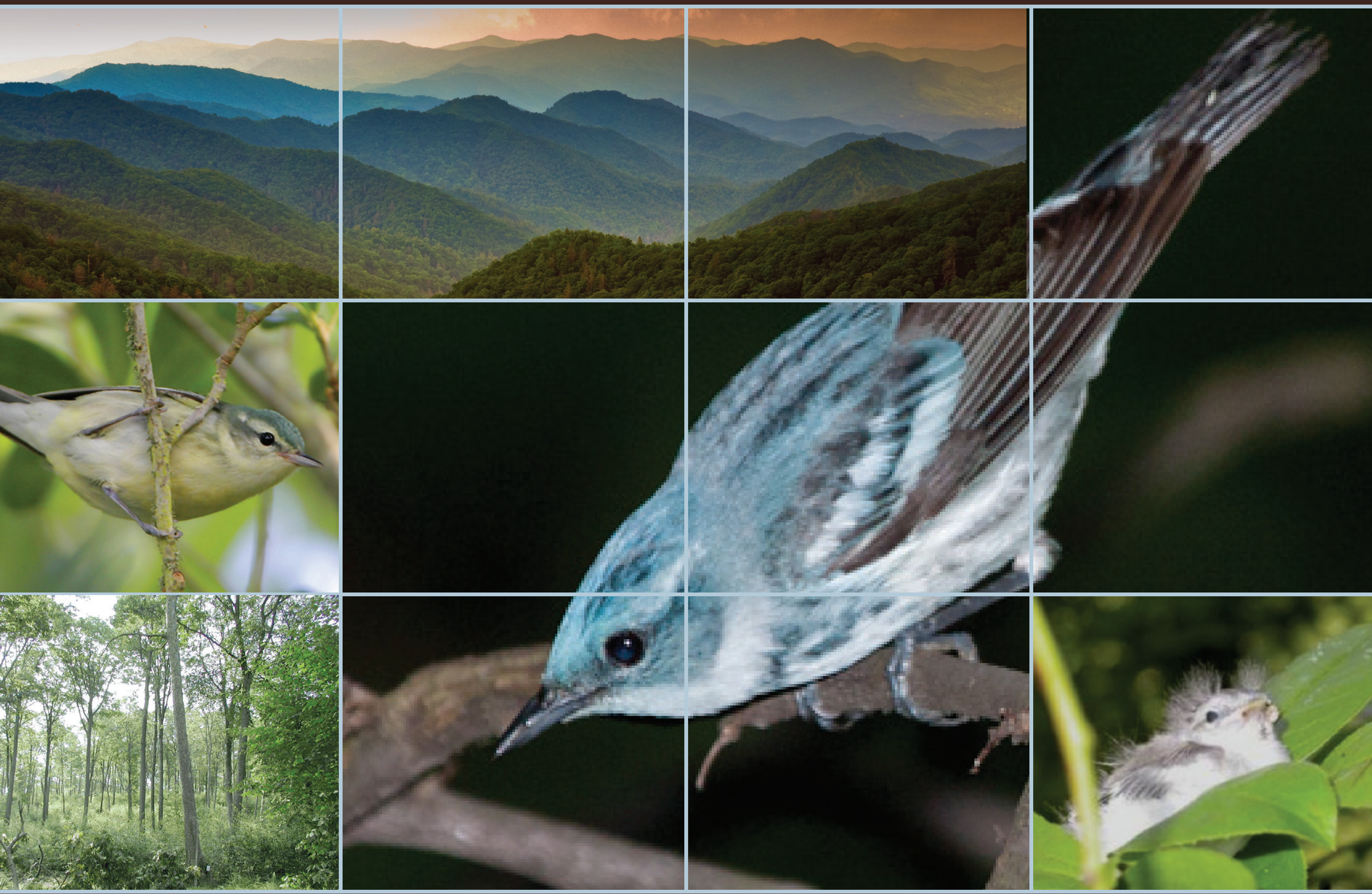
CERULEAN WARBLER

Management Guidelines for Enhancing Breeding Habitat in Appalachian Hardwood Forests



February, 2013

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Cerulean Warbler. Bill Hubick

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Photos: Cover: Clockwise: Appalacian landscape, Charlie Choc; Cerulean Warbler, Bill Hubick, http://www.billhubick.com; Fledgling, Marja Bakermans; Shelterwood, Scott Stoleson; Female, Bill Hubick

Appalachian breeding habitat. Than Boves

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Male Cerulean Warbler. Marja Bakermans

Introduction

The Cerulean Warbler (*Setophaga cerulea*) is a migratory songbird that breeds in mature deciduous forests of eastern North America. Cerulean Warblers (hereafter, ceruleans) require heavily forested landscapes for nesting and, within Appalachian forests, primarily occur on ridge tops and steep, upper slopes. They are generally associated with oak-dominated (*Quercus* spp.) stands that contain gaps in the forest canopy, that have large diameter trees (>16 inches diameter breast height (dbh)), and that have well-developed understory-and upper-canopy layers. Ceruleans primarily use the mid- and upper-canopy where they glean insects from the surface of leaves and conceal their open cup nests. Because they are severely declining across much of their range (Fig. 1), habitat management is a high priority. Management for this species can also improve conditions for a number of other wildlife species that depend on the same structure.

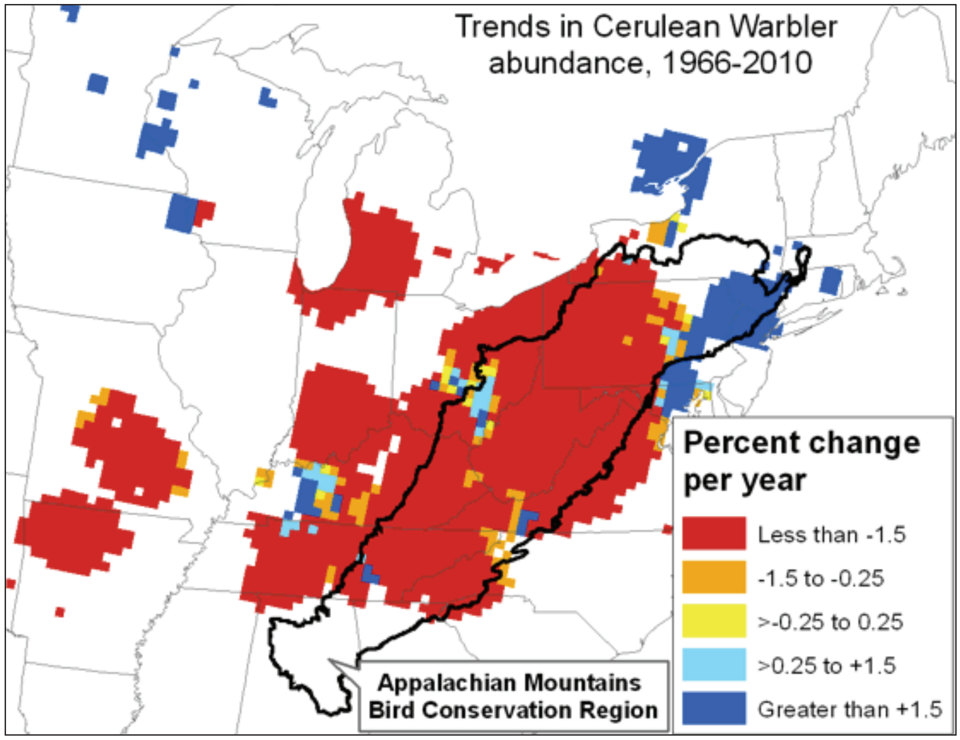


Figure 1. Cerulean Warbler distribution and trends in abundance across their breeding range from Breeding Bird Survey data (1966-2010; Sauer et al. 2011). The Appalachian Mountains Bird Conservation Region boundary is in black.

Adult Cerulean Warbler feeding chick. Wayne Miller

Goals

This document provides land managers in the Appalachian Region with guidelines for retaining and enhancing habitat for Cerulean Warblers and a diverse bird community based on the current available science. They are intended for use by federal, state and private foresters, biologists, and other land managers. These management guidelines are based to a large extent on the recently completed Cooperative Cerulean Warbler Forest Management Project (CWFMP) but also incorporate relevant findings from other research projects. All literature incorporated into this document is listed in the Reference section. The guidelines apply primarily to upland oak-dominated habitats where the majority of the research reported was completed.

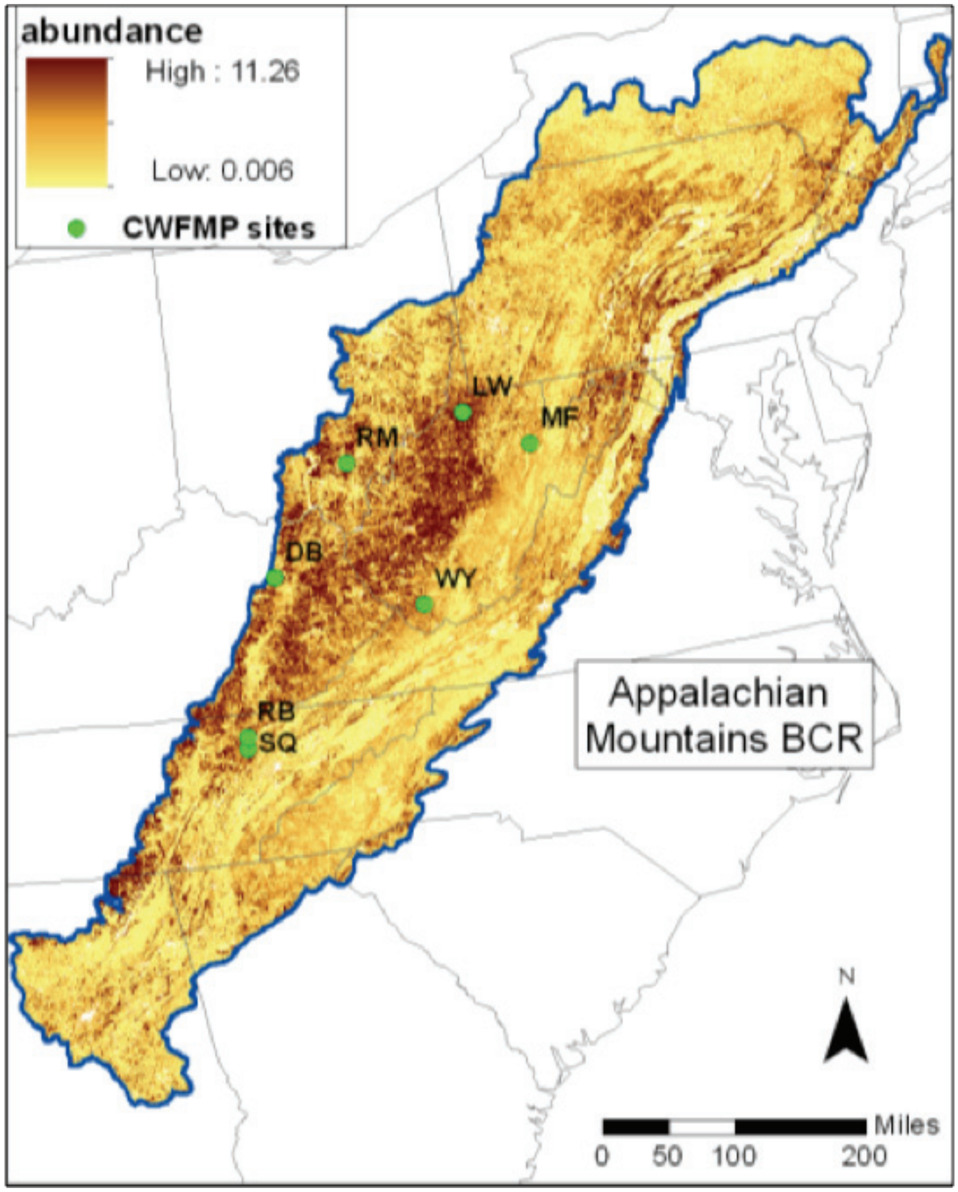


Figure 2. Cerulean Warbler abundance (number per route) estimated from Breeding Bird Survey data for the Appalachian Mountains Bird Conservation Region (BCR) (adapted from Shumar 2009). Study areas from the Cerulean Warbler Forest Management Project (CWFMP) are in the core range of the species.

Conservation

Male Cerulean Warbler. Than Boves

About 80% of the total cerulean population breeds within the Appalachian Mountains Bird Conservation Region (BCR; Fig. 1), and they are particularly abundant within the central part of the region (Fig. 2). Declines have occurred across most of their range (Fig. 1). A range-wide loss of ~70% of the population (Fig. 3) led to their designation as a species of national conservation concern by the U.S. Fish and Wildlife Service (USFWS) and as a Continental Watch List species by Partners in Flight.

Cerulean declines are primarily related to the loss and reduced suitability of habitat on breeding, migration, and wintering grounds. On breeding grounds, the second growth forests that occur throughout most forested landscapes often lack the complex forest structure favored by ceruleans. Old-growth forests naturally develop a more open and complex canopy structure, as well as multi-layered shrub and mid-story layers. Maintaining older, structurally diverse forest within cerulean breeding range may be important to sustain populations in the long-term and to support the ecosystems on which they and other organisms depend. In managed forests, however, foresters and landowners can use silviculture as a tool to develop stands with structural and compositional characteristics that are favorable for cerulean and associated species. Partial harvesting to benefit ceruleans can be consistent with forest management goals such as promoting oak regeneration and managing for a diverse wildlife community.

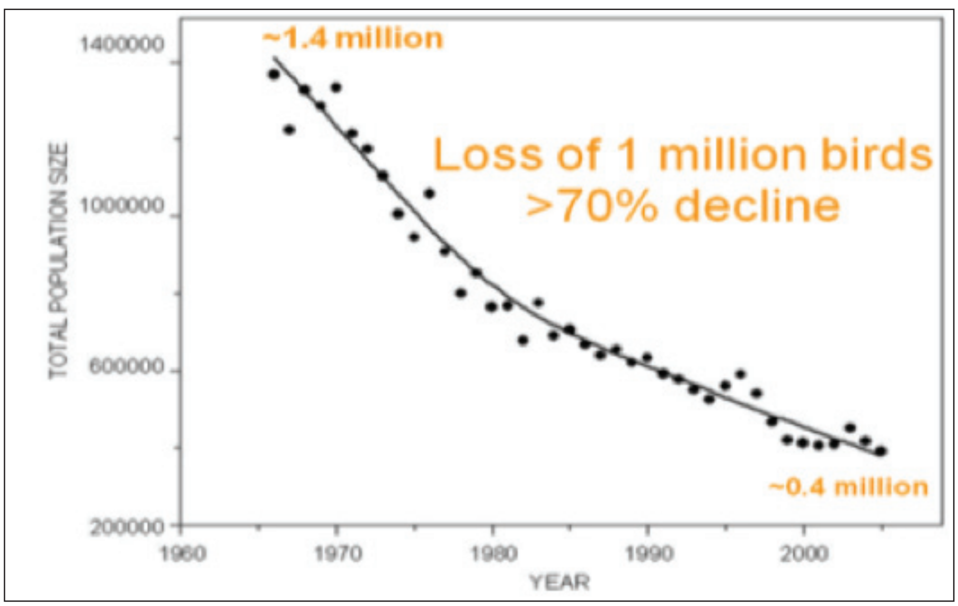


Figure 3. Cerulean Warbler population decline modeled using Breeding Bird Survey data from 1966-2006 (W. Thogmartin, unpubl. analyses).

Cerulean Warbler Habitat Association

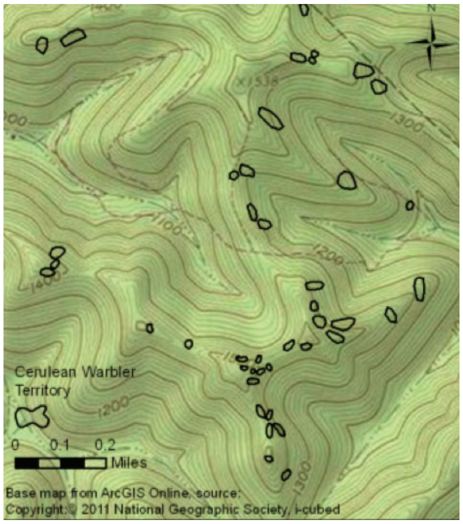


Figure 4. Cerulean Warbler territories on a topographic map of the Lewis Wetzel Wildlife Management Area, West Virginia, showing territories aligned along ridgelines and clustering near areas of local relief.

Cerulean breeding density is variable across the Appalachian region (Fig. 2). Their distribution is often patchy in part due to the patchy nature of canopy disturbance in mature forests and their strong association with ridge tops. In a southern West Virginia study, for example, they occurred at 40% of randomly placed sample points.

Landscape and Topography

Small forest tract size and the presence of large-scale edge (e.g., agricultural lands, mountaintop mines) can limit use of a site by ceruleans. Although the minimum forest tract size required by ceruleans to breed successfully is not known, smaller, more fragmented forest patches tend to have lower densities of territories and lower nest success. Ceruleans will use relatively small forest patches (~25 ac), but typically in landscapes that are primarily forested (e.g. >75% forest cover within ~6 miles of the project area). In landscapes with a relatively low proportion of forest cover (e.g. those that are dominated by agriculture), ceruleans are less likely to occur within small forest tracts. In the heavily deforested Mississippi Alluvial Valley, ceruleans require ~4000 acre tracts, in the highly fragmented Mid-Atlantic region ~1730 acres, and in the more forested Ohio Hills ~60 acres.

Ceruleans are often associated with canopy gaps and also use internal forest edges including narrow roads, narrow utility rights-of-way, narrow-cut strip mines, edges of small timber harvests, and trails. However, they are less abundant near abrupt or “hard” edges between forest cover and large expanses of open land (e.g., commercial, residential, and industrial development). In southern West Virginia, for example, cerulean abundance decreased near mountaintop mine edges and in northern West Virginia, they avoided edges of a large powerline right-of-way that was ~75 feet wide.

In the Appalachians, ceruleans primarily occur along ridges and steep, upper slopes and appear to cluster near areas of local relief such as knobs and bluffs (Fig. 4). The soil characteristics and topography of these features contribute to stratification of canopy trees so that ridge top forests often have a complex overstory structure containing large oaks with expansive crowns. Thus, ridge top forests often offer the structure and composition sought by breeding ceruleans. Within ridge top forests, ceruleans often favor mesic, north- and northeast-facing slopes, although other aspects are used. In some sections of the Appalachians (e.g. Delaware River valley), ceruleans are most dense at lower slope positions and along major waterways.

Appalachian landscape. Than Boves

Minimum patch size used by ceruleans depends on the amount of forest cover in the landscape.

Stand structure and Composition

Before extensive clearcutting in the late 19th and early 20th century, tree mortality from old age, windthrow, ice storm damage, and fire contributed to the development of structurally complex and relatively open stands in which oaks were dominant. In the even-aged stands that developed following those extensive harvests, natural canopy disturbances tended to be unevenly distributed and relatively small thereby creating a relatively homogenous canopy structure (e.g., a closed canopy forest with an undeveloped understory and/or mid-story).

Important Components of Cerulean Habitat

Large Diameter Trees

Ceruleans place territories and nests in hardwood forests with well-spaced, large diameter trees (>16 inches dbh). Nests are typically in the largest trees available at a site.

Canopy Gaps and Structure

Ceruleans favor the complex canopy structure characteristic of uneven-aged stands and old growth forest. Canopy gaps allow mid- and upper-canopy trees the growing space to form long horizontal branches and develop dense foliage. Tree species composition is relatively diverse with shade-intolerant species abundant in the overstory.

Upland forest used by Cerulean Warbler. Marja Bakermans

Heterogenous stand structure including large trees, canopy gaps, and understory vegetation promote density and reproductive success of ceruleans.

A relatively open canopy structure provides ceruleans with dominant trees (i.e., taller than the surrounding canopy) where exposed perches aid the birds in broadcasting their song and whose expansive crowns offer ample foliage in which to forage and conceal nests. Nests are often placed along flat lateral branches that extend over a relatively open midstory and a relatively dense understory, conditions that occur adjacent to a regenerating canopy gap. Ceruleans preferentially use canopy gaps ~400-1000 ft^2 in size and that contain vegetative growth within them.

Oaks and Hickories

In the Appalachians, ceruleans are strongly associated with stands in which oaks and hickories (*Carya* spp.) predominate. They preferentially forage and nest in white (*Q. alba*) and chestnut oak (*Q. montana*), but they avoid red maple (*Acer rubrum*) and oaks from the red oak group (scarlet (*Q. coccinea*), black (*Q. velutina*), and northern (*Q. rubra*) and southern red oak (*Q. falcata*). On sites dominated by species other than oaks, ceruleans preferentially used black cherry (*Prunus serotina*) and black locust (*Robinia pseudoacacia*) in West Virginia and American elm (*Ulmus americana*) and sycamore (*Platanus occidentalis*) in Ohio for various activities.

Grapevines

Grapevines provide a favored source of nest material. Cerulean nest success was positively associated with density of grapevines (*Vitis spp.*) in Ohio perhaps because vines add complexity to the canopy and, consequently, reduce the search-efficiency of nest predators. In Maryland, fledglings often were observed perching within clumps of grapevines.

Understory Vegetation

Density and nest success of ceruleans have been positively associated with understory vegetation. In Ohio, vegetation surrounding nest locations had 24% greater understory vegetation density than random locations in the stand. A high density of understory vegetation is beneficial to ceruleans because 1) females frequently drop to the understory for intensive foraging bouts during incubation and brooding, and 2) fledgling birds often seek the dense vegetation for protection from predators.

Leave some grapevines to provide nest material.

Female Cerulean Warbler incubating; note grapevine bark on the nest rim. This is a typical location for nests, i.e. on a lateral branch, next to a vertical twig, with an umbrella of leaves above the nest. Than Boves

Cerulean Warbler fledgling in thick understory vegetation. Marja Bakermans

Cerulean Warbler nest of grapevine and other materials. Marja Bakermans

Cooperative Cerulean Warbler Forest Management Project

The Cooperative Cerulean Warbler Forest Management Project (CWFMP), implemented under the auspices of the Cerulean Warbler Technical Group, was initiated to allow the scientific and management communities to test ideas about the habitat needs of ceruleans through experimental manipulations of timber harvest. The objective of the CWFMP was to study the response of ceruleans and the overall bird community to three silvicultural treatments and an unharvested control, collectively representing a canopy disturbance gradient. Seven study sites, each containing the four treatments, were established within mixed-mesophytic forest in Tennessee, Ohio, Kentucky, and West Virginia (Fig. 2). Sites were closed-canopy mature forest and located in heavily forested regions; forest cover within six miles of study areas averaged 83%. All stands were oak dominant.

Pre-harvest, West Virginia LW study area, basal area = 121 ft^2/acre Patrick McElhone

Light harvest in 2007 (1 yr post-harvest), West Virginia LW study area, RBA=83.6 ft^2/acre. Patrick McElhone

Treatment plots were 50 acres in size and included an unharvested plot, a light harvest, a medium harvest, and a heavy harvest (Fig. 5). In harvested plots, treatments included a 25-acre harvest and a 25-acre section of undisturbed forest that bordered the harvest (hereafter buffers). Light harvests were single tree removals and residual basal area (RBA) averaged 93 ft^2/acre (range 84-106) resulting in stands that had~80% stocking. The goal of medium harvests was to thin the stand to

Medium harvest in 2010 (4 yrs post harvest), West Virginia LW study area, RBA=45.5 ft²/acre. Jim Sheehan

Heavy harvest in 2008 (2 yrs post-harvest), Tennessee, RB study area. residual basal area (RBA)=34.5 ft²/acre. Than Boves

a residual stocking of 60-70% and favor the crown release of the best quality dominants and codominants. All other commercial stems (>6 inches dbh) were removed. The heavy harvests were applied with the objective of creating an understocked residual stand comprised of scattered dominants and co-dominants with all other commercial stems (>6 inches dbh) removed. After harvesting, the medium harvest had average RBA of 62 ft²/acre (range 46-81) resulting in ~55% stocking. The heavy harvests had average RBA of 27 ft²/acre (range 12-34). Basal area for unharvested plots averaged 117 ft²/acre (range 95-138) with ~100% stocking.

The CWFMP is the largest forest management experiment ever conducted to evaluate cerulean warbler and associated songbird response to forest management. The results of the study demonstrate the initial response of ceruleans (first four years post-harvest) to forest management. Additional studies are needed to track cerulean response over the life of a managed stand to fully characterize the nature of the changes in habitat structure that occur in these stands and how ceruleans respond to these changes.

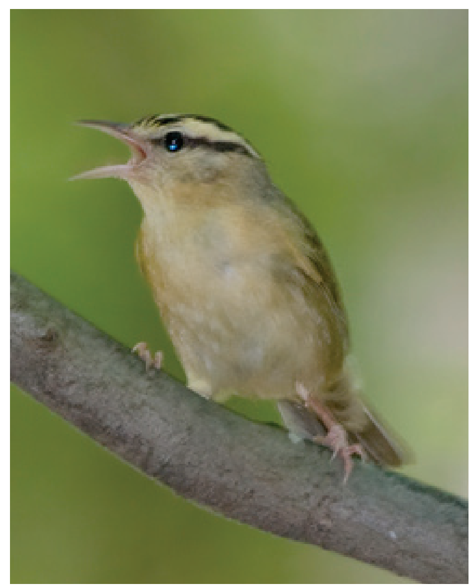
During two pre-harvest field seasons (2005-2006) and four post-harvest field seasons (2007-2010), data were collected on cerulean nest success, territory density, and habitat use. We also measured composition and relative abundance of the overall bird community to characterize response to partial harvesting and mapped territories of six other focal species in addition to Cerulean Warbler: Hooded Warbler (*Setophaga citrina*), Kentucky Warbler (*Geothlypis formosus*), Ovenbird (*Seiurus aurocapillus*), Scarlet Tanager (*Piranga olivacea*), Wood Thrush (*Hylocichla mustelina*), and Worm-eating Warbler (*Helmitheros vermivorus*).


Kentucky Warbler. Bill Hubick


Ovenbird. William Majoros


Scarlet Tanager. Bill Hubick


Wood Thrush. USFWS


Worm-eating Warbler. Bill Hubick

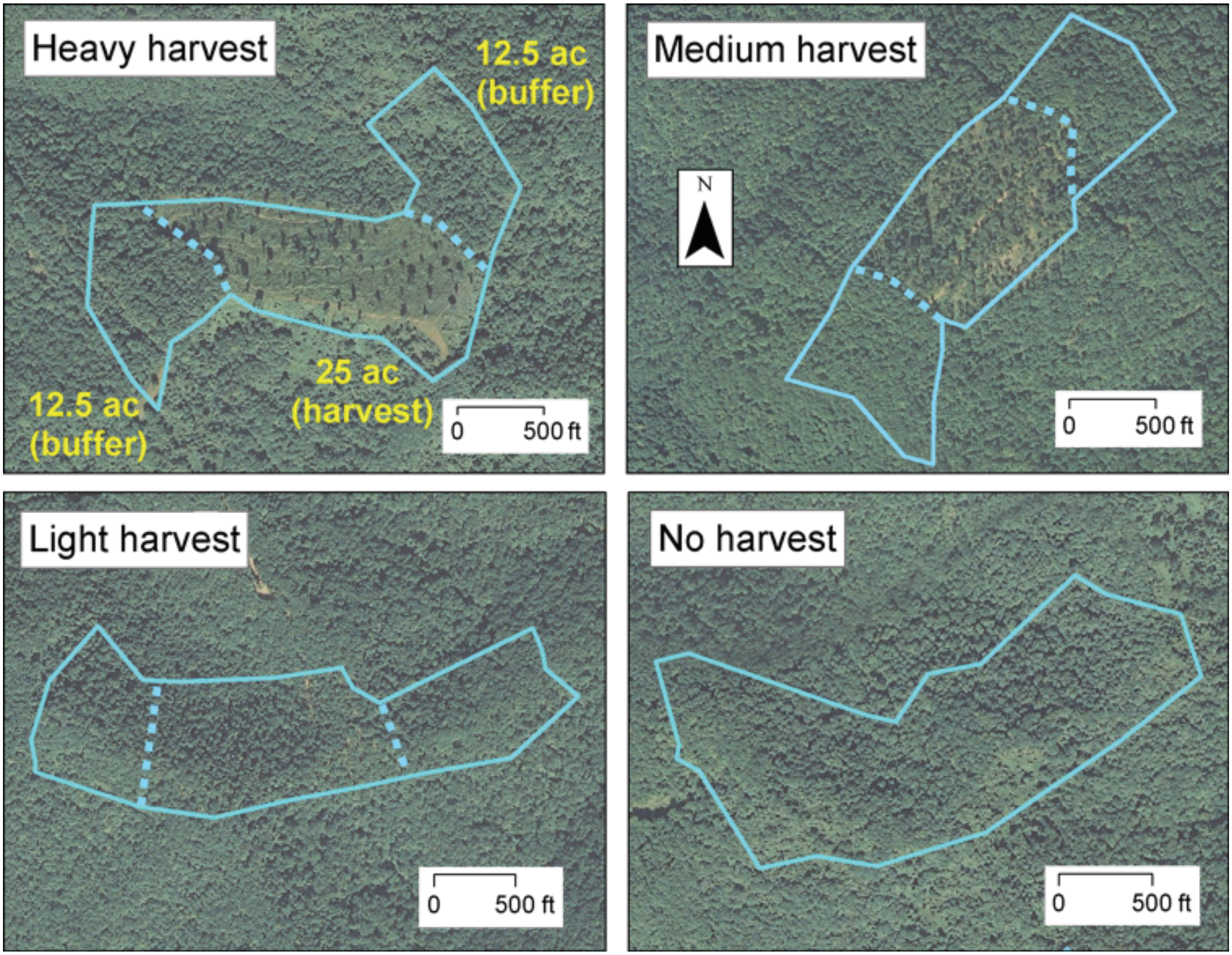


Figure 5. Plot layout in the CWFMP showing harvests and unharvested buffer areas one year after harvests were implemented on LW in WV.

Findings Relevant to Silvicultural Prescriptions

Short-term Response of Cerulean Warblers to Harvests

Territory Density

■ Across all harvests, cerulean territory density generally increased or was maintained and rarely decreased from pre-harvest densities (Fig. 6 top). The modeled response indicated that annual increases occurred (Fig. 7).

■ The largest and most consistent increases occurred when RBA was between ~40 and 90 ft^2/ac (Fig 6 top, Fig 7). An extreme increase occurred in a harvest ~45 ft^2/ac RBA where ceruleans were absent preharvest; post-harvest territories here were densely clustered.

■ Territory density increases that occurred at low levels of RBA (<40 ft^2/ac) were typically delayed 2-3 years, likely in response to the time needed for understory foliage and structural development to occur in the residual stand. Within these heavy harvests, territories were often situated along the harvest edge (Fig. 8) and nests were rarely located within the harvest.

■ Single tree selection harvests with RBA >90 ft^2/ac produced little increase in cerulean territory density (Fig 6 top).

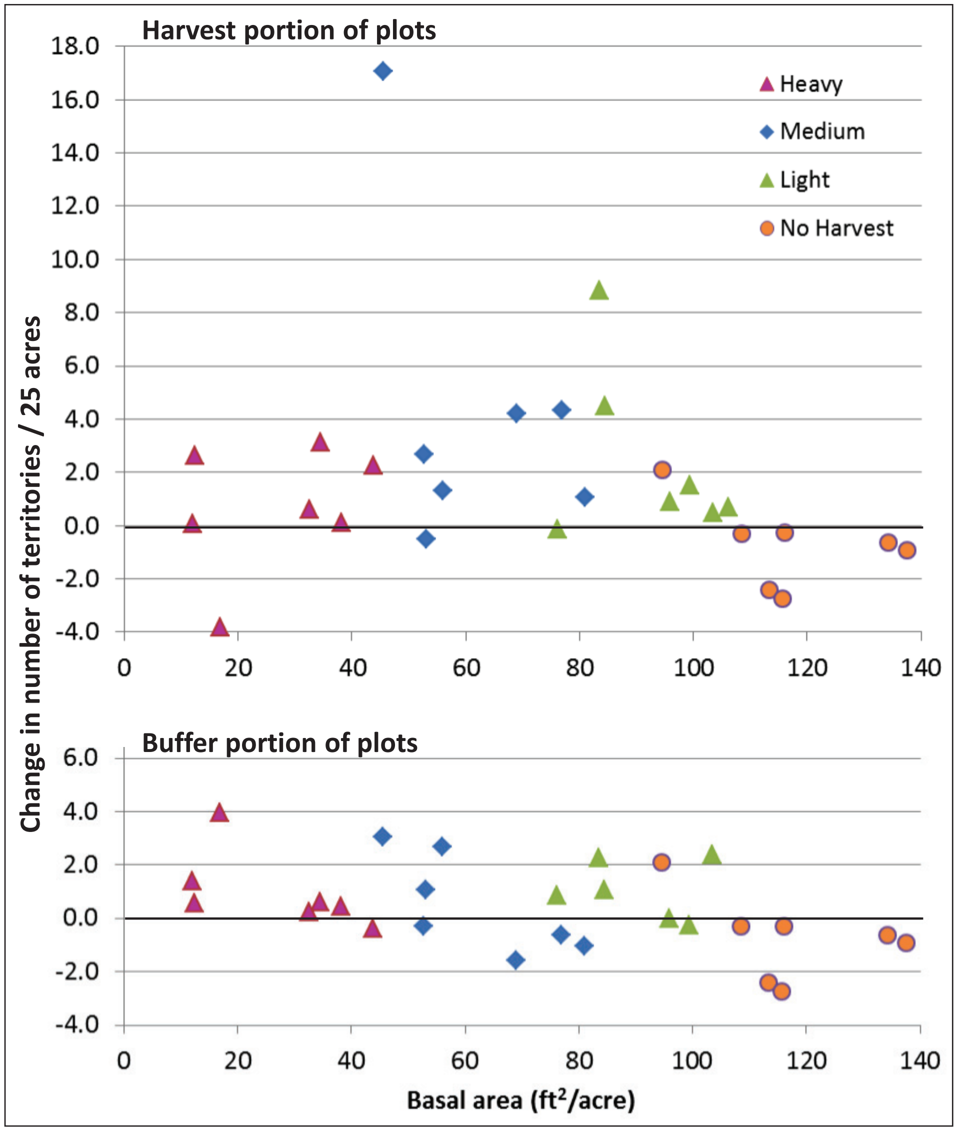


Figure 6. Mean change in number of cerulean warbler territories per 25 ac from 2006 (pre-harvest) to 2007-2010 (post-harvest) relative to post-harvest basal area and harvest intensity. Top figure is within harvests and bottom figure is within unharvested buffers. Points above the 0 line indicate plots with a mean increase in number of territories.

Ceruleans favor residual basal area of ~40 to 90 ft^2/acre of canopy trees.

■ Although the territory density response to harvests was generally positive (Fig. 6 top, Fig. 7) it was variable across study sites likely due to differences in pre-harvest cerulean densities, topography, and forest structure and composition.

■ In the majority of unharvested buffers (Fig. 6 bottom), cerulean territory density mostly increased or was maintained regardless of intensity of the adjacent harvest.

■ Some degree of thinning in the canopy of oak-dominated stands with basal area >~130 ft^2/ac would likely benefit ceruleans because territory density generally was low on these highly stocked stands (Fig 7).

Cerulean Warbler male with color bands. Matt Shumar

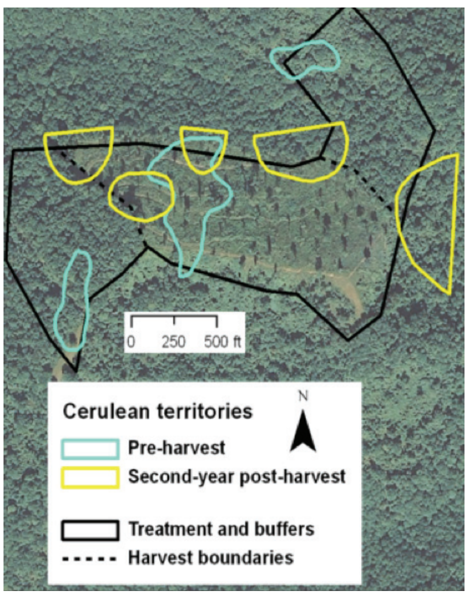


Figure 8. Cerulean Warbler territories aligned along the edge of a 20 acre heavy harvest with 12.5 ft^2/ac of residual basal area. Territories before the harvest are shown in blue and after harvest are in yellow. The birds used little of the interior of the cut.

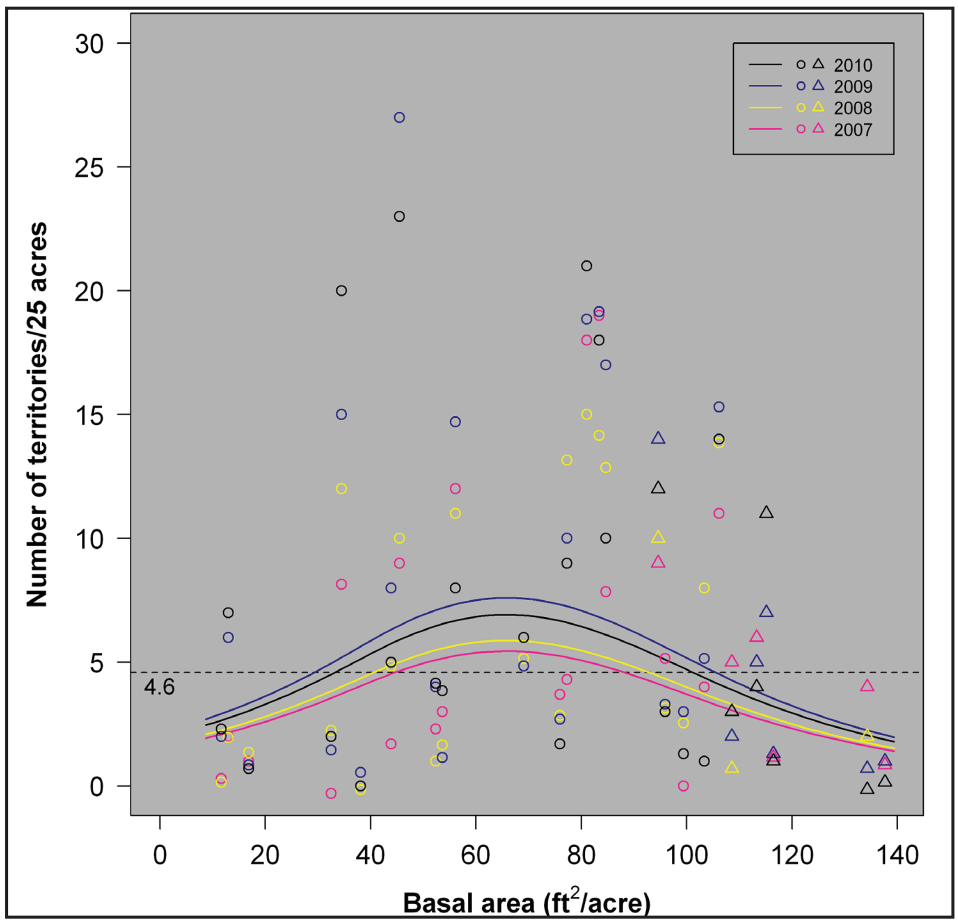


Figure 7. Annual number of post-harvest (2007-2010) cerulean warbler territories per 25 acres (circles=harvests; triangles=no-harvest control) relative to post-harvest basal area. Curved lines are the annual post-harvest predicted response for a plot with 4.6 pre-harvest territories/25 acres (the pre-harvest mean indicated by the thin dotted horizontal line).

Nest Success

■ Nest success varied strongly by study site and year and was relatively low at many of the study areas. Harvest intensity had less influence on nest success than study area and year.

■ Unharvested buffers adjacent to the harvests had nest success similar to that of the unharvested control stands.

■ Of the three harvest treatments, medium harvests had higher nest success than light or heavy harvests (Fig. 9). However, unharvested control stands in the South region (the two Tennessee study areas) had higher nest success than any harvest.

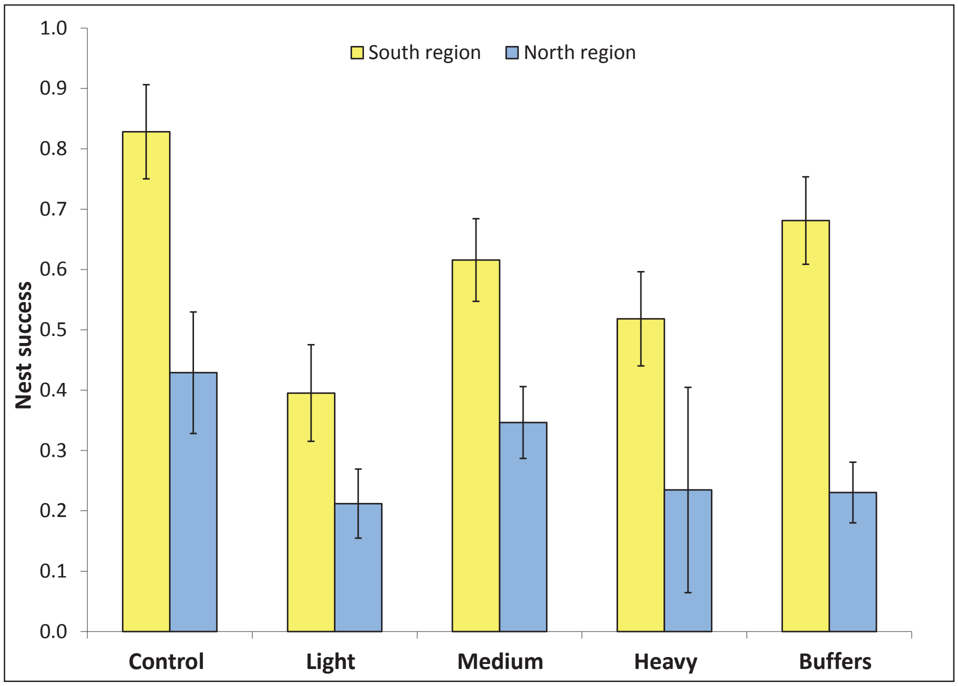


Figure 9. Cerulean Warbler nest success (with standard error bars) for the no harvest control, the three harvest treatments, and the unharvested buffers.

Male Cerulean Warbler with newly hatched chicks. Ohio DNR

Habitat Use

■ For nest trees, ceruleans preferred white oak, sugar maple (*A. saccharum*), and cucumber magnolia (*Magnolia acuminata*) as nest trees and avoided red maple and oaks from the red oak group (scarlet, black, and northern and southern red oak) (Fig. 10).

■ For foraging, they preferred sugar maple, chestnut oak, and hickories and again avoided oaks from the red oak group (Fig. 11).

■ Ceruleans placed their nests in trees that averaged 15-19 inches dbh across the study areas. Nest trees were larger than random trees within the territory. Vegetation structure adjacent to nest trees had less mid-canopy cover and more understory cover than generally available within the surrounding territory. These conditions are characteristic of canopy gaps that have some vegetative growth within them.

White oaks, hickories, and sugar maples are favored for nesting and foraging.

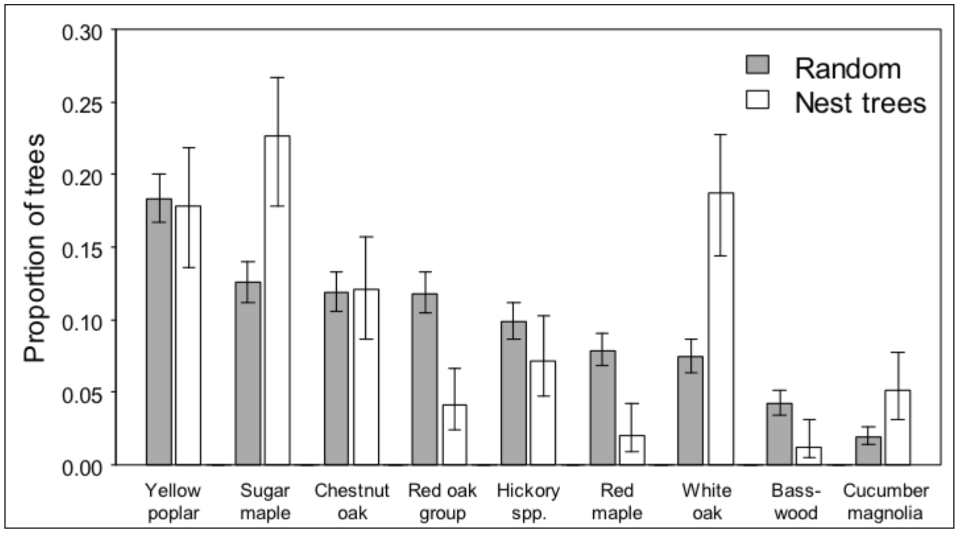


Figure 10. Nest tree selection by Cerulean Warblers at all study areas (pooled) in the Appalachian Mountains, 2008–2010. For each tree species, bars and 95% confidence intervals are the proportion of total trees within randomly sampled plots (gray) and the proportion of total nest trees (white). Red oak group includes northern red (Quercus rubra), black (Q. velutina), and scarlet (Q. coccinea) oak, and hickory species include mockernut (Carya tomentosa), bitternut (C. cordiformis), pignut (C. glabra), and shellbark (C. laciniosa) hickory. Only the most common tree species are shown.

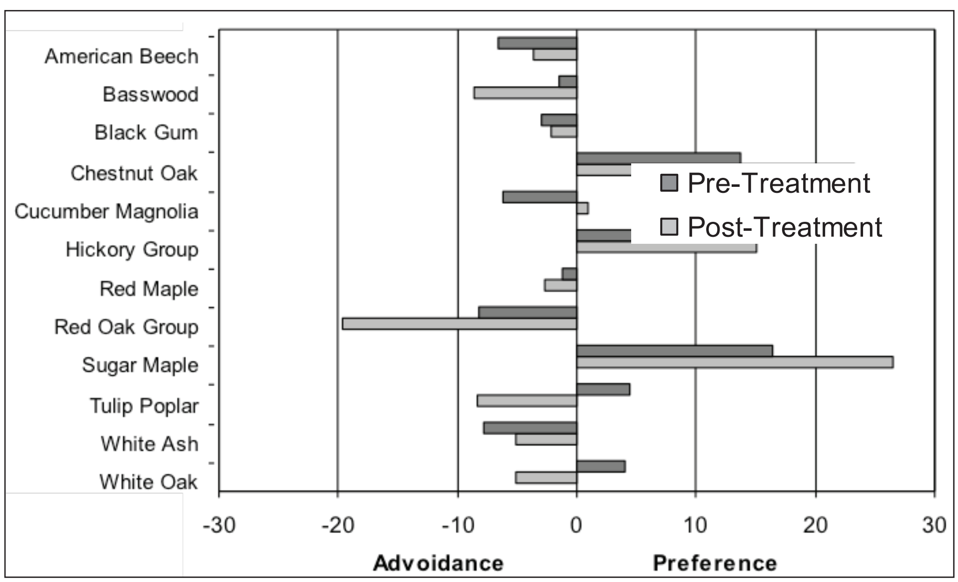


Figure 11. Pre-harvest (2006) and post-harvest (2007) indices of tree species preference and avoidance by Cerulean Warblers for the 12 most commonly available tree species.

Changes in Allied Bird Communities

Appalachian forests are considered some of the most biologically diverse temperate forests in the world. They provide breeding habitat for many avian species including those dependent on closed-canopy forest, others that require young forest habitat, and some species that require mature forest with canopy gaps. Consequently, individual species responded in various ways to different levels of RBA (Table 1).

■ Ovenbird, a species that nests and forages on the ground, had its greatest abundance at high RBA (>90 ft^2/ac; Fig. 12). An immediate negative response to canopy removal persisted four years after harvests in heavy and medium harvests. Ovenbirds occurred at moderate densities in light harvests (>85 ft^2/ac).

■ Species that nest in the midstory of older forests such as Wood Thrush and Acadian Flycatcher (*Empidonax virescens*), also had immediate and persistent reductions in abundance in response to canopy removal in heavy and medium harvests. This was likely in response to midstory removal and the open canopy and dense understory conditions that developed in response to these harvest levels.

■ Heavy and medium harvests increased abundance and diversity of shrub-nesting species including Hooded Warbler (Fig. 12), Indigo Bunting (*Passerina cyanea*), Yellow-breasted Chat (*Icteria virens*), Kentucky Warbler, and Eastern Towhee (*Pipilo erythrophthalmus*). These species are associated with low RBA and high shrub cover. Response of some species, e.g. Hooded Warbler and Kentucky Warbler, was delayed until dense shrub cover developed.

■ Certain canopy-nesting species such as Cerulean Warbler and Blue-gray Gnatcatcher (*Polioptila caerulea*) generally increased in abundance at intermediate levels of RBA across the study sites while Eastern Wood Pewee (*Contopus virens*) increased only in Ohio at intermediate RBA. Some canopy-nesters that are less sensitive to small-scale harvesting, like Scarlet Tanager, had similar abundance across the range of harvest intensities.

These short term effects are from small-scale harvesting (~25 ac) within relatively continuous mature forest. Avian species may respond differently to larger harvests, more extensive harvesting, or harvesting within landscapes with less forest cover.

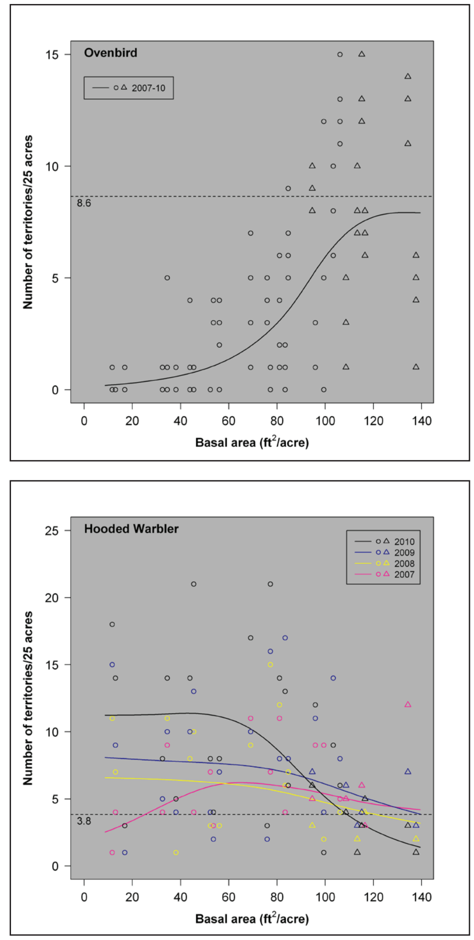


Figure 12. Number of post-harvest (2007-2010) Ovenbird and Hooded Warbler territories per 25 acres (circles=harvests; triangles=no-harvest control) relative to post-harvest basal area. Negative (Ovenbirds) and positive (Hooded Warbler) predicted responses to basal area are shown by curved lines (the pre-harvest mean indicated by the thin horizontal line). For Hooded Warbler, there was an annual increasing response during 1 to 4 years post-harvest.

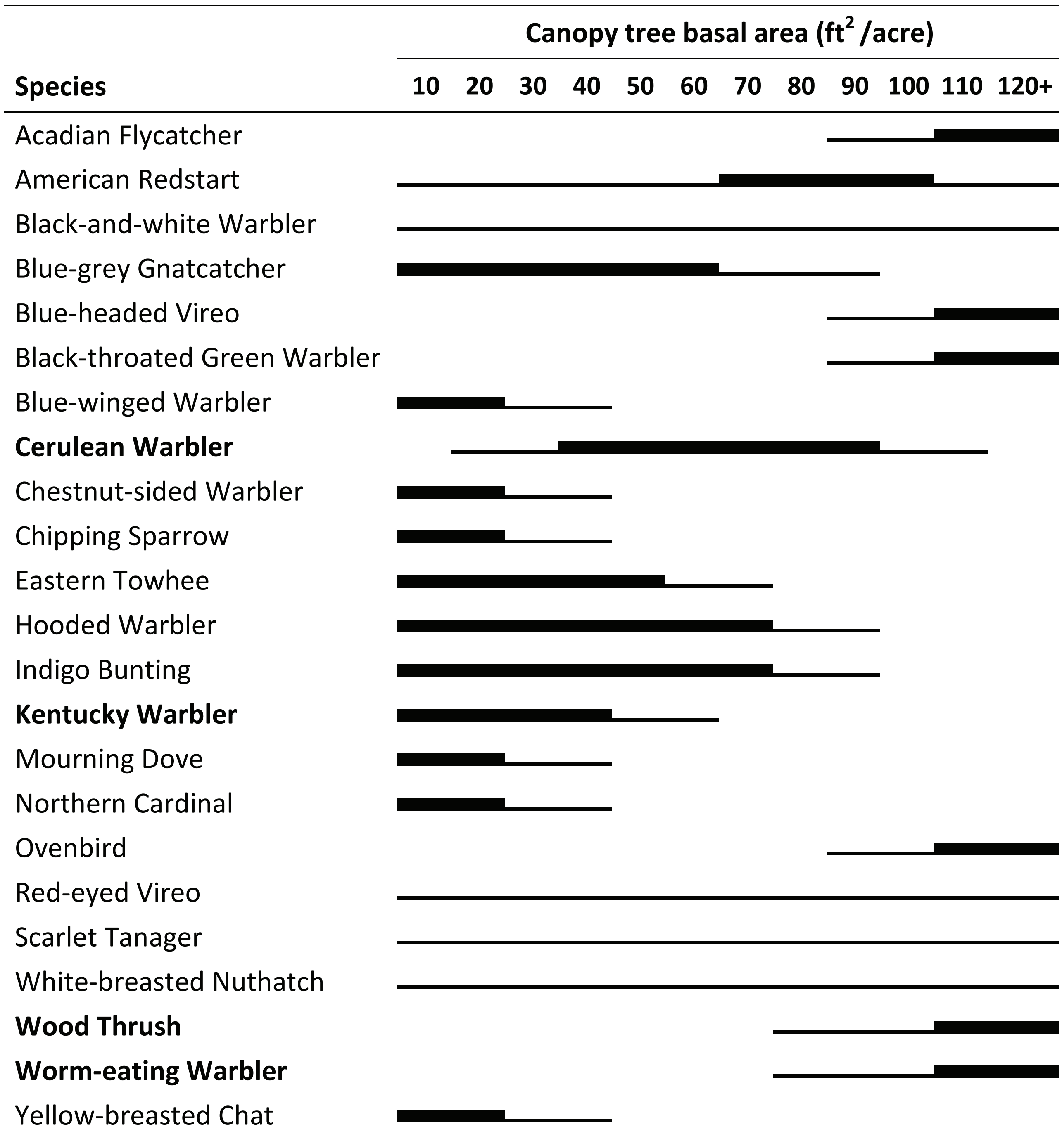


Table 1. Suitable and optimal (thickest line) basal areas for migratory songbirds that were common at CWFMP study sites. Bolded species are USFWS Birds of Management Concern. Relative abundance and/or territory density for a given species was highest under optimal basal area ranges and the species was present under suitable ranges.

Management Considerations

Cerulean Warblers occur on forested lands throughout its range. Landowners desirous of keeping their lands in forested condition can do so using the economic benefits derived from productive forest management. In mature forest stands that have high cerulean densities and high nest success, the no-harvest option is most favorable for sustaining cerulean populations. In actively managed forests, there are opportunities to use forest management practices to mimic the structure and natural disturbance regimes of old-growth forests to enhance habitat for this species. The results from the CWFMP indicate that retaining RBA levels of ~40-90 ft^2/acre after harvesting trees in 25 acre harvest units in oak-dominated stands creates a forest structure that is generally favorable for ceruleans. Small-sized harvest stands (~10-27 acres) and their edges are not avoided by ceruleans.

Female Cerulean Warbler. Ohio DNR

In addition to enhancing stand conditions for ceruleans, small-scale harvests that result in intermediate levels of RBA are consistent with promoting oak regeneration and a diverse wildlife community. These harvests create habitat for early-successional birds, many of which are experiencing long-term population declines. For example, in northeast Pennsylvania, stands of regenerating timber attract Cerulean Warblers to use both the mature forest edge and adjacent residual trees in the harvest while providing breeding habitat for Golden-winged Warblers (*Vermivora chrysoptera*). Opening the canopy also can enhance habitat for many species of forest-dwelling bats. A study of bat use of the CWFMP treatments found increased bat foraging activity within partial harvests than in unharvested plots.

Important considerations for implementing harvests for ceruleans include the following:

Landscape-scale Considerations

Forest Cover

Some studies of forest songbirds have found decreased nest success in landscapes with a low proportion of forest cover. In heavily forested regions, the abundance and productivity of ceruleans and other forest songbirds appear to be more heavily influenced by stand structure than by landscape or edge effects. Thus, habitat enhancements for ceruleans located in heavily forested regions (>70% forest cover at the six mile scale) are more likely to be effective at attracting ceruleans and landscape context may have less influence on reproductive success.

Scale of Harvesting
Even in heavily forested regions, maintaining a significant portion of the management area as mature forest cover is important for sustaining populations of forest-interior birds because many forest-interior birds are sensitive to the amount of mature forest cover at larger spatial scales. In addition, several mature forest dependent species (e.g., Wood Thrush, Worm-eating Warbler, and Acadian Flycatcher) are likely to decrease in abundance at intermediate levels of RBA. Thus, where these species are high priority, maintaining about 50% of large forest blocks in the >50 year-old age class will provide structural complexity yet retain closed-canopy forest availability.


White Oak dominated habitat. Fran Trudeau

Stand-scale Considerations

Local Cerulean Density
Where cerulean density is relatively high (>5 territories/25 acre), immediate habitat enhancements are not necessary because harvesting may reduce reproductive success which may outweigh any increases in cerulean breeding density. Ideal locations to focus management efforts are where local cerulean densities are low (<5 territories/25 acre). If no ceruleans are present near the management site (within ~5 miles), they may be less likely to colonize the managed area.

Retain large diameter white and chestnut oak trees in any management scenario.

White Oak Dominance
Maintaining white and chestnut oak dominance in the residual stand is a primary consideration in implementing management strategies for ceruleans. Thus, site productivity and the presence of sufficient advance regeneration of white and chestnut oaks are important considerations in management. Where feasible, favor white oak, chestnut oak, hickories, and sugar maple in the residual stand and do not retain red maple or red oaks. Retain some of the largest diameter individuals of the preferred species as residual trees. Prescribed fire at regular intervals may be necessary to promote oak regeneration, maintain small canopy gaps, and facilitate understory vegetation diversity.

Topography
In much of the Appalachians, harvests located along ridgetops and upper slopes are likely to be more effective in attracting ceruleans. Mesic, north- and east-facing slopes are often favored by ceruleans although other aspects are used.

Size of Canopy Gaps
Ceruleans preferentially use canopy gaps that are ~400-1000 ft^2 in size, particularly those with advanced vegetative growth within them. Thus, group-selection harvests that allow already established regeneration to grow into a stratified canopy may benefit this species.

Temporal and Silvicultural Considerations

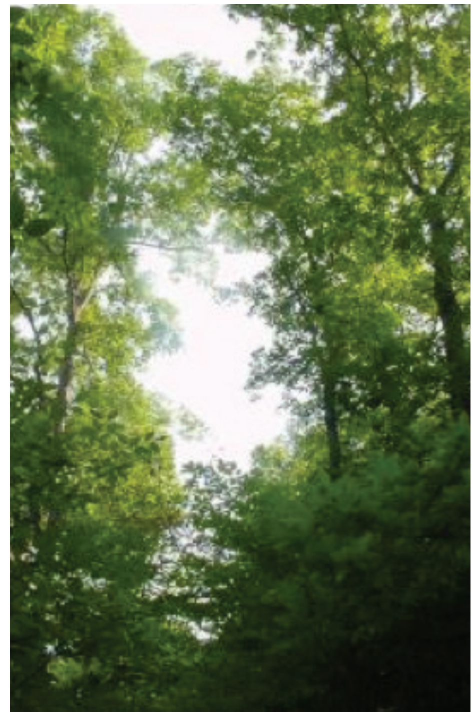
A number of different silvicultural practices could achieve residual basal areas in the harvested stand that are suitable for cerulean warblers (~40-90 ft^2/acre). Some additional considerations for various silvicultural treatments are below.

■ *Single-tree selection harvests* (our light harvest treatment) were less effective in increasing cerulean numbers and rapid canopy closure may limit the duration of suitable habitat. Single-tree selection with RBA above ~90 ft^2/acre also led to lesser nest success than harvests with lesser RBA. However, if single-tree harvest is favored by a landowner for providing income, cerulean densities would still be maintained particularly if non-preferred trees are removed and preferred oaks are retained.

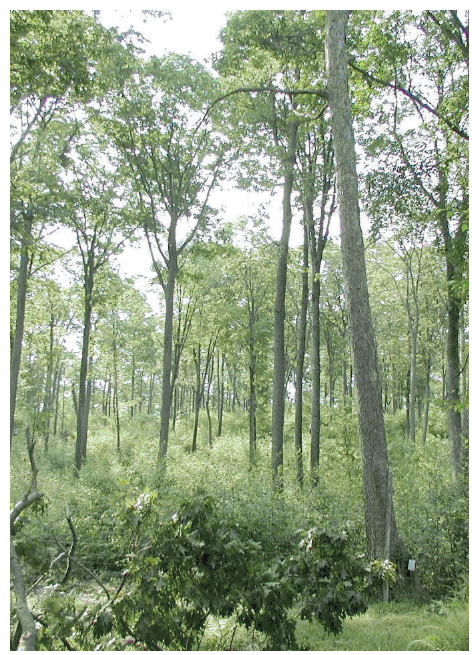
■ *Group selection as part of an uneven-aged system* can improve cerulean habitat and would likely be effective longer than single-tree selection. The small group openings provide for diverse canopy structure and understory development. This approach has been shown to advance stands toward late successional structure beneficial to many avian species.

■ *Shelterwood harvests* are often compatible with promoting oak regeneration and, in the CWFMP, generally resulted in increased cerulean density and intermediate levels of nest success. However, complete overstory removal during the second stage of a shelterwood harvest will substantially reduce numbers of mature forest species including Cerulean Warbler, Wood Thrush, Acadian Flycatcher, and Worm-eating Warbler. If managing for forest birds, retain the residual canopy as long as possible and until adjacent habitat has been enhanced with shelterwood or other types of harvests and colonized by ceruleans.

■ *Thinnings* as part of intermediate harvest treatments would open the canopy and provide the structure favored by ceruleans. These could take the form of a crown thinning or shelterwood seed cut.



Canopy gap in West Virginia. Scott Bosworth



Shelterwood harvest. Scott Stoleson

■ *Modified even-age regeneration* can be used to create future opportunities for cerulean habitat improvement. Leaving large-diameter residual stems in a harvest unit can lead to development of two-aged stands. Such stands achieve more complex canopy structure earlier in their development than similar single-aged stands and the residual stems allow for some use of the stand by forest birds. Ceruleans had increased density in RBA of >~40 ft^2/acre.

■ *Crop-tree release* is a practice that is used to accelerate development of crop-trees on higher quality sites. The practice is typically applied in 15 to 20 year-old stands. It can allow for earlier canopy differentiation by accelerating growth of dominant stems. Impact on habitat suitability for ceruleans will not be immediate, but benefits should be seen as the stand develops and where earlier entry into the stand for commercial harvest is made possible.

Complex canopy structure in a deferment cut creates future opportunites for Cerulean Warbler habitat improvements. Doug Becker

Summary

Forest management that incorporates these guidelines and that is applied to oak-dominated stands in the Appalachian region can enhance habitat for Cerulean Warblers and other avian species, as well as other wildlife. Managers can choose a range of residual basal area targets depending on their priority avian species of interest.

For ceruleans, the RBA target range of ~40-90 ft^2/acre results in the most increases for the longest time period. A variety of silvicultural approaches can achieve this range. Where cerulean densities are high (>5 territories/20 acres), habitat management is not likely to be needed.

Landscape considerations are also important. These recommendations may be most beneficial in areas with high forest cover. They have not been tested in landscapes where forest cover is low.

Sitting pretty. Bill Hubick

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Appalachian landscape. Charlie Choc