Forest Ecology and Management 427 (2018) 392–413

Contents lists available at ScienceDirect

Forest Ecology and Management

journal homepage: www.elsevier.com/locate/foreco

Regenerating clearcuts combined with postharvest forestry treatments promote habitat for breeding and post-breeding spruce-fir avian assemblages in the Atlantic Northern Forest

Brian W. Rolek[a,*], Daniel J. Harrison[a], Cynthia S. Loftin[b], Petra B. Wood[c]

[a] Department of Wildlife, Fisheries, and Conservation Biology, University of Maine, Orono, ME, United States
[b] U.S. Geological Survey, Maine Cooperative Fish and Wildlife Research Unit, Orono, ME, United States
[c] U.S. Geological Survey, West Virginia Cooperative Fish and Wildlife Research Unit, West Virginia University, Morgantown, WV, United States

ARTICLE INFO

Keywords:
Acadian forest
Avian abundance
Birds
Clearcut
Forest management
Forestry
Fragmentation
Northern New England
Spruce-fir
Richness

ABSTRACT

The quantity of spruce-fir forest and some conifer-associated breeding bird abundances in the Atlantic Northern Forest have declined in recent decades emphasizing the need to better understand avian responses to forest management and to identify options that proactively conserve habitat for birds during the breeding and post-breeding period. We conducted avian point counts and vegetation surveys on publicly and privately-owned lands with known management histories to assess relationships between avian assemblages in harvest and postharvest treatments that could provide habitat for passerine birds associated with the spruce-fir forest type. We sampled regenerating conifer-dominated stands 5–41 years-since-harvest (YSH) in three harvest treatments (selection, irregular first-stage shelterwood, and clearcuts) and three postharvest treatments including regenerating clearcuts treated with aerially applied herbicide (e.g., glyphosate), precommercial thinning (PCT), both herbicide and PCT, and mature stands (≥48 YSH). Spruce-fir obligate and associate birds were more abundant in stands with greater spruce-fir tree composition (≥70% and ≥60%, respectively). Avian richness of spruce-fir obligates, associates, and species of concern was greater in clearcuts and clearcuts with postharvest treatments. Vegetative features associated with greater richness and abundance of spruce-fir birds, such as greater spruce-fir composition and smaller tree diameter at breast height, were prominent in regenerating clearcuts and postharvest treatments and suggested that these management practices promote local abundances and richness of spruce-fir birds. Richness and abundances of spruce-fir birds were least in selection, shelterwood, and mature stands, and vegetative features associated with greater richness and abundance of spruce-fir birds were diminished in these stands. Forestry trends in Maine indicate that the extent of the clearcut suite of treatments has decreased on the landscape while selection and shelterwood harvests have increased. Thus, changes in incentives for managers to apply even-aged management coupled with post-harvest applications of herbicides or precommercial thinning might mitigate further declines in habitat for spruce-fir passerines assemblages. A greater ratio of clearcuts with postharvest treatments 11–40 YSH compared to other treatments (mature forest ≥48 YSH, selection and shelterwood 5–41 YSH) would maintain diverse spruce-fir bird communities on the landscape. Use of clearcuts with postharvest treatments in the hemiboreal forests of northern New England, southern Quebec, and Maritime Provinces of eastern Canada may enhance habitat for breeding and post-breeding spruce-fir birds, especially where the quantity of conifer forests are declining and residual patches of conifers are increasingly fragmented.

1. Introduction

Forest management has global consequences for conservation of biodiversity. Vegetative physiognomy and composition are important for the maintenance and creation of diverse ecological communities (MacArthur, 1958; MacArthur and MacArthur, 1961), and management has long-term effects on vegetative structure and composition, which are important for wildlife habitat (Keller et al., 2003; Seymour and Hunter, 1999; Thompson et al., 2013). Ecologically sustainable forestry seeks to promote biodiversity and combine forest resource extraction with ecologically sound stewardship of land using disturbance-based harvest techniques (Seymour and Hunter, 1999).

* Corresponding author at: 5755 Nutting Hall Rm 210, Orono 04469, United States.
E-mail address: brianrolek@gmail.com (B.W. Rolek).

https://doi.org/10.1016/j.foreco.2018.05.068
Received 8 February 2018; Received in revised form 29 May 2018; Accepted 31 May 2018

Over 75% of the land area in Maine, New Hampshire, and Vermont is forested, and > 70% of these forests are timberlands harvested primarily for saw logs, pulpwood, strandboard, wood pellets, and biomass energy (McCaskill et al., 2011; Morin et al., 2012). Forest managers use a diverse suite of treatments for timber extraction, but influences on forest bird communities during later stages of regeneration are poorly understood in northern New England's mixed and conifer-dominated systems. Three broad harvest treatment categories include clearcuts, partial harvests including irregular shelterwood and selection harvests, and clearcuts that subsequently receive postharvest treatments. Clearcuts have fallen out of favor because of public disapproval of their immediate post-harvest appearance (Costello et al., 2000; McDermott and Wood, 2009; Miller et al., 2006); forest health and hydrological effects (Costello et al., 2000; McDermott and Wood, 2009); avian population declines resulting from edge and fragmentation effects (Wilcove, 1989); and removal of vertical vegetation diversity that enhances wildlife diversity (MacArthur and MacArthur, 1961). Partial harvests are often promoted because they retain diverse vertical forest structure compared to clearcuts and create uneven-aged stands during stages of the management cycle (Raymond et al., 2009; Seymour and Hunter, 1992). While partial harvests reduce the intensity of harvest from forestry within an individual stand, managers must harvest a greater area to extract a similar value of product which may spread the effects from forestry over a larger area (Lindenmayer et al., 2012).

The shift toward partial harvests in Maine from 1982 to 2015 (Maine Forest Service, 2018) coincides with decreases in the area clearcut annually and a decrease in coniferous forest cover (Maine Forest Service, 2018). Legaard et al. (2015) examined remotely sensed data in northern Maine from 1975 to 2004 and documented a shift in tree composition from conifer to deciduous-dominated forest composition in response to widespread partial harvesting. Furthermore, studies documented preferential removal of large conifer trees by managers when conducting selection harvests (Fuller et al., 2004) and fewer regenerating conifer saplings in stands after partial harvests compared to clearcuts (Robinson, 2006).

Postharvest treatments, such as precommercial thinning (hereafter PCT; elsewhere referred to as timber or forest stand improvement) and herbicide, can be applied after an initial treatment, usually clearcuts, to accelerate regrowth (Pitt and Lanteigne, 2008). Clearcuts with herbicide application promote conifer sapling growth (reviewed by Lautenschlager, 1993; Newton et al., 1989) relative to partial harvests (Robinson, 2006). Few studies have empirically evaluated the influence of postharvest treatments on spruce-fir bird communities (but see Kroll et al., 2017; Rankin and Perlut, 2015; Thompson et al., 2013), especially in the Atlantic Northern Forest.

The Atlantic Northern Forest (Fig. 1) provides breeding and postbreeding habitat for many passerine birds (DeGraaf et al., 1998; Hagan et al., 1997; King and DeGraaf, 2000; MacArthur, 1958; Titterington et al., 1979), and breeding avian communities of this region are diverse (Hagan et al., 1997). Managing avian populations within this region has implications for the conservation of biodiversity, policy, and forestry certification programs. Ralston et al. (2015) showed that eastern populations of several bird species associated with the spruce-fir forest type have declining population trends in the United States. USGS Breeding Bird Survey data and results (Sauer et al., 2017) corroborate these declines within the Atlantic Northern Forest with significant declines in abundance for 11 of 17 bird species (Sauer et al., 2017) that are associated with the spruce-fir forest type (Bicknell's Thrush is omitted because of lack of data, Ralston et al., 2015). A shift from coniferous to deciduous-dominated forest composition (Legaard et al., 2015; McCaskill et al., 2011; Simons-Legaard et al., 2016) coincides with declines in populations of coniferous forest birds in the eastern United States (Ralston et al., 2015), suggesting that the quantity and spatial pattern of spruce-fir habitat on the landscape may be affecting populations of spruce-fir birds.

Although effects of forestry on bird abundance and richness in the Atlantic Northern Forest have received some study (e.g. Costello et al., 2000; DeGraaf et al., 1998; Derleth et al., 1989; Hagan et al., 1997; King and DeGraaf, 2000; Rudnicky and Hunter, 1993; Titterington et al., 1979; Welsh and Healy, 1993), few have considered the breadth nor cumulative effects of forest harvest techniques over longer periods, especially for postharvest treatments that are applied extensively across this region. Additionally, few studies have considered response by entire avian assemblages to forest harvest practices and postharvest treatments that affect regeneration patterns. Here, we assess effects of forest management on vegetative attributes and spruce-fir avian communities.

Our overall objective is to identify forest management that may enhance habitat for birds associated with the spruce-fir forest type and for species of concern. To accomplish this objective, we ask three questions. (1) Does vegetation vary among harvest treatments and how does vegetation vary among treatments? (2) Do avian assemblages vary among harvest treatments? (3) How do avian assemblages respond to harvest treatments and vegetation?

2. Methods

2.1. Study sites and design

Our study was conducted within the hemiboreal Atlantic Northern Forest in the northeastern United States (Fig. 1). This region transitions from temperate deciduous forest to eastern boreal forest (Seymour and Hunter, 1992). Our study sites were located on lands actively or formerly managed by forestry, including publicly-owned lands within Baxter State Park and U.S. Fish and Wildlife Service National Wildlife Refuges (NWR; Umbagog, Aroostook, Moosehorn, and Nulhegan Division of Silvio O. Conte) in New Hampshire, Vermont, and Maine, and privately-owned areas (Telos, Clayton Lake) in the North Maine Woods.

Within study sites, we surveyed forested stands that were ≥12.1 ha (≥30 acres) in area to minimize edge effects (King et al., 1997; Ortega and Capen, 2002) and stands approximately > 50% spruce or fir trees to focus on conifer-associated birds. We considered stands to be areas that were managed in a spatially contiguous manner during temporally similar periods with a prescribed forestry treatment and from polygons provided by land owners or from digital ortho quarter quad tiles from the National Agriculture Imagery Program (United States Department of Agriculture) where abrupt changes in forest structure were visible. We surveyed lowland conifer forests < 500 m elevation, with dominant tree species ≥10 cm diameter at breast height (dbh) primarily comprised of the following tree species in descending order of abundance: balsam fir (*Abies balsamea*), red spruce (*Picea rubens*), Atlantic white cedar (*Chamaecyparis thyoides*), black spruce (*Picea mariana*), red maple (*Acer rubrum*), white pine (*Pinus strobus*), white spruce (*Picea glauca*), paper birch (*Betula papyrifera*), tamarack (*Larix laricina*), and yellow birch (*Betula alleghaniensis*).

2.2. Harvest treatments

We surveyed stands (Appendix A) within seven treatment types (described below) to capture a range of spruce-fir dominated and mixed-wood forest conditions on the landscape including: mature, selection, shelterwood, clearcut, clearcut with herbicide, clearcut with PCT, and clearcut with herbicide and PCT. We characterized harvest treatments using basal area and years-since-harvest (YSH, Table 1). We measured basal area with a two-factor metric glass prism, and summarized these data as stand-level averages, standard deviations, and ranges across vegetation plots (Table 1). We could not obtain dates of PCT treatments at four stands (two clearcut-PCT and two clearcut-herbicide-PCT), and could not obtain YSH for three clearcut-PCT stands, so they were omitted from data summaries involving these variables (Table 1, Appendix B), however are included other analyses.

Selection harvest stands were partial harvests where managers