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Do forests treated by partial cutting provide growth conditions similar to old-growth forests for epiphytic lichens?

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ABSTRACT

In boreal forests, partial cutting is increasingly proposed as a suitable alternative to the widespread use of clearcutting in order to conciliate forest management with habitat conservation for epiphytic species. We compared the growth of two epiphytic lichen species, *Bryoria nadvornikiana* and *Evernia mesomorpha,* in old forest stands recently treated by partial cutting and untreated controls, located in black spruce boreal forests of western Québec. Lichen growth rates were measured over a period of two years from transplants of the two species, and several environmental variables (e.g., canopy openness, thallus temperature, and thallus wetness) were also measured directly at the sampling sites. Despite important within-treatment variation in growth rates among transplants, we observed reduced growth rates in partial cuts for both species. Canopy openness measurements of more than 40% resulted in negative growth rates for *B. nadvornikiana*, a species typically associated with relatively closed canopies, and canopy openness over 70% resulted in negative growth rates for *E. mesomorpha*, a species that tends to be associated with open canopies. This negative growth response contrasts with what is generally reported in the literature about the effect of canopy opening creation on epiphytic lichen growth. As a function of the environmental parameters that were measured on site, we suggest that a reduction in the duration of hydration periods, and an increased risk of thallus fragmentation in partially cut stands, especially for *B. nadvornikiana*, could explain this result. Because this negative effect could be more likely to occur during dry periods, future trends in the response of epiphytic lichens to the creation of canopy openings could be influenced by climate change. This study suggest that even if partial cuts can be a good alternative to clearcutting for the conservation of epiphytic lichen species, they are more likely to succeed if dense clumps of residual trees (canopy cover > 70%) are retained in the treated stands.

1. Introduction

Epiphytic lichen biomass accumulation in natural forests generally increases with stand age (McCune, 1993; Esseen et al., 1996; Boudreault et al., 2009). In the central and eastern sections of the Canadian boreal forest, old stands of irregular structure formed a significant portion of pre-industrial landscapes, often between 40% and 70%, depending on natural fire return intervals (Cyr et al., 2009). This proportion has declined significantly in contemporary eastern Canadian boreal landscapes (Cyr et al., 2009; Bouchard and Pothier, 2011), mostly because natural fires continue to occur concomitantly with clear-cut logging, which is by far the most widespread harvesting method used in boreal forests (Harvey et al., 2002). Because several lichen species have limited propagule dispersal capabilities and are dependent on structural attributes or microclimatic conditions present in old stands, they need a sufficient quantity of old forest stands to persist at the landscape scale (Dettki and Esseen, 2003), and the question of finding alternate management techniques that allow the maintenance of lichen populations at the stand scale is highly relevant from a conservation perspective.

Partial cutting has been proposed as a complementary strategy to clear cutting in order to maintain or recreate structural characteristics associated with old-growth coniferous forests (Harvey et al., 2002; Franklin et al., 2002; Kuuluvainen, 2009). In the short term partial cuts will allow forest managers to maintain epiphytic lichens that are present on residual trees within treated stands, but modifications in local environmental conditions that follow harvesting may influence the subsequent dynamics and viability of

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these populations. Some epiphytic lichens are potentially sensitive to small changes in light, temperature, and moisture availability because they are poikilohydric organisms, meaning that they are unable to regulate their uptake or loss of moisture, and consequently depend on atmospheric sources for water and inorganic nutrients (Nash, 2008).

Understanding the impact of small-scale disturbances on epiphytic lichen may have important management implications in selecting forestry interventions that are compatible with the conservation of residual populations of epiphytic lichens. Because low light conditions are known to restrict the growth of epiphytic lichen species in coniferous forests (Gaio-Oliveira et al., 2004; Gauslaa et al., 2006, 2007; Jansson et al., 2009), some authors found that partial cutting might create acceptable conditions for epiphytic lichens (Rominger et al., 1994; Coxson et al., 2003; Stevenson and Coxson, 2003; Coxson and Stevenson, 2005; Stevenson and Coxson, 2007; Muir et al., 2006; Stone et al., 2008; Jairus et al., 2009). However, in some circumstances, the abrupt creation of canopy openings could negatively impact the growth or the vitality of epiphytic lichens (Hedenås and Ericson, 2003; Coxson and Stevenson, 2005) and could thus potentially affect population dynamics.

We implemented a partial cutting experiment with diverse removal intensities to study the response of epiphytic lichens to changes in canopy openness in the Abitibi region of northern Québec (Fenton et al., 2009). The study area is part of the large boreal coniferous zone of eastern Canada, where no such study has been undertaken so far. The general objective of this study was to evaluate the response of two epiphytic lichens with different ecological requirements, *Bryoria nadvornikiana* (Gyelnik) Brodo & D. Hawksw. and *Evernia mesomorpha* Nyl., to canopy openness. We addressed two major hypotheses in this study: (1) that the growth of *B. nadvornikiana*, a species typically associated with closed-canopy forests, would be lower in the opened forest canopies than the growth of *E. mesomorpha*, a species more commonly associated with open-canopy forests, and (2) that the growth of the two species would be favoured when small increases in canopy openness occurred, but would decline above some threshold. Results showing comparable growth between partial cuts and control forests would indicate that partial cutting may maintain an adequate environment for epiphytic lichen growth and constitutes a good alternative to generalized use of clear cutting to maintain the environment and species associated with old forests.

2. Methods

2.1. Study area

We studied lichen growth at three sites which are located more than 50 km from one another, in the northwestern boreal forest of the Abitibi region of Quebec (Fig. 1). The sites are located in the northern Clay Belt (Rowe, 1972), a broad physiographic unit of the Canadian boreal forest characterized by lacustrine deposits originating from the last glaciation. Clay soils predominate, the topography is relatively flat, and the forest mosaic is dominated by black spruce (*Picea mariana*) stands. A meteorological station located at Matagami, close to our study sites (Fig. 1), indicates a mean annual temperature (1971–2000) of −0.7 °C, and mean total annual precipitation (1971–2000) of 906 mm (Environment Canada, 2004). The weather station recorded more precipitation and lower temperatures during summer 2004, the first year of the experiment, than in summer 2005 (Fig. A1). June was particularly warm in 2005 with a mean temperature of 16.6 °C compared to 11.4 °C in 2004. Total summer precipitation (June, July, and August) in 2004 was twice as high as that of summer 2005 (Environment Canada, 2010; Fig. A1).

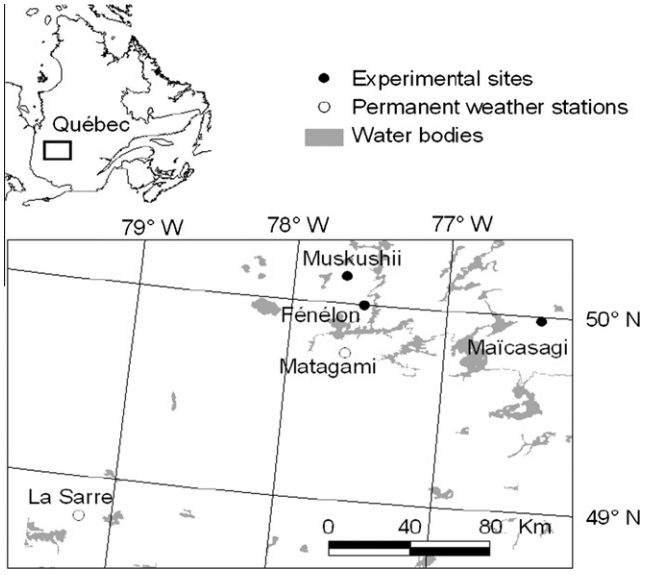

Fig. 1. Map of the study area.

Each site contains a block of at least 25 ha of stands treated with partial harvests (between 45% and 85% basal area removal at the stand scale), and a block of at least 25 hectares where no harvest was done, and which was used as a control. These sites were part of a larger study on the effects of tree removal on stand dynamics, and the plot selection procedure is detailed in Fenton et al. (2009).

Within each of the three sites, we conducted lichen growth studies in 12 circular 400 m^2 plots located in partially cut treatments, and 12 plots located in uncut control treatments, for a total of 72 plots. All plots were dominated by black spruce. Each sample plot was located at least 100 m from the main roads to avoid any edge effect. Stand density and basal area after removal were measured inside each plot.

2.2. Studied species

We selected two species as indicators of canopy openness for this experiment: *E. mesomorpha* and *B. nadvornikiana*. These two species were selected because they have different ecological requirements and we expected that their responses to canopy openness would also differ. *E. mesomorpha* is a common species associated with open-canopy forests and occurs on trunks or branches of coniferous and deciduous trees. This species has a yellowish green color, is relatively robust and has a pendant or shrubby thallus (Brodo et al., 2001). *B. nadvornikiana* is more often found in closed and humid forests of the southern part of the boreal forest in Québec (Brodo and Hawksworth, 1977). In the study area, *B. nadvornikiana* was generally less abundant than *E. mesomorpha* or other *Bryoria* species associated with open-canopy forests (Boudreault et al., 2009), and was generally found in partially shaded conditions on the lower branches of conifers. *B. nadvornikiana* is pale gray, and has a finely dissected shrubby to almost pendant thallus (Brodo et al., 2001).

2.3. Lichen growth

Growth rates of *E. mesomorpha* and *B. nadvornikiana* were assessed with repeated measurements of transplants attached to artificial substrates. We collected thalli of *E. mesomorpha* and *B. nadvornikiana* in undisturbed forests at the three sites. Thalli approximately 3 cm long were collected between 1.5 and 3 m above the ground. Under a dissecting microscope, collected thalli