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Relationships between the structural complexity and lichen community in coniferous forests of southwestern Nova Scotia

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ABSTRACT

The relationships between the structural complexity of coniferous forests and the epiphytic lichen communities that inhabit them were examined in 51 conifer-dominated stands in southwestern Nova Scotia. One hundred and fifteen lichen species were studied in stands in the age range of 50–300 years. Environmental variables shaping the structural complexity of each forest stand were measured and their relationship with lichen species were assessed using a canonical correspondence analysis (CCA). The CCA revealed that the considerable variation in lichen community composition can be explained by several environmental variables associated with forest structure. The stand orientation on the first axis of the CCA found the most important variables for lichen richness to be stand age, tree stem density and snag stem density. The stand orientation on the second axis is strongly correlated with deciduous stem density and abundance including specific deciduous tree species such as *Acer rubrum* abundance. The analysis indicates that the greater the structural complexity in the forest, and thus the more microhabitats available, the greater the lichen species richness. These results should provide forest managers with a better understanding of the environmental variables that influence lichen diversity, and contribute to the development of more sustainable forest management strategies.

1. Introduction

Lichen community composition in forest stands has been shown to change over time (Rose, 1974, 1976; Selva, 1994, 2003). As a forest develops, its structural complexity increases, which includes an increase in canopy irregularity, thus allowing for greater light variation (Stewart et al., 2003; Pesklevits, 2006). When trees age, increasingly fissured bark and lignum at different stages of growth and decay become available for colonization (Pipp et al., 2001; Stewart et al., 2003; Pesklevits, 2006). As variability in these conditions increase, so does microhabitat diversity, which in turn increases the number of organisms able to survive in the forest (Carey, 1989; Carey and Johnson, 1995). One of the most ubiquitous and diverse groups of organisms in forests is the lichen community, some species of which tend to be unique to old-growth forests; this is underscored by the application of lichens as surrogates or "bioindicators" of forest structure (Goward, 1994; McMullin et al., 2008).

Rose (1974, 1976) was the first to use lichens as bioindicators of forest continuity, which is a measure of time since a forest was undisturbed by major natural or unnatural events. He used a particular suite of lichen species that appeared to prefer older forests to determine a continuity value for forests in Britain. The greater the number of lichen species from his suite meant a greater continuity value. In recent years, Selva (1994, 1999, 2002), and Coppins and Coppins (2002) have extended Rose's work by developing unique suites of lichen species that exhibit preference for mature forests in different ecological regions in Canada, the United States and Britain. If the number of lichen species in the forest increases with time and the structural complexity of the forest also increases with time, then the environmental variables that shape structural complexity may be predictors of the lichen communities in forest stands.

Individual environmental variables are often examined for their influence on lichen diversity (Adams and Risser, 1971; Kuusinen, 1996; Coxson and Stevenson, 2007). A comparison among those variables, however, appears to not have been done in the Acadian

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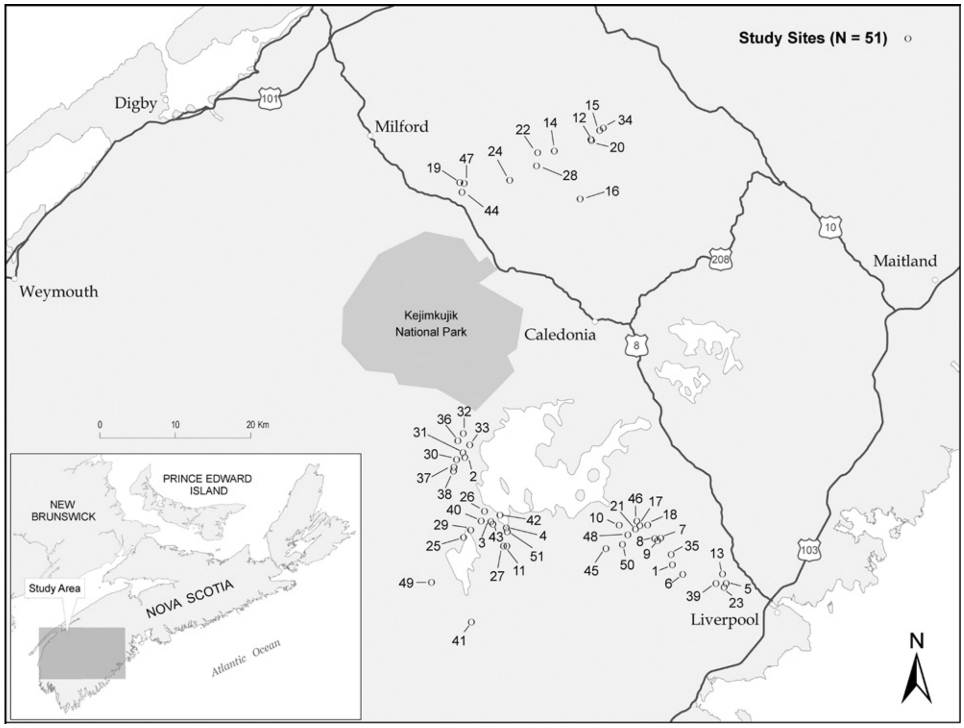

Fig. 1. Location of study sites in southwestern Nova Scotia, Canada.

forest region of northeastern North America. Therefore, the aim of the present study was to explore patterns of lichen community composition at a stand scale using relationships between stands, species, and environmental variables in forests from southwestern Nova Scotia. The lichen richness data used in this study were first presented by McMullin et al. (2008). In that study, 135 lichen species were identified, but that number was reduced to 115 for this study. All genera that were not broken down into species, and species with a high uncertainty of being located in each stand, particularly those in the genus *Usnea*, were not included to maintain accurate community compositions. The data obtained by examining the environmental variables in each forest stand are newly presented information.

The results of this study should provide forest managers with a better understanding of the environmental variables that influence lichen diversity, and contribute to the development of more sustainable forest management strategies. Additionally, this research contributes information to a larger project supported by the Sustainable Forest Management Network that is focused on gaining a greater understanding of old-growth forests and ultimately on developing conservation strategies for these forests (Brassard et al., 2008; McMullin et al., 2008; Moyer et al., 2008; Owen et al., 2008).

2. Methods

2.1. Study sites

During the summers of 2005 and 2006, 115 epiphytic lichen species were identified in 51 conifer-dominated forest stands in southwestern Nova Scotia that ranged between 52 and 292 years of age (estimated using dendrochronology) and had no visible evidence of timber harvesting (Fig. 1). The UTM coordinates of each stand are listed in McMullin (2007), coordinates range between 4875697 and 4934239N and 316510 and 355584E (Zone 20T). This area is covered by the Rossignol and South Mountain eco-districts which are characterized by undulating low-elevation post-glacial topography and forests with well-drained medium-textured till (Neily et al., 2003). The criteria for the composition of the trees in each stand was > 70% conifer. The minimum stand size was large enough to establish a 30 m × 300 m sampling plot within a 50 m marginal buffer. The stands were initially identified using Bowater Mersey Paper Company's (now AbitibiBowater) forest resource inventory maps and aerial photos. A visual ground survey was then conducted to ensure that the site criteria were met. The stands were assessed by recording the stem density of live trees and snags (≥1.3 m in height and ≥8 cm dbh), the composition of tree species, stand coordinates (in the universal-transverse-mercator projection), the proximity of wetlands (lakes and rivers) and swamps (marsh and treed bogs), the amount of light reaching the forest floor throughout the stand (canopy closure), and the calculated stand ages using tree cores. Additional details about the methods are provided in Pesklevits (2006), McMullin (2007), and McMullin et al. (2008).

2.2. Lichen diversity (richness) plots

Within each forest stand, a plot was established at least 50 m from the stand edge (as depicted on forest-inventory maps) to limit edge effects (Esseen and Renhorn, 1998; Rheault et al., 2003), which results in increased light exposure, reduced moisture and greater wind exposure (Chen et al., 1993; Renhorn et al., 1997). A total of 51 plots for assessing lichen richness were established. Lichens were surveyed within a rectangular plot (30 m × 300 m; 9000 m^2), which included five plots that were used to examine structural complexity (see below). The sampling effort in each lichen plot was 2.5 h by one person (the lead author). Sampling was restricted to 0.5–2.0 m above the ground on the boles of all trees, snags, and shrubs including accessible branches within this zone. The lower trunk was not examined to avoid terricolous lichens that often grow on the base of boles. The 'floristic habitat sampling' method described by Newmaster et al. (2005) was used and each epiphytic lichen species encountered in a plot was collected, including both microlichen and macrolichen species. Selva (1994, 1999, 2003) described this