DEVELOPING MANAGEMENT GUIDELINES FOR CERULEAN WARBLER BREEDING HABITAT

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Abstract—Recovery activities for species of conservation concern may be directed to acquire and protect habitats known to contain the species, or to produce suitable habitats or locations suspected to be capable of supporting populations of the species. Management of those habitats ultimately becomes necessary, especially where production of additional habitats is deemed necessary. The Cerulean Warbler Technical Group (CWTG) is working to maintain current Cerulean Warbler (*Dendroica cerulea* (Wilson), Aves: Parulidae) populations and ultimately to double them within the Partners in Flight North American Conservation Plan. This species' population has declined as much as 70 percent since 1965, as measured by our only rangewide yardstick of breeding distribution and trends, the Breeding Bird Survey. These birds were listed as Vulnerable in the prestigious Threatened Birds of the World in 2004. Previously a candidate species under provisions of the U.S. Endangered Species Act (ESA), a petition to list them as Threatened under ESA was lodged in 2000. Ongoing CWTG research activities address three fronts in development of guidelines for habitat management: response of breeding populations to controlled manipulations of existing stands for vegetation management, distribution of the birds among Society of American Foresters' Forest Cover Types, and suggestion of specific practices to improve habitat suitability of particular stands. These practices will vary geographically throughout the species' range, but will focus on common structural elements (e.g., patchy emergent tree canopies) that occur in a variety of forest types. Work on breeding habitats indicates that silvicultural manipulation of the vegetation ultimately will become an important management tool for the species. The studies are, however, in their early stages, permitting us to suggest possible guidelines and illustrate possible objectives and potential consequences. We are not yet in position to specify outcomes of application of particular prescriptions with defined confidence limits.

INTRODUCTION

Why should forest managers in the Central Hardwoods Region care about a songbird, the Cerulean Warbler, that spends only part of the year on their land? Answering this question is the purpose of this paper. We will present a compelling rationale for managing forests for this species, review what is known of its behavioral habitat use and relate this to discussion of silvicultural activities to produce habitat, and suggest methods of evaluating the success of such prescriptions. We will address the important question whether management objectives should be designed for nongame birds, such as Cerulean Warbler, or whether management objectives should be designed to produce specific wood products, and the birds' response to their application subsequently monitored.

Current knowledge of Cerulean Warblers is limited, and it is important that the available management information be assembled into a single, cohesive source that can be distributed to land managers throughout the range of the species. Preliminary guidelines can be developed on the basis of current knowledge and future manipulative studies. We suggest such guidelines here, for consideration in management planning processes for federal as well as state forestry and wildlife agencies. Private landowners may wish to use this information as well. Experience gained through testing the effectiveness of these guidelines will improve our approach to conserving the species.

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METHODS

The Songbird in Question

Cerulean Warbler, a neotropical migratory songbird weighing about 9 gm, is accorded official conservation status in at least 13 states and provinces principally because its population has persistently declined (Link and Sauer 2002). Reasons for the decline are not fully known and may include changes in land use, in forest structure or composition, or in climate of breeding habitats; factors affecting the nonbreeding grounds; or events during migration (Robbins and others 1992). Designated a Vulnerable species by the International Union for the Conservation of Nature and Natural Resources (Birdlife International 2004), the species is listed as one of conservation concern by the U.S. Fish and Wildlife Service (Ruley 2000, Williams 2002). Partners in Flight has identified it as a first priority for conservation efforts throughout its range (Rich and others 2004). NatureServe, however, ranks it as apparently secure globally (G4) (http://www.natureserve.org/explorer, [Date accessed March 20, 2006]).

Migration, south during July-October and north during March-May, and nonbreeding residency in South America, August-March, occupy most of the annual cycle. Breeding occurs during April-August, and the breeding range coincides closely with the Central Hardwoods Region (fig. 1). Breeding habitat includes a great variety of hardwood forests in sawtimber stages of development. Thus, managers of mature hardwood forests in the Central Hardwoods Region are the primary stewards of the reproductive potential of these birds. Furthermore, areas in the most dependably occupied part of the breeding range (Baldy 2005) are

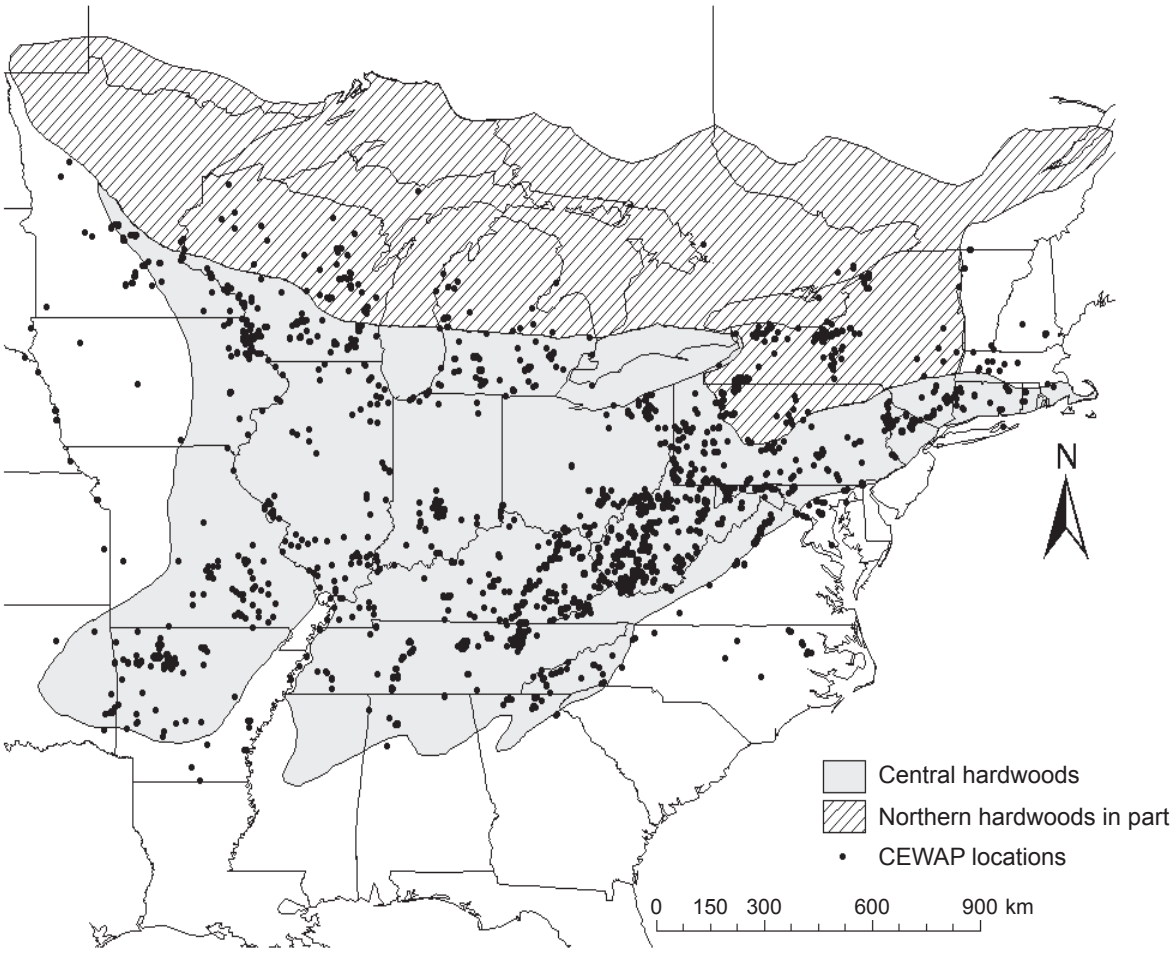

Figure 1—Breeding range of Cerulean Warbler as identified by the Cerulean Warbler Atlas Project (CEWAP; Rosenberg and others 2000), with outline of Central Hardwoods Region after Fralish (2003) and Pijut (2003).

also areas in which intensive coal extraction by mountaintop removal-valley fill methods is practiced, further emphasizing the importance of management of Central Hardwoods breeding habitats (Weakland and Wood 2005).

Cerulean Warbler Technical Group

The Cerulean Warbler Technical Group (CWTG) was formed in 2001 to inform conservation actions directed toward these birds. Founders of this *ad hoc* group recognized an opportunity to take a proactive approach to Cerulean Warbler conservation. They initiated a broad-based forum to exchange technically sound information about the birds. Members seek to preempt contentious and unproductive interactions that might otherwise result were the species to be listed under ESA. "By seizing the initiative and bringing a number of key stakeholders and technical experts together, the CWTG seeks to keep the focus on developing meaningful conservation solutions through sound science, clear communication, and trust" (Hamel and others 2004). With membership from seven nations, numerous states and provinces, international and national conservation and land management agencies and consortia, as well as timber companies, this effort encompasses the entire international range of the species (Hamel and others 2004). Current concern over effects of mountaintop removal-valley fill coal extraction on Cerulean Warblers (see Wood and Edwards 2001) suggests that the CWTG will be an efficacious forum to address issues of bird conservation and energy production. To better understand habitat distribution and management response of Cerulean Warbler in the central portion of the range, the CWTG has initiated a large-scale, replicated experiment in which the effects on the species of timber harvest to reduce canopy will be evaluated. An explicit CWTG goal is to develop forest management guidelines compatible with industry needs as well as with conservation goals to maintain and increase Cerulean Warbler populations.

Methods Used in the Review

We have compiled information presented in Hamel (2000a, 2000b), the Cerulean Warbler Atlas Project (CEWAP; Rosenberg and others 2000), and published and unpublished subsequent materials. We present the results of our review in a series of descriptions of habitat at several hierarchical scales from rangewide to nestsite. From these descriptions of habitat we infer treatments that may produce such habitats and suggest these as potential silvicultural practices that may produce habitat for the species.

HABITAT ASSOCIATIONS OF CERULEAN WARBLERS

Few publications specifically address relationships between silvicultural activities and Cerulean Warbler habitats. Kahl and others (1985) long ago suggested a vector of habitat conditions believed suitable for the birds in Missouri. Rodewald (2004) and Stoleson (2004) presented results of analyses of the birds' response to certain silvicultural practices in the Central Hardwoods Region. The Missouri Department of Conservation (2005) produced a short list of beneficial and detrimental practices for the species as part of a series on Best Management Practices. Hamel (2005) identified elements of a silvicultural prescription through analysis of observations of behavioral habitat use in the Lower Mississippi Alluvial Valley (LMAV). Hamel and others (2005) applied some of that prescription to an Arkansas site.

Scale Description

Cerulean Warbler response to habitat varies across the breeding range (Rosenberg and others 2000) for unknown reasons, and this suggests that management guidelines also will need to vary geographically. We present a sequence of habitat descriptions at successively finer scales. Similarities and differences identified in literature and unpublished studies can be viewed at regional, physiographic, forest type, topographic, edaphic, successional stage, tree species and size, nest vicinity, and nest microsite scales.

Breeding rangewide and regional—Cerulean Warblers breed in deciduous forests of eastern North America (fig. 1). The majority of populations today, as historically, occur in the Central Hardwoods Forest Region. Within this range, the species' association with tracts of different sizes is not consistent (fig. 2; Hamel 2000b). Across the Southeast and on the western edge of the range, the species is found predominantly in very large tracts. In the Midwest the species appears to use tracts of widely varying

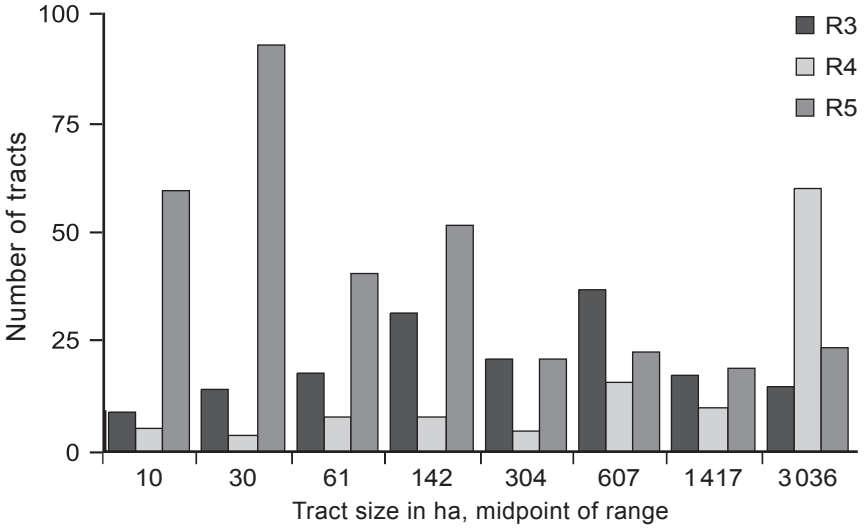

Figure 2—Distribution of Cerulean Warblers by size of tract, from Cerulean Warbler Atlas Project (Rosenberg and others 2000). R3 (Midwest), R4 (Southeast), and R5 (Northeast) correspond to states of the named regions of the U.S. Fish and Wildlife Service. Graph shows differences among parts of the range in the relative frequency of occupancy of tracts of different sizes.

sizes. In the Northeast a large proportion of sites identified in CEWAP were of modest size, while West Virginia birds occurred at lower density in small tracts (Weakland and Wood 2005). No data exist on demographic responses to different tract sizes. Why the species varies in its distribution among tract sizes across its range is not known; variation in Brown-headed Cowbird [*Molothrus ater* (Boddaert)] brood parasitism may be associated with it (Chace and others 2005).

Physiographic regions—The northern Cumberland and Allegheny Plateaus of the Mixed Mesophytic Region of the Central Hardwoods Forest (Fralish 2003) harbor 70 percent of the breeding population. Breeding also occurs in several other Regions, principally in those Sections that form part of the Central Hardwoods Forest. We believe the wider distribution results from association with Central Hardwoods Forest types as they occur in these Regions. The greater abundance in the northern Allegheny and Cumberland Plateaus results from the more continuous distribution of these forest types there.

Forest type—The Cerulean Warbler has repeatedly been identified as having a wide habitat distribution among mesic deciduous forest types within its geographic range (Hamel 2000b). Of 49 hardwood forest cover types in the East (Eyre 1980), Cerulean Warblers have nested in the nominate tree species of 33. However, this does not imply use of those forest types without preference throughout the range. In contrast, the species is often restricted to a few forest types, types that may differ from region to region. In a local area, the distribution is often bi-modal, with birds occurring in bottomland situations and on ridgetops, but not between. In the CEWAP report, numerous state summaries mention oaks and hickories and/or sycamore and cottonwood as the dominant tree species at occupied sites. Reports from different areas may conflict. For example, Stoleson (2004) reports Cerulean Warbler aversion to the black cherry-maple (*Prunus serotina* Ehrhart-*Acer* L. sp.) type in Pennsylvania, while Nicholson (2004) finds black cherry to be among the most frequent nest trees in eastern Tennessee. Our inference from this distribution is that the birds use situations of higher than average local fertility on mesic but neither xeric nor very hydric sites.

Elevation and aspect—Edaphic factors include elevations, topographic situations, aspect, and soil types. Cerulean Warblers nest at a wide range of elevations—almost the full range of elevations in the states in which they occur (Rosenberg and others 2000). Aspect has been evaluated in several studies. Bosworth's (2003) West Virginia results agree with Nicholson's (2004) demonstration in Tennessee that nest sites were

on more mesic north-facing slopes than expected based on random point locations in the same plots (χ^2, 5 df, = 36, P < 0.0001). As with forest type and topographic situation, use of a wide variety of elevations across the range is the result of occurrence in different restricted subsets of elevations within individual localities.

Topographic situations—Cerulean Warbler breeding habitat includes upland and bottomland situations, apparently without preference (fig. 3). Some recent work suggests that the birds are partial to areas of local relief and areas of higher than average local elevation, from natural levees close to riverbanks (Castrale and others 1987, Robbins and others 1998), to ridgetops (Weakland and Wood 2005). The birds have access to upland as well as LMAV bottomland habitats at Meeman Shelby Forest State Park, Shelby Co., Tennessee. In the uplands there, they are often found at the edge of a bluff or crest of a saddle and seldom on side slopes. They occur only in the highest floodplain sites at the toe of the bluff at the edge of the floodplain (Hamel, P.B. Unpublished observation. Author can be reached at USDA Forest Service, Center for Bottomland Hardwoods Research, Stoneville, MS 38776).

Spatial distribution within stands—Barg and others (2005) show that individual male Cerulean Warblers concentrate their activities in specific core areas within their territories. Cerulean Warblers are frequently considered to be associated with forest canopy gaps. Nicholson (2004) found this for nest sites in east Tennessee. One carefully controlled test of this hypothesis compared nest to nearest gap distances with distances to nearest gap from randomly selected points in the same LMAV stands. Significant differences existed among stands in average distance to gap, but not between nest-gap and point-gap distances (Hamel 2005). Gap size criteria were not the same in these studies, however. Hunter and others (2001), Rodewald (2004), Stoleson (2004), and Wood and others (2005) associate the birds with canopy disturbance; Jones (2000), working in Ontario, does not.

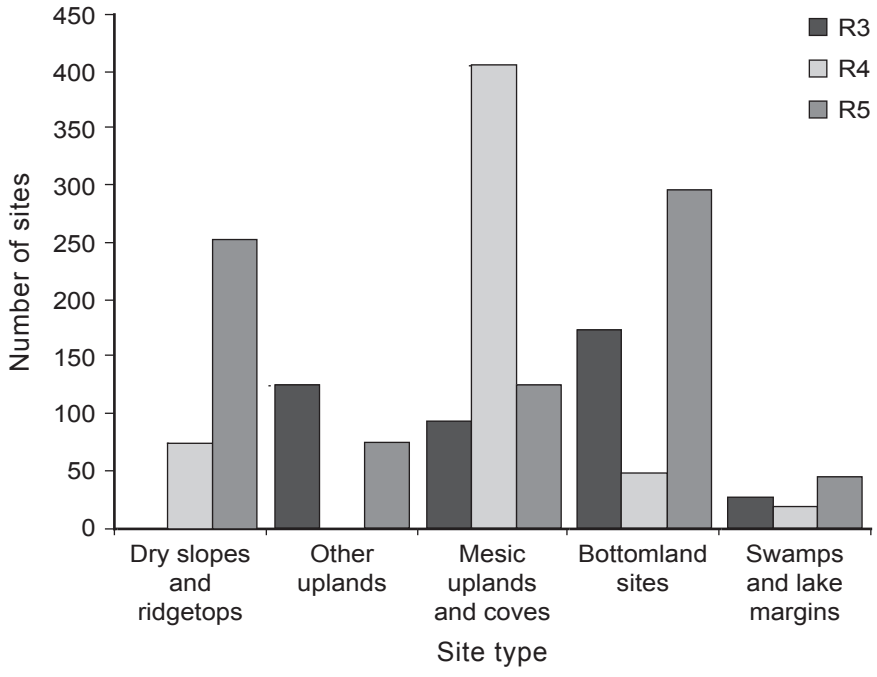

Figure 3—Distribution of Cerulean Warblers by broad site classes, from Cerulean Warbler Atlas Project (Rosenberg and others 2000). R3 (Midwest), R4 (Southeast), and R5 (Northeast) correspond to states of the named regions of the U.S. Fish and Wildlife Service. Graph shows differences among parts of the range in the relative frequency of occupancy of tracts on different site types.

Successional stage—Although the breeding distribution of the species includes many hardwood forest types, it is not so variable in its association with tree size. Cerulean Warblers breed in areas with large trees. One evaluation of tree size association of breeding territories (Robbins and others 1992) demonstrated that in upland as well as bottomland situations in Tennessee, males chose as song perches trees of larger than expected diameter compared to trees in their territories. The territories were located in areas of larger than expected tree diameters compared to the surrounding stand. The stands in their turn were composed of trees of larger than expected diameter compared to the regional norm. It is clear that the birds occur in stands in later successional stages, stands that have achieved mature sawtimber stature.

Tree species—From tree species selected by Cerulean Warblers, particularly for nesting (fig. 4), we can infer what silvicultural practices may be useful. The many species selected include both shade tolerant and shade intolerant trees. The list includes species across a wide range of flood and drought tolerance. The inference is that, within a stand of suitable forest type and size in a suitably forested landscape, the birds will use early successional species such as black locust (*Robinia pseudo-acacia* L.), eastern cottonwood (*Populus deltoides* Marshall), or yellow-poplar (*Liriodendron tulipifera* L.) when those trees achieve large stature. As these stands age and become dominated by large individuals of later successional oaks (*Quercus* L. sp.), hickories (*Carya* Nuttall sp.), and maples, the birds will continue to use such stands.

Tree size—From its description (Wilson 1811), Cerulean Warbler has been associated with large trees (Oliarnyk and Robertson 1996). Further, the birds are purported to use "tall trees." In the LMAV, Cerulean Warblers choose nest trees that are tall relative to heights expected from trees of their species and diameter based on norms derived from Forest Inventory Data sets (P.B. Hamel, unpublished ms). Mean height of 67 nest trees was 100 percent (± 3.9 percent S.E.) of the maximum height expected for a tree of that species

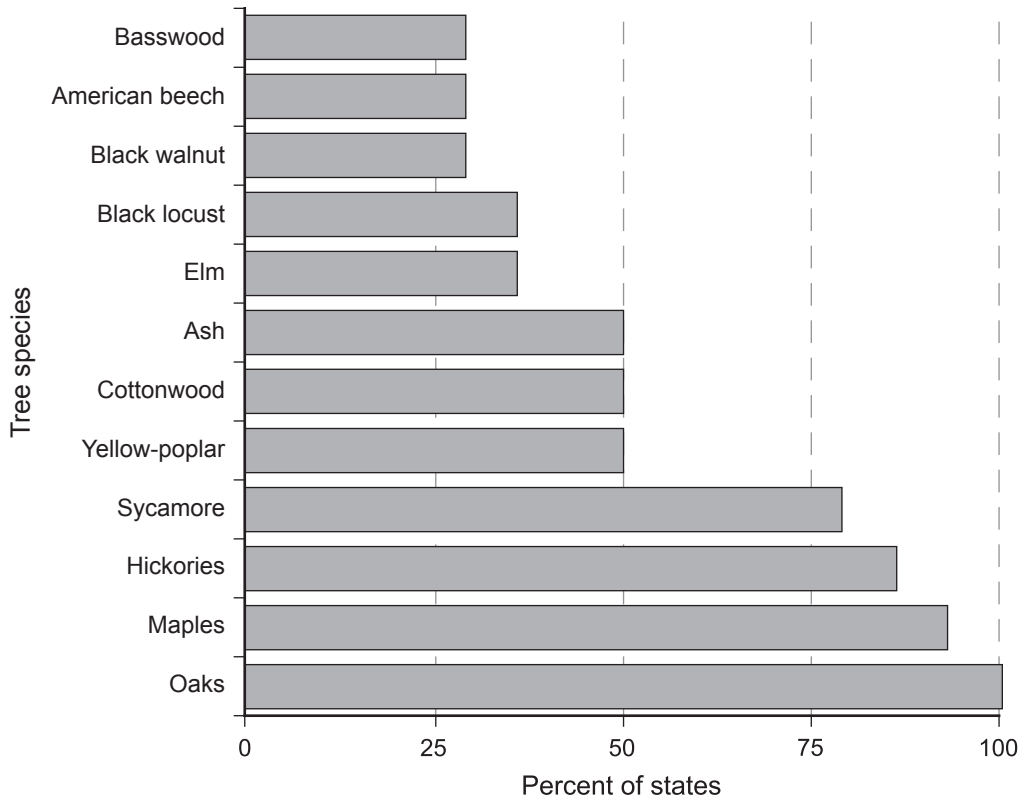

Figure 4—Tree species listed as dominant components of overstory in the Cerulean Warbler Atlas Project, grouped by state (from Rosenberg and others 2000).

and diameter recorded in the LMAV in the most recent Forest Inventory data set. This suggests that Cerulean Warblers prefer to nest in trees that are relatively tall for their diameters.

Nest site—Typically, Cerulean Warblers choose to place their small cup nest on the surface of a branch high in the canopy, closer to the outer edge of the canopy than to the bole. Often, the length of the branch on which the nest is placed approximates the radius of an open-grown tree of that species and diameter (Hamel 2005). This suggests that nest trees have experienced full sunlight on at least that side for some portion of their life. Often, the nest is placed at or near a fork in the nest branch; frequently a small cluster of leaves either of the nest tree or of vines on the nest branch provide some cover over the nest site.

Vertical distribution of vegetation near nests—Heterogeneous vertical distribution of vegetation in stands may be the common thread in understanding breeding habitat. Numerous authors indicate this is so and attribute it to stand structure (Hamel 2005, Jones and Robertson 2001), to topography (Bosworth 2003, Nicholson 2004, Wood and others 2005), or both. Existing methods to measure this structure are either too crude (James and Shugart 1970), or inapplicable at relevant heights (Mills and others 1991). Jones and others (2001) and Weakland and Wood (2005) use optical methods that are promising but imprecise. Describing how to produce this structure may be easier than measuring it.

Development of Management Prescriptions: Alternative Approaches

We challenge the management and silvicultural community generally to consider how objectives for a songbird can become incorporated into silvicultural practice at a regional scale. Cerulean Warbler, as Rodewald (2004) observed, is a species whose future population trajectory may profoundly affect forest management activities in Central Hardwoods. How, then, are we to identify appropriate management prescriptions for this bird? Potential silvicultural prescriptions for Cerulean Warbler habitat can be (1) inferred from habitat characteristics measured on breeding locations, (2) specified as techniques required to produce conditions identified from behavioral habitat selection, or (3) assessed from comparative responses of populations to management operations.

Habitat preference inferred from observed habitat use—The first two techniques lead to specification of management objectives with particular Cerulean Warbler outcomes anticipated. Where the inferences of quality habitat are correct, properly translated into silvicultural practices, and applied in such a way that the inferred habitat is produced, these practices constitute management for the species.

Starting from the premise that required habitat can be specified, the first two techniques build a prescription from the individual tree up. Kahl and others (1985) specify ranges observed at known sites of occurrence for canopy cover (total 85-90 percent, not <65 percent), density of large (>30 cm in d.b.h.) stems (100-125/ha, not <50 or >150), and tall canopy (>18 m), with modest density of shrubs (2100-2800 stems/ha, not <1030), moderate number of dead stems 2.5-10 cm in d,b,h,/ha (50-100/ha, not >175), and a subcanopy cover slightly less than that of the canopy (total 65-70 percent, not <45 percent). These values suggest a stand stocking percent of 65-80 (Ginrich 1967). Presumably a stand in one of the proper forest types, on a mesic site, which met these criteria would be a candidate stand to support Cerulean Warblers in Missouri, and perhaps in other areas.

Studies in Pennsylvania by Rodewald (2004) and by Stoleson (2004), and in West Virginia by Wood and others (2005), identified the silvicultural technique associated with the history of the stands in which the birds occurred. Stoleson (2004) reported that the shelterwood cut with prescribed burning treatments commonly used to manage oak stands resulted in higher abundance and frequency of Cerulean Warbler occurrence than did other treatments. Rodewald (2004) addressed the effects of forest management at the landscape scale. The birds in her Pennsylvania study area were positively associated both with high proportion of forest area within 1km and with nearness to recent forest harvest. Wood and others (2005) reported that Cerulean Warbler use of two-age stands harvested 15-18 years previously was greater than

use of clearcut stands of similar age. The results of Kahl and others (1985), Rodewald (2004), Stoleson (2004), and Wood and others (2005) are testable hypotheses of silvicultural prescriptions.

Hamel (2005) designed a prescription around the trees selected by the birds. It combines (1) large, tall sawtimber trees from which males can broadcast their songs, with (2) suitable long-limbed trees in which nests might be placed. The tall sawtimber trees may be of shade-tolerant or more likely shade-intolerant species, and well-spaced in the stand. In the close vicinity of these trees should be favored the development of potential nest trees: large, long-limbed midstory trees of shade-intolerant, or more likely shade-tolerant, species. The prescription is based on extensive work in the LMAV. Implications of the prescription for other species and resources are secondary to the intent of producing habitat specifically for Cerulean Warbler. Difficulties with the prescription lie in the many assumptions involved in determining "required" habitat elements. Hamel and others (2005) are conducting an experimental test of this prescription in an unreplicated study.

Evaluation of alternative standard silvicultural practices—The third technique for establishing a prescription is to evaluate Cerulean response to alternative stand structures that result from standard silvicultural practices. This is the approach taken in the large-scale CWTG experiment, which is contrasting treatments that differ largely in the degree of canopy cover retained following harvest. The treatment with the strongest positive Cerulean Warbler response is inferred to produce the best habitat for the birds from among the alternatives tested. Alternatives that appear to be good candidates are treatments designed to produce large sawtimber trees with spreading crowns, in the vicinity of intermediate midstory crowns. The series of thinning treatments identified in the CWTG experiment appear to be appropriate to produce variants of this structure, provided they do not too greatly reduce either regeneration of canopy species or maintenance of shade-tolerant midstory. The application of standard treatments has the advantage that implications of these treatments for the production of other benefits from the forest are known. Thus, these practices are likely to be applied by landowners. However, unless the treatments are designed with sensitivity to the behavioral ecology of the species, this approach runs the risk of failing to produce good habitat without leading to an explanation for its own failure. On the other hand, silvicultural practices based exclusively on behavioral ecology of the Cerulean Warbler will never be implemented by landowners unless they are economically viable and silviculturally practicable.

Management Risks: Our Caveat

This is a review of existing data from which hypotheses about desired forest conditions can be derived. Virtually none of it represents validated, completed experimental tests of manipulations designed to produce hypothesized habitat conditions. For this reason it is likely that these hypotheses are not entirely accurate, and that the proposed silvicultural treatments will produce habitats that only approximate those chosen by Cerulean Warblers or observed to be used by Cerulean Warblers in the past. We therefore propose the guidelines as a specific, testable set of predictions of what is habitat for Cerulean Warblers and how it can be produced. We believe firmly that by making such predictions we can accelerate the process by which a silvicultural prescription for the birds can be developed. We are further convinced that sufficient time exists in which to test and improve the prescription and to compare the results of a prescription directed toward producing habitat specifically for the species to the results of prescriptions designed for other objectives and applied to habitats in which the birds occur. The ultimate conservation of the species is an achievable goal. We are further aware that factors external to any property may intervene to compromise tests of silvicultural prescriptions applied to that property. Such external factors include (1) climate variations that reduce or enhance the probability of occurrence of the birds on that property during the test, (2) land use changes in the local and regional landscape that may alter the relative proportion of forest above or below threshold values for "fragmented forest" landscapes, (3) catastrophic events occurring during migration, and (4) events occurring to nonbreeding habitats in South America and stopover habitats in Central America and North America that may affect survival, and hence abundance, of the birds. Despite the existence of such risks, however, we are dedicated to the ideal of effective

stewardship of Cerulean Warbler habitats, stewardship that can likely be achieved most appropriately with respected tools of silviculture.

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