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Avian response to timber harvesting applied experimentally to manage Cerulean Warbler breeding populations

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ABSTRACT

Timber harvesting has been proposed as a management tool to enhance breeding habitat for the Cerulean Warbler (*Setophaga cerulea*), a declining Neotropical–Nearctic migratory songbird that nests in the canopy of mature eastern deciduous forests. To evaluate how this single-species management focus might fit within an ecologically based management approach for multiple forest birds, we performed a manipulative experiment using four treatments (three intensities of timber harvests and an unharvested control) at each of seven study areas within the core Cerulean Warbler breeding range. We collected pre-harvest (one year) and post-harvest (four years) data on the territory density of Cerulean Warblers and six additional focal species, avian community relative abundance, and several key habitat variables. We evaluated the avian and habitat responses across the 3–32 m^2 ha^{-1} residual basal area (RBA) range of the treatments. Cerulean Warbler territory density peaked with medium RBA (~16 m^2 ha^{-1}). In contrast, territory densities of the other focal species were negatively related to RBA (e.g., Hooded Warbler [*Setophaga citrina*]), were positively related to RBA (e.g., Ovenbird [*Seiurus aurocapilla*]), or were not sensitive to this measure (Scarlet Tanager [*Piranga olivacea*]). Some species (e.g., Hooded Warbler) increased with time post-treatment and were likely tied to a developing understory, whereas declines (e.g., Ovenbird) were immediate. Relative abundance responses of additional species were consistent with the territory density responses of the focal species. Across the RBA gradient, greatest separation in the avian community was between early successional forest species (e.g., Yellow-breasted Chat [*Icteria virens*]) and closed-canopy mature forest species (e.g., Ovenbird), with the Cerulean Warbler and other species located intermediate to these two extremes. Overall, our results suggest that harvests within 10–20 m^2 ha^{-1} RBA yield the largest increases in Cerulean Warblers, benefit additional disturbance-dependent species, and may retain closed-canopy species but at reduced levels. Harvests outside the optimum RBA range for Cerulean Warblers can support bird assemblages specifically associated with early or late (closed-canopy) successional stages.

1. Introduction

Management focused on the critical needs of a single species (i.e., a "fine-filter" approach; Hunter, 2005) is warranted for species of high conservation concern. Focus on these species is important for developing clear conservation targets and evaluating management outcomes (Villard and Jonsson, 2009). However, it is also important to consider positive and negative effects on other species. A focal species may be an "umbrella species" (*sensu* Roberge and Anglestam, 2004) if managing for it also benefits naturally co-occurring species. Knowledge of the effects on a wider range of species may also be valuable, particularly if obtained across multiple habitats included in an overall management approach. For example, while intensive management of breeding

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habitat for the endangered Kirtland's Warbler (*Setophaga kirtlandii*) may benefit other bird species associated with its primary habitat (5–23 year old jack pine [*Pinus banksiana*] plantations), other bird species assemblages are likely supported by the recent clearcuts and mature stands involved in this management (Corace et al., 2010). Corace et al. (2010) suggest a shift in Kirtland's Warbler management toward a more ecologically based approach for multiple bird species across jack pine habitat types.

Managing for the severely declining Cerulean Warbler (*Setophaga cerulea*) may have similar implications for avian associates and the broader forest bird community. The Cerulean Warbler is a Neotropical–Nearctic migratory songbird of mature deciduous forests in the eastern US. The majority of its population lies within the Appalachian Mountains region where a 3.2% year^{-1} decline in abundance occurred during 1966–2011 (Sauer et al., 2012). Declines have been linked to land use changes on the breeding and wintering grounds as well as forest fragmentation and lack of appropriate forest structure on the breeding grounds (Bakermans and Rodewald, 2009). Timber harvesting has been proposed to increase Cerulean Warbler breeding populations, as they appear to respond positively to disturbances that create canopy gaps in even-aged forests (Boves et al., 2013; Hunter et al., 2001). Although studies have identified forest birds that may associate with Cerulean Warbler habitat (Carpenter et al., 2011; Jones et al., 2004), to our knowledge none have been in the direct context of timber harvesting in the core breeding range. Management strategies specifically intended to benefit Cerulean Warblers may be implemented across large areas in their core breeding range, and thus may have a large effect on the overall bird community. While studies within the core range of Cerulean Warblers have examined effects of specific timber harvest prescriptions on bird communities (e.g., Newell and Rodewald, 2012), knowledge of the effects of Cerulean Warbler management on a full range of early to late successional forest bird species is lacking.

Of the many studies that have addressed stand level, numeric responses of bird species to various harvest prescriptions (e.g., see review by Haulton, 2008), those that examine a wide range in the amount of timber removed (e.g., Annand and Thompson, 1997; Baker and Lacki, 1997; McDermott and Wood, 2009; Norris et al., 2009) clearly indicate a continuum of early to late successional forest bird responses along a harvest intensity gradient. At a much broader scale, Vanderwel et al. (2007) modeled this continuum in a meta-analysis of 42 North American studies of harvesting effects on birds. A number of forest birds had non-linear responses along the gradient, and species generally responded in a consistent way across their breeding ranges (Vanderwel et al., 2007). Thus a direct measure of harvest intensity may usefully quantify effects of forest management on the Cerulean Warbler and the avian community, and provide a basis for comparing species responses across a range of harvest intensities. Furthermore, identifying habitat alteration thresholds (e.g., density or volume of remaining trees) for species responses to harvesting provides quantitative targets for management of these species (Guenette and Villard, 2005).

We conducted a manipulative forest management experiment at seven study areas, across four states, in the Cerulean Warbler's core breeding range. In Boves et al. (2013) we focused exclusively on the Cerulean Warbler response in comparisons among silvicultural techniques that varied in harvest intensity. Here, we used the wide gradient in harvest intensity across our study plots to examine (1) how forest birds responded numerically to the harvest intensity range that was optimum for increases in Cerulean Warbler territory density; and (2) how the broader avian community responded numerically across the full range of harvest intensity. Specifically, we used the residual basal area (RBA) of our plots to analyze avian and key understory habitat responses measured from pre-harvest to four years post-harvest. We integrated our results to identify species-specific optimal ranges of RBA, and suggest broader RBA ranges as ecologically based management approaches for multiple bird assemblages in actively managed, upland hardwood forests.

2. Methods

2.1. Study areas and region

We conducted this research during 2006–10 in mature forest stands at seven, widely spaced study areas within the Central Hardwoods mixed-mesophytic forest region (Fralish, 2003) of the central Appalachian Mountains (Fig. 1). This region generally corresponds with the core Cerulean Warbler breeding range as indicated by mapped relative abundance (Sauer et al., 2012). The study areas were: Royal Blue Wildlife Management Area, TN (RB), Sundquist Forest, TN (SQ), Raccoon Ecological Management Area, OH (RM), Daniel Boone National Forest, KY (DB), Lewis Wetzel Wildlife Management Area, WV (LW), Monongahela National Forest, WV (MF), and private lands in Wyoming Co., WV (WY). We selected study areas based on the presence of Cerulean Warbler breeding populations, potential to implement timber harvests, and absence of existing canopy disturbances. All study areas were within a matrix of mature forest; mean forest cover within 10 km of the geographic center of each study area was 84% (±3 SE, range = 74–94%; 2006 National Land Cover Database [Fry et al., 2011]). Mean elevation was 550 m (±80 SE, range = 250–850 m). Tree species composition differed somewhat among study areas (Table 1), but common overstory tree species included oaks (*Quercus rubra*, *Q. coccinea*, *Q. velutina*, *Q. alba*, *Q. montana*), hickories (*Carya* spp.), maples (*Acer rubrum*, *A. saccharum*), and yellow poplar (*Liriodendron tulipifera*).

2.2. Habitat manipulations

At each study area, four 20-ha plots were placed on ridgetops and north- or east-facing upper slopes, the predominant topographic location of the region's Cerulean Warbler populations (Buehler et al., 2006; Weakland and Wood, 2005; Wood et al., 2006). Plots were generally rectangular with the long axis parallel to the ridgeline or perpendicular to the general slope direction. We randomly assigned the four plots in each study area to the four study treatments. Three treatments were varying intensities of timber harvests that represented common silvicultural practices

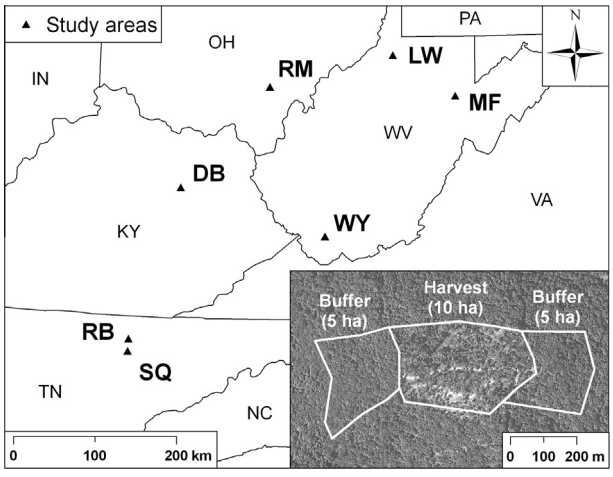

Fig. 1. Location of the seven study areas in the central Appalachians. Inset: a ridgetop, 20-ha plot within a study area (LW) showing layout of the harvest and the unharvested buffers (2007 aerial photo of the shelterwood harvest treatment).