.

### Changes in Standing Dead Wood over Time since Fire

Significant differences in standing dead wood availability were observed among forest landscapes (*fig. 3*). Availability of snags was highest in the 1-year post-burned forest landscape and was lowest in the old-growth forest landscape (*fig. 3*). Landscapes burned 20 years and 100 years (mature forests) were similar with intermediate values.

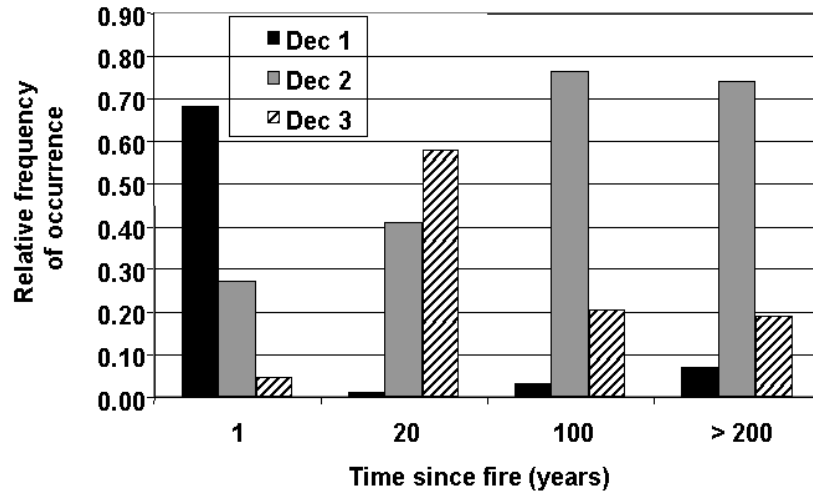


**Figure 3**—Changes in availability of standing dead wood in relation to forest landscapes' time since last fire in the eastern boreal black spruce forest in Abitibi, Québec. Significant differences ( $P < 0.05$ ) for mean values ( $\pm 1$  SE) among landscapes are indicated by different letters.

The decomposition stage of snags varied significantly among forest landscapes (Kruskal-Wallis:  $\chi^2 = 27.7$ ,  $df = 3$ ,  $P = 0.001$ ). The majority of standing dead trees were scarcely decayed in the early post-fire landscape, whereas the 20-year burned landscape showed the highest proportion of highly decayed snags (*fig. 4*). Decay stages of dead trees were similar between the mature and the old-growth forest landscapes. In these landscapes, the largest proportion of standing dead trees were in the intermediate decay class (*fig. 4*).

### Birds and Dead Wood in Managed Forests

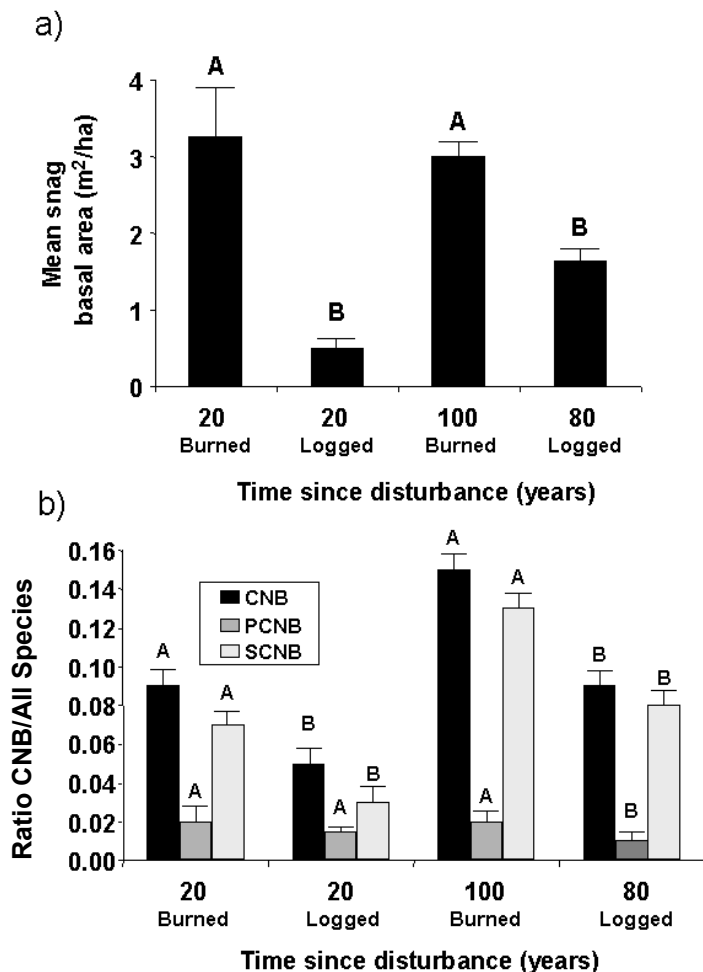
Comparisons between managed and natural forest landscapes were conducted for two time periods: 20 years after disturbance and 80 to 100 years after disturbance. Mean basal areas of snags  $> 5$  cm were significantly higher in both 20 and 100 year post-burned landscapes than in logged forests (*fig. 5a*). The proportion of birds associated to snags was also higher in post-burned landscapes than in their logged counterpart for both time periods (20 years and  $> 80$  years after disturbance). The only comparison that showed no significant difference was with the proportion of primary cavity nesters in the 20-year-old logged and burned landscapes (*fig. 5b*).



**Figure 4**—Decay stage of standing dead wood in relation to forest landscapes' time since last fire in the eastern boreal black spruce forest in Abitibi, Québec. Decay classes (Dec 1= weakly decayed, Dec 2= intermediate, Dec 3= highly decayed) were derived using scores on the first axis of a PCA conducted on the set of decay variables for standing dead trees.

## Discussion

Old-growth forests are usually considered key habitats for wildlife due to the overall increase in complexity of forest structure, amount of dead wood, and increases in live and dead tree diameter (Probst and others 1992, Raphael and White 1984). Our results show that in the black spruce forest, this age-class type does not have the same importance in the distribution of birds associated with dead wood than what has been suggested by other studies. For instance, no primary cavity-nesting birds were detected in the old-growth forest landscape, and the importance of secondary cavity-nesting birds in these forests was mainly related to Winter Wren's (*Troglodytes troglodytes*) abundance, which in our study area was widespread across the age-class gradient sampled (Drapeau and others 1999b). Coincident with these results, data on the mean basal area of snags was at its lowest in the old-growth forest landscape. Thus, snag availability was significantly reduced in old-growth forests, in particular for the larger snags (>15 cm dbh) that are significantly more likely to show evidence of feeding and nesting use by birds (Hutto 1995, Nappi 2000) than are smaller trees. This may explain why primary nesting birds were absent in the old-growth landscape. Our results suggest that old-growth forests in this portion of the boreal forest ecosystem may not play a key role for cavity-nesting birds. This is contrary to Shieck and others (1995) findings on the importance of old-growth stands for birds that nest in tree cavities in aspen-dominated boreal forests in Alberta. The importance of old-growth forests for birds may change depending on forest ecosystem or geographic area. In a recent review on silviculture and Rocky Mountain forest birds, Hejl and others (1995) found that assigning species as old-growth associates is not an easy task. They also found that even though some species were more abundant in some old-growth forests of the Rocky Mountains, none of these species were consistently more abundant in all old-growth forests among the studies they compared.



**Figure 5**—Distribution of (a) standing dead wood and (b) cavity-nesting birds in post-logged and post-burned forests in the eastern boreal black spruce forest in Abitibi, Québec. Significant differences ( $P < 0.05$ ) between means ( $\pm 1$  SE) for combinations of age-related harvested and naturally disturbed landscapes are indicated by different letters.

Comparisons among all four natural forest landscapes showed highest occurrence of primary cavity nesters (woodpeckers) and secondary cavity nesters in recently-burned forests and mature to over-mature stands, respectively. In early post-fire forests some species, like the black-backed woodpecker (*Picoides arcticus*), were not only more abundant but were restricted in their habitat distribution (Nappi 2000). Distribution of this woodpecker species in eastern boreal forests is thus consistent with Hutto's (1995) and Saab and others (1998) results in northern Rocky Mountain coniferous forests. Across their range, black-backed woodpeckers seem to be specialists of recently burned forests. The abundance of secondary cavity nesters reached its peak in mature to over-mature forests possibly because this age-class had a higher density of large live trees (> 20 cm) with few large snags, which may provide the combination of habitat characteristics that is important for species like the red-breasted nuthatch (*Sitta canadensis*), the brown creeper (*Certhia americana*), and the boreal chickadee (*Poecile hudsonicus*).

Quantity and quality of standing dead trees also indicate that early post-fire forests are key habitats for snag recruitment. This is not surprising in boreal systems where trees killed by fire is clearly a major source of dead wood. The importance of recently burned forests in our study area is, however, exacerbated by the fact that, in contrast to other forest ecosystems, the basal area or snags did not increase in our old-growth forests but was significantly less than in mature forests (Clark and others 1998, Tyrrell and Crow 1994).

Comparisons between logged and burned forest landscapes suggest that even though the availability of snags is low in natural landscapes at these time periods (20 and 100 years), clearcutting is not only significantly reducing the amount of snags but also the proportion of cavity-nesting birds. Secondary cavity nesters are particularly reduced in these forest age-classes. Retention of snags and living trees in black spruce forests during timber operations should be given more attention in future managed landscapes.

## Management Implications

Although forest management's main objective is to perpetuate forests not to convert them to other land uses as with other human disturbances (Hejl and others 1995), it may nevertheless alter the composition and structure of forest mosaics and hence biodiversity in the long term. In eastern boreal mixed-wood forests, large-scale conversion of mature forests from mixed-wood to deciduous cover due to the impacts of industrial logging on vegetation regeneration (Carleton and McLellan 1994) coupled with short timber rotations (Spies and others 1994, Gauthier and others 1996) may jeopardize the ecological integrity of bird communities (Drapeau and others 2000). In the black spruce forest, even though tree species composition will not be affected by short rotations, changes in the structural complexity are expected, notably in the overall decrease of over-mature and old-growth forests (Bergeron and others 1999a). Although our results are not consistent with those of other studies as for the importance of old-growth forests for cavity-nesting birds, they nevertheless raise concerns on the future of mature and over-mature stands that are key habitats for many species of secondary cavity nesters. For our study area, Bergeron and others (1999a) have showed that the natural forest stand age distribution follows a negative exponential with over 23 percent of the stands in intermediate stage (between 100–200 years). Hence, even though old-growth forests are not as important for birds as they are in other forest biomes, the dramatic reduction in the proportion of intermediate-aged seral stages in black spruce forests under normal rotations may pose a serious threat to bird communities.

Changes in bird communities we observed may be attenuated, provided that current forestry practices are modified in managed forest landscapes. The use of silvicultural practices designed to maintain specific structure of intermediate-aged stands may provide a means for maintaining species of secondary cavity nesters. For instance, diversified forest practices including partial cutting and careful logging that simulates the natural evolution of over-mature black spruce stands could be used to maintain an equivalent proportion of forests stands that retain intermediate-aged stand characteristics across the landscape (Bergeron and others 1999a).

Finally, given the major contribution of recently burned forests, both as a key habitat for primary cavity-nesting birds and as the main source of recruitment for dead wood, the intensification of salvage cutting raises serious concerns in black

spruce forests. It not only may compromise the maintenance of viable populations for species that require this specific forest type, but it may reduce the overall availability of dead wood to wildlife across current and future landscapes.

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