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Will they come? Long-term response by forest birds to experimental thinning supports the "Field of Dreams" hypothesis

Rebecca E. Cahall [a], John P. Hayes [b], Matthew G. Betts [a,*]

[a] Department of Forest Ecosystems and Society, 321 Richardson Hall, Oregon State University, Corvallis, OR 97331, United States
[b] Department of Wildlife Ecology and Conservation, University of Florida, Gainesville, FL 32611, United States

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ABSTRACT

Intensifying forest management practices via use of tree plantations represents a common response to rising global demand for wood and paper products. However, a large proportion of tree plantations, globally, exist in closed-canopy mid-seral stages, which are frequently associated with reduced biodiversity. In some regions, silvicultural techniques such as thinning have been used to accelerate the development of complex vertical structure and composition (e.g., shrubs, understory, midstory, large trees) in these plantations; these attributes are expected to constitute suitable habitat for species associated with particular forest structures. We report on the results of a 15-year randomized-block manipulative study based in Oregon, USA, designed to test the hypothesis that 'if you build it they will come' (i.e., the "Field of Dreams" hypothesis; the 'creation' of complex vertical structure in forests via thinning will result in colonization by bird species associated with these structures). We conducted point counts of forest birds 7 times each year in stands thinned at two different intensities and in unharvested controls. Responses to thinning by some bird species [e.g., hermit warbler (*Setophaga occidentalis*), Swainson's thrush (*Catharus ustulatus*) and Wilson's warbler (*Cardellina pusilla*)] changed from being negative in the short term (<6 years), to being positive over the longer term. However, some species were sensitive to thinning disturbance even after 15 years of recovery [e.g., Hutton's vireo (*Vireo huttoni*)]. Disturbance-associated species initially increased following thinning; but over the longer-term, detections of several of these species [American robin (*Turdus migratorius*) and Townsend's solitaire (*Myadestes townsendi*)] notably declined or ceased. Our findings indicate that results from short-term studies (⩽6 years) cannot be used to predict the longer-term response of birds to forest management treatments, particularly for species of birds whose response to thinning over time was non-linear. Further, none of the management prescriptions tested were alone sufficient to maintain long-term occupancy for all of the species in the study. Implementing thinning at intervals across landscape scales to develop different seral stages and stand-structures, while also maintaining unthinned areas for species negatively impacted by thinning, will likely have the greatest positive impact on beta diversity of birds in managed plantation landscapes.

1. Introduction

Intensifying forest management practices represents one common response to rising global demand for wood and paper products. Intensive management includes practices such as short-rotation harvesting, planting genetically improved seedlings, and chemical control of competing vegetation. In addition, maximum efficiency of wood fiber production has been sought through extensive replacement of naturally regenerated forests with conifer plantations in temperate regions around the world (Kittredge, 1996; Lindenmayer and Hobbs, 2004; Betts et al., 2005; Paquet et al., 2006). However, trade-offs may exist between management intensification and the maintenance of biological and functional diversity (Hayes et al., 2005). Such trade-offs may become particularly apparent in later stages of plantation development once the forest canopy has closed; reduced light to the forest floor and subsequent negative impacts on vertical structure (Franklin et al., 2002) have been argued to be the key drivers of reduced biodiversity in intensively managed stands (Swanson et al., 2011). A critical conservation question then, is whether management practices can be applied to older plantations that increase their conservation value.

In the United States, previous land management or natural disturbances (e.g., fire) followed by tree planting have created relatively even-aged second-growth forests across much of the Pacific Northwest (Harris, 1984; Forest Ecosystem Management Assessment Team (FEMAT), 1993; DeBell et al., 1997). Frequently,

* Corresponding author. Tel.: +1 541 737 3841.
E-mail address: matthew.betts@oregonstate.edu (M.G. Betts).

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these stands are comprised of closed-canopy, even-aged Douglas-fir (*Pseudotsuga menziesii*) that lack the understory vegetation (Franklin et al., 2002) and structural complexity typical of old-growth forests in the Pacific Northwest (Spies and Franklin, 1991). In Douglas-fir forests, many faunal species are associated with features more typical of mature and old-growth forests (e.g., snags, large trees, downed logs) (Hansen et al., 1995), leading to concern that large tracts of second-growth forest may be unsuitable for old-forest associated species (Carey, 2009).

Managing even-aged stands with silvicultural treatments such as operational thinning has been hypothesized to promote development of structural diversity (Smith, 1986; Barbour et al., 1997; Bailey and Tappeiner, 1998). Commercial thinning of forest stands can produce cascading ecological effects by reducing competition among overstory trees thereby increasing growth, size, branch diameter, and crown ratio of remaining overstory trees (Long et al., 1983; Maguire et al., 1991; Marshall et al., 1992; Barbour et al., 1997). Thinning may initially reduce understory vegetation due to mechanical operations, but eventually understory vegetation may be greater in thinned than unthinned stands (Tappeiner and Zasada, 1993; Messier and Mitchell, 1994; Bailey and Tappeiner, 1998). Structural and vegetative diversity are expected to increase the diversity of niches available to birds and other wildlife species (MacArthur and MacArthur, 1961; MacArthur et al., 1966; Wilson, 1974; Roth, 1976; Whelan, 2001); indeed, in correlative studies it appears that structural complexity improves habitat for some vertebrate species (McComb et al., 1993) and may increase overall species richness (see Tews et al., 2004 for review).

Unfortunately, this effect has only rarely been tested experimentally. The experimental studies that do exist tend to be conducted over too short a time period to adequately test the hypothesis that increased structural complexity increases habitat quality for faunal species. Previous studies on the response of birds to thinning have primarily focused on the time period immediately following thinning (⩽6 years) (Verschuyl et al., 2011). Those studies that do have an extended time period (>6 years) are observational, lack pre-treatment data, and combine treatments applied over multiple years (Hagar et al., 1996; Siegel and DeSante, 2003; Twedt and Somershoe, 2009), making it difficult to relate bird response to a specific time after thinning. Immediate bird response to thinning (⩽6 years) has generally been consistent with the natural history of species examined. Canopy foragers and closed-canopy specialists tend to decrease (e.g., brown creeper, scientific names for birds are provided in Appendix A) with the removal of canopy, ground foragers (e.g., dark-eyed junco) increase with new availability of bare ground, and no response has generally been detected for generalists (e.g., chestnut-backed chickadee) (DellaSala et al., 1996; Hagar et al., 1996; Chambers et al., 1999; Hayes et al., 2003; Siegel and DeSante, 2003; Hagar et al., 2004). While decreasing overstory appears to elicit an immediate response from some species of birds, development of understory vegetation, recruitment and growth of tree seedlings, and canopy and midstory development require longer time periods (Kuehne and Puettmann, 2008; Davis and Puettmann, 2009; Ares et al., 2010). Thus, the "Field of Dreams" hypothesis that "if you build it, they will come" ('creation' of diverse vertical structures in forests via thinning will result in colonization by bird species associated with these forest structures), has not been adequately tested. Since thinning produces some immediate changes in vertical structure (e.g., closed-canopy to canopy openings), as well as changes that develop through time (e.g., midstory vegetation), a secondary question relates to the timing (e.g., immediate versus delayed) and duration of birds response to thinned forests ("if you build it, how long will they stay?) Here, we present the results of a 15-year manipulative study designed to examine the response by forest bird species to experimental thinning of Douglas-fir plantations.

2. Methods

2.1. Study area and experimental design

We conducted our study in the Tillamook State Forest in the northern Oregon Coast Range. The study area has a maritime climate with cool, wet winters (average rainfall 114–280 cm), and mild, dry summers. Between 1933 and 1951 a series of fires burned 140,000 ha and was subsequently salvage logged. The area was replanted or seeded with Douglas-fir resulting in an even-age class distribution. The forest is comprised primarily of Douglas-fir and red alder (*Alnus rubra*), with components of western hemlock (*Tsuga heterophylla*), grand fir (*Abies procera*), and western redcedar (*Thuja plicata*). Common understory plants include vine maple (*Acer circinatum*), huckleberry (*Vacciniium* spp.), swordfern (*Polystichum munitum*), and Oregon grape (*Mahonia nervosa*).

We selected three blocks (replicates) for study. Each replicate consists of three 26–40 ha stands of 35–45 year old forest plantation, with an initial stand density of 410–710 trees per hectare. Selected replicates had similar management history, minimized differences among stands within a replicate for density of trees, age of stands, and proportion of hardwoods, and the management agency (Oregon Department of Forestry) requirement of distribution of replicates across the landscape. After screening all available stands for these criteria, only four blocks were available, one of which was cut in the early 2000s, leaving three replicates. Replicates are at least 5 km apart. Stands within a replicate are within 500 m of one another, except for one stand that was ~1.5 km from the other stands. Elevation of stands ranges from 420 to 920 m.

2.2. Treatments

Within each replicate, we randomly assigned stands to one of three treatments: no thinning (control, 410–700 trees/ha), moderate thinning (240–320 trees/ha), or heavy thinning (180–220 trees/ha). Trees were thinned from below (Smith, 1986), removing small diameter trees and leaving the larger co-dominant and dominant trees, in the autumn of 1994 and spring of 1995. The moderate thinning was designed to emulate commercial thinning typically used in the area to achieve wood fiber production goals. The heavy thinning was designed to increase the size of canopy openings, accelerate growth of overstory trees, and enhance structural complexity of the stands (Hayes et al., 1997). Initial changes of the vegetation and stand structure are detailed in Suzuki and Hayes (2003).

2.3. Bird census data

To examine bird response to thinning, we established five point-count stations in each stand. Stations are located at least 160 m apart, 50 m from perennial streams, and 100 m from stand boundaries. We visited points seven times each year between 10 May and 03 July before implementing treatments (1994), the initial 6 years (1995–2000) and 14 and 15 years after (2008–2009) treatment implementation. Observers recorded all birds seen or heard within 80 m of the point-count station during an 8-min count. Observers noted whether a bird had been detected at a previous station that day, and these observations were later excluded from analysis. Surveys did not occur on days with heavy rain or strong wind because of decreased bird activity and observers' decreased ability to detect birds. We conducted point counts between 15 min before and 4 h after sunrise. Point counts were conducted within a replicate on the same day or on consecutive days. Surveys of the same stands occurred at least 2 days apart. To minimize observer bias, avian surveyors rotated among replicates and