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Songbird response to experimental retention harvesting in red pine (*Pinus resinosa*) forests

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ABSTRACT

Traditional harvesting practices frequently result in simplification of the structure and composition within managed forest stands in comparison to their natural counterparts. In particular, loss of heterogeneity within stands may pose a problem for maintaining biodiversity in perpetuity. In this study, we survey breeding bird diversity and abundance in response to different spatial harvesting patterns in mature red pine forests located on the Chippewa National Forest of northern Minnesota, USA. Treatments are designed to increase structural complexity over time and include three overstory manipulations (dispersed retention, aggregate retention with small gaps, and aggregate retention with large gaps), one understory manipulation (brush removal), and controls (no harvesting, and/or no brush removal). In 2003, the first breeding season following the harvest, we found little difference in bird community composition between control and treatment stands. In 2005, the third breeding season following harvest, avian abundance, richness, and diversity were all greater within treatments. Species associated with edge, shrub, and early successional habitats generally show positive response to treatments (e.g. Chestnut-sided Warbler [*Dendroica pensylvanica*], Mourning Warbler [*Oporornis philadelphia*], Chipping Sparrow [*Spizella passerine*]), as do some species associated with mature forest (e.g., Pine Warbler [*Dendroica pinus*], Rose-breasted Grosbeak [*Pheucticus ludovicianus*]). Ovenbirds (*Seiurus aurocapilla*) and Black-throated Green Warblers (*Dendroica virens*) were more abundant in control stands. There are, as of yet, no discernable differences in avian community composition among the three overstory treatments or between the single understory treatment and the understory control, but differences are expected as the treatments diversify due to understory development. While overstory retention harvests provide habitat for a diverse and abundant bird community, the temporal divergence in avian community composition that we observed between treatment and control stands reveals the importance of uncut, mature red pine forest as a component of a biodiverse landscape.

1. Introduction

Ecologically-based forestry has been proposed as a means of meeting silvicultural objectives beyond tree regeneration, including forest restoration, biodiversity enhancement, fuel reduction, disease control, and improved aesthetics (Franklin et al., 1997; Moore et al., 1999; Palik et al., 2003a; Halpern et al., 2005; Seymour and Hunter, 1999). The use of overstory retention at harvest is one of the key implementation approaches for ecological forestry, and is grounded in the concept of biological legacies (i.e., organism, organic materials, and organic patterns that survive a disturbance and provide complexity to the new stand; Franklin et al., 1997). Retention at harvest, particularly of large residual trees, is increasingly employed to enhance the complexity of forests traditionally managed for a single-cohort structure (Franklin et al., 1997; Palik et al., 2003a). Retained trees can be left in various spatial distributions, either uniformly dispersed or aggregated in clumps of varying sizes.

Though supported by principle, few tests of the effects of overstory retention on biodiversity response and community dynamics have been published (Schulte et al., 2006), although work in various regions is being conducted (Monserud, 2002; Palik et al., 2003a; Halpern et al., 2005). The level and spatial pattern of retention may have substantial, direct impacts on future forest composition, productivity, and diversity by altering stand-level resource availability and competitive environments (Palik et al., 2003a; Halpern et al., 2005). While studies have long shown that many wildlife species, and birds in particular, respond to the

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structural heterogeneity of habitat within forest environments (MacAurthur and MacAurthur, 1961; Hilden, 1965; Willson, 1974; Schulte and Niemi, 1998; Saab, 1999), the specific habitat elements to which wildlife respond are less well-known. It is expected that wildlife will respond positively to ecologically-based forestry practices that mimic the structural complexity of natural stands (Schmiegelow and Monkkonen, 2002), but on-the-ground tests from geographically and ecologically varied locations are needed before such practices can be broadly recommended (Erhlich, 1996; Schulte et al., 2006). In particular, it is important to differentiate wildlife response to key structures which can be incorporated into forest management regimes (e.g., green tree, snag, shrub, and coarse woody debris retention) versus responses that might be more local in character (e.g., edaphic conditions, ephemeral ponds, abundance of fruit or nut bearing trees).

Ecological forestry approaches have specifically been proposed as a means of restoring and enhancing red pine (*Pinus resinosa*) forests in the northern Great Lakes region of the U.S. (Palik and Zasada, 2003). Today, the extent and dominance of red pine in the northern Great Lakes region is greatly reduced compared to pre-Euro-American settlement levels (Schulte et al., 2007). Following the initial cutover of the region between the mid-1800s and the early 1900s, red pine regenerated naturally on some of the sites that it had historically occupied; other stands were artificially regenerated in even-aged plantations. In either case, the historically important process of fire disturbance was eliminated from red pine ecosystems, resulting in structural and compositional differences in present day red pine forests relative to their historical counterparts (Heinselman, 1996; Radeloff et al., 1999). Historically, for instance, red pine forests could exhibit a multi-cohort age structure, were highly variable in tree density, and frequently contained a mixture of tree species (Frelich and Reich, 1995; Heinselman, 1973; Whitney, 1986). In locations where fire was very frequent (10–50 years), red pine even existed in a savanna condition (Heinselman, 1996; Radeloff et al., 1999). Red pine forests today are largely single-cohort and monospecific (Palik and Zasada, 2003). Where the intention is to manage these stands for ecological goods and services beyond timber production, ecological forestry approaches may assist in meeting non-timber goals, including sustainability of native wildlife communities and diversity.

To improve understanding of wildlife response to overstory retention, we tested for differences in initial bird response to experimental retention harvest of red pine forests in northern Minnesota. This research is part of the Red Pine Ecosystem Complexity Study, which seeks to develop and evaluate approaches which increase the compositional and structural complexity of red pine forests while maintaining wood production (Palik and Zasada, 2003; Seymour et al., 2006). Overstory retention was incorporated into harvests to provide residual tree legacies and, ultimately, to enhance the size, age, and compositional complexity of what were largely single-cohort, monotypic stands. Overstory treatments consist of differing spatial patterns of retention, including dispersed retention and several types of aggregate retention (Fig. 1). Stands are now being managed for a two-cohort structure and may potentially be managed as multi-cohort in the future. Compositional diversity is being enhanced by underplanting eastern white pine (*P. strobus*), red pine, and jack pine (*P. banksiana*). Manual shrub control is also being implemented, in lieu of prescribed surface fire, to enhance understory competitive environments for tree seedlings, to improve tree recruitment, and to encourage the development of a more floristically diverse understory.

In the context of this experiment, we hypothesized that bird abundance and richness would increase concomitantly with the level of aggregation of the retained overstory trees. We based this hypothesis on the following: (1) studies showing that forest songbirds respond to the amount and configuration of vegetation heterogeneity (MacAurthur and MacAurthur, 1961; Hilden, 1965; Willson, 1974; Schulte and Niemi, 1998; Saab, 1999), including heterogeneity created by retention of residual canopy trees over decadal timeframes (Schieck and Song, 2006), (2) research showing that single-cohort red pine plantations generally have low vegetation heterogeneity (Palik and Zasada, 2003), and (3) the supposition that understory response is expected to be greatest and most diverse in the large gap retention, due to a more heterogeneous light environment (Palik and Zasada, 2003).

2. Methods

2.1. Study area

The four replicated blocks that formed our study area are located within largely single-cohort, monotypic red pine forests on the Chippewa National Forest in northern Minnesota, USA. All four experimental blocks are low in elevation, have low topographic relief, are located on an outwash ice contact landform with deep sandy soil, and are similar in climate (average annual temperature = 3.9 °C; average annual precipitation = 70.0 cm; MRCC, 2006). According to National Forest records, study stands regenerated naturally after a seed tree cut (10% residual pine) between 1910 and 1912 and have since been entered two to three times for thinning (Palik et al., 2003b). A few stands were burned in the 1990s to increase blueberry production. Pre-harvest basal areas of the study stands averaged 36 m^2/ha for trees above 10 cm diameter at 1.4 m height. Red pine comprised about 90% of total basal area. Species found in lesser amounts included trembling aspen (*Populus tremuloides*), bigtooth aspen (*P. grandidentata*), paper birch (*Betula papyrifera*), eastern white pine, balsam fir (*Abies balsamea*), northern red oak (*Quercus rubra*), red maple (*Acer rubra*), white spruce (*Picea glauca*), burr oak (*Q. macrocarpa*), and black spruce (*P. mariana*).

Our experimental design was a randomized complete block replicated four times. Blocks consisted of three overstory retention treatments and an unharvested control, each of which was further divided into an understory competition treatment and an understory control (Fig. 2). Blocks were approximately 64 ha in extent and consisted of four ~16 ha stands. Overstory treatments retained a residual basal area of ~18 m^2/ha, but residual trees were left in different spatial configurations (Fig. 1), including (1) a

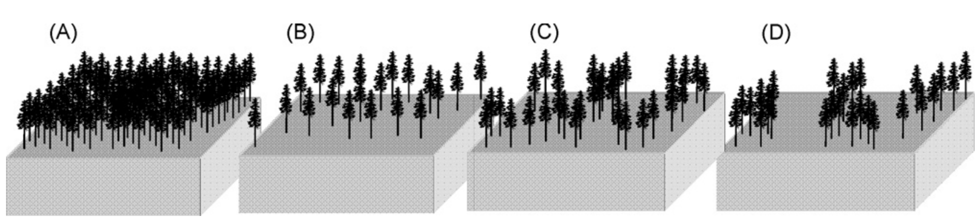

Fig. 1. Conceptual representation of overstory treatments: (A) unharvested forest (control), (B) dispersed retention of overstory trees, (C) retention of overstory trees between small gaps, and (D) retention of overstory trees between large gaps.