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# Are old boreal forests a safe bet for the conservation of the avifauna associated with decayed wood in eastern Canada?

Philippe Cadieux *, Pierre Drapeau

*Université du Québec à Montréal, NSERC-UQAT-UQAM Industrial Chair in Sustainable Forest Management, Centre for Forest Research, C.P. 8888, Succursale Centre-Ville, Montréal, Québec H3C 3P8, Canada*

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ABSTRACT

Old boreal forests are considered quality habitats for birds associated with decaying and dead trees. However, the quantity and quality of these structural attributes in old forest stands are likely to be influenced by important latitudinal changes in tree species composition and productivity from the southern boreal mixed to the northern coniferous forests. We measured habitat occupancy of cavity and bark nesting birds in old forests when the boreal forest landscape shifts from a mixed to a dominant coniferous matrix in the Clay Belt of Québec and Ontario, a region where paludification dominates. Using playback calls, songs, and recent woodpeckers' foraging signs on trees, we measured the occurrence and foraging habitat use of 11 bird species associated with deadwood in 86 unmanaged forest stands along a forest age gradient in both mixed and coniferous stands. In coniferous stands dominated by black spruce, deadwood birds showed a modal distribution in response to the aging of black spruce forests that reached a peak in stands of 160 years and then declined. Unproductive paludified stands, which made up more than 40% of our study area, were associated with a significantly lower species richness of deadwood birds. At the opposite, although they represented less than 4% of the forest cover in our study area, old boreal mixedwood forests (>90 years) were highly utilized habitats by deadwood birds. Structural diversity of trees (diversity of degradation stages and diameter of trees) was the variable that best explained species richness of this functional group of birds whereas at the individual species level, the quantity and quality of dead trees (degradation and size) in stands best explained species occurrence and abundance of foraging signs. Conservation efforts for deadwood birds should focus on old productive stands of both mixed and coniferous composition. However, our study pinpoints old mixedwood stand as habitats of special concern given their disproportionate importance for deadwood birds in northern boreal forests.



## 1. Introduction

In old boreal forests, decaying and dead wood represent key structural attributes for biodiversity (Stokland et al., 2012). Birds that use decaying and dead wood for nesting represent a major component of old forest bird communities (Angelstam and Mikusiński, 1994; Niemi et al., 1998; Imbeau et al., 1999, 2001; Schmiegelow and Mönkkönen, 2002; Drapeau et al., 2003, 2009; Schieck and Song, 2006). They have been proposed to be general indicators of old forests' biodiversity (fungi, insects, birds, mammals) (Mikusiński et al., 2001; Virkkala, 2006; Drever et al., 2008; Roberge et al., 2008). Within this focal group, woodpeckers are considered keystone species and ecosystem engineers since they produce most of the cavities that are used by a wide range of other vertebrates that cannot create their own cavities for roosting and reproduction (Aubry and Raley, 2002; Bednarz et al., 2004; Martin et al., 2004; Cockle et al., 2012; Tremblay et al., 2015a).

In recent years, studies on cavity-nesting communities in subalpine and boreal forests across Canada have found that large decaying and dead deciduous trees, particularly trembling aspen (*Populus tremuloides*), are the primary nesting substrates for most cavity users (Martin et al., 2004; Cadieux, 2011; Cooke and Hannon, 2012; Ouellet-Lapointe et al., 2012). Whereas decaying and dead trembling aspens are found in a wide range of old forest

* Corresponding author at: Université du Québec à Montréal, Département des sciences biologiques, C.P. 8888, Succ. Centre-Ville, Montréal, Québec H3C 3P8, Canada.

*E-mail address:* cadieuxp@gmail.com (P. Cadieux).

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cover types in the southern boreal forest (Bergeron and Charron, 1994), their availability may be reduced at more northerly latitudes due to changes in natural disturbance regimes linked with fire size and severity (Bergeron et al., 2004) which affects tree species composition of the forest cover (Gauthier et al., 2000). In addition, in some regions, such as in northwestern Québec and northeastern Ontario, northerly dominant black spruce stands are prone to paludification, a process of gradual conversion of a mesic forest to a forested peatland through the accumulation of organic material and water table rise (Taylor et al., 1988; Simard et al., 2007). Old black spruce stands thus present a wide spectrum of stand structures (Harper et al., 2002, 2003) ranging from increased vertical heterogeneity to extensive open canopy with smaller sized trees where the oldest stands may resemble bogs (Lecomte et al., 2006a,b).

Preliminary results on bird communities in black spruce forests of these regions have shown that species associated with canopy cover (foliage gleaners, canopy nesters) and old decaying trees (bark foragers, cavity nesters) become rare and are replaced by open habitat specialists (shrub nesters) in very old black spruce stands (>200 years since last fire), as they are not evolving into more complex vertical structures but are more simplified with an extreme canopy openness (Drapeau et al., 2003). Such turnover in bird community composition depicts a broad change in forest structure between recently old (100–200 years) and very old forests (>200 years) in landscapes prone to paludification. Clear understanding of the degree to which deadwood birds track structural changes in old black spruce forests is, however, lacking.

The latitudinal changes in structure and composition of old forests may thus diminish their role in providing key habitat conditions to deadwood bird species. Increased knowledge on how regional distribution patterns of this focal group of bird species changes over the natural transition from mixed to a conifer-dominated matrix in the boreal forest is thus critical to develop conservation planning of biodiversity in old stands in managed landscapes. This is still the case as commercial timber harvesting is unfolding in the north with extensive implementation of short-rotation even-aged management favoring an increase in the proportion of early-seral habitats and concurrent reduction in late-seral habitats even though ecosystem-based management mitigates this change (Gauthier et al., 1996; Bergeron et al., 2002, 2007).

In this study, we evaluate the importance of old boreal forests for deadwood birds when the boreal forest shifts from a mixed to a conifer-dominated matrix in the Clay Belt region of Québec and Ontario which is greatly affected by paludification. We hypothesize that old forest stands in this part of the boreal forest provide limited nesting and foraging conditions, reducing deadwood birds species richness patterns. More specifically, we make the following predictions at the community and individual species' levels. At the community level, we predict that in black spruce stands there will be a modal distribution of deadwood birds species richness and foraging habitat use, increasing along the age and structure gradient and declining as forests are affected by paludification. Second, since they are strongly isolated in the conifer-dominated forest matrix, boreal mixedwood stands will not have a higher species richness or foraging habitat use than black spruce stands. Third, the quantity and structural diversity of live and dead trees (size and degradation) will be the best predictor of deadwood birds' species richness and abundance of foraging signs. Fourth, at the species level, deadwood birds' occurrence and foraging habitat use patterns will translate into individualistic responses associated with specific structural attributes of live and dead trees.

## 2. Methods

### 2.1. Study area

The study was conducted in northwestern Québec in the black spruce-moss bioclimatic domain (Robitaille and Saucier, 1998). This region is part of a broad physiographic unit, the clay belt, which is located south of James Bay and extends across northern Québec and Ontario. The flat topography of the region originates from clay deposits left by proglacial lake Ojibway (Vincent and Hardy, 1977; Veillette, 1994). The study region is characterized by lower altitude (250 m) and the abundance of wetlands.

To obtain a representative sample of the range of forest cover types in the boreal forest of northwestern Québec, we sampled a large area of Québec's Clay Belt (Fig. 1). Specifically, we selected study sites in two regions, north of La Sarre (48°48′37.5″N 79°12′34.1″W) in the forest management units (FMU) 8551 and north of Lebel-Sur-Quévillon (49°03′18.1″N 76°59′42.2″W) in the FMU 8763 that differ in their topography and therefore their potential for paludification. The average annual temperature was 0.0 °C with an average annual precipitation of 909 mm, taken at the nearest weather station in Joutel, Québec, 1981–2010 (49°27′N; 78°18′W) (Environment Canada, 2016).

### 2.2. Site selection

We selected sites along a gradient of forest age, composition and structure, combining information from digital forest cover maps (MRNF, 2011) and field validation. Coniferous black spruce dominated stands were selected using digital forest cover maps and time since last fire estimates from two data sources. First, a study of fire history reconstruction provided extensive information on past historical fire events on a regional scale (Bergeron et al., 2004). Second, precise estimates of forest stand age were provided by detailed local scale dendrochronological analysis of stems (see Chaieb et al., 2015 for details). We selected 43 black spruce dominated stands aged 61–215 years: 60–90 years (n = 8), 90–120 years (n = 11), 120–160 years (n = 14), 160–215 years (n = 10). We enlarged this structural gradient by adding 21 stands that were in the process of paludification (n = 7) and paludified (n = 14). For the former, we selected stands 83–460 years considered forested in the first regional forest inventory that were later classified as bogs in the third regional forest inventory (MRNF, 1994; MRNF, 2009). Paludified stands (between 75 and 3849 years) were considered as bogs on digital forest cover maps. We selected 22 mixedwood stands dominated or co-dominated by trembling aspen and from two age-class categories provided on the digital forest cover maps 70–90 years (n = 11) and >90 years (n = 11). In each stand we positioned one playback station (total n = 86 stations) at least 100 m away from the edge of the stand and separated by >400 m.

### 2.3. Habitat sampling

We positioned three 400 $m^2$ sampling plots within a 100 m radius centered on the location of the playback stations to measure woodpecker foraging signs and to characterize the vegetation. One plot was positioned at the playback station whereas the two others were positioned 60 m away on randomly chosen cardinal directions. Precise measures were taken for every tree >10 cm in DBH (diameter at breast height): tree species, degradation class and the presence or absence of woodpecker