Population Monitoring and Habitat Assessment of Cerulean Warblers (*Dendroica cerulea*) in the Ozark and Ouachita National Forests of Arkansas

Erin Lea Combs

A Thesis Submitted to the Faculty of Fisheries and Wildlife Biology
of Arkansas Tech University in Partial Fulfillment
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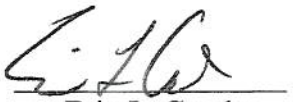

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THESIS ABSTRACT

Populations of cerulean warblers (*Dendroica cerulea*) have declined throughout their breeding range. Cerulean warblers are found in mature deciduous forests with large trees and a closed canopy. Habitat fragmentation and loss of large tracts of mature deciduous forest may be important factors in population declines of cerulean warblers. Cerulean warblers are habitat specialists, making it harder to adapt to changes. To fully evaluate habitat loss, a complete understanding of habitat features required by cerulean warblers is necessary.

I monitored populations in the Ozark and Ouachita National Forests to determine if populations were stable or changing. Twenty stands (i.e. portions of a forest that averaged 16-20 ha) in the Ozark National Forest and 56 stands in the Ouachita National Forest were censused for cerulean warblers from 2004 to 2006. I also conducted point count surveys to determine avian community structure within and outside of stands that support cerulean warblers.

Between 2004 and 2006 the population of cerulean warblers in the Ozark National Forest increased by 10% in 16 stands, and average change per stand was 15.8 ± 77.2%. However, the increasing trend was not statistically significant (R^2=0.80, $F_{1,3}$=3.918, p=0.298). Average number of birds per stand did not differ significantly between years ($F_{2,54}$=0.07, p=0.936).

Management practices can influence occurrence and abundance of cerulean warblers. Eight stands were monitored consistently from 1998 to 2006. Three of those stands were unaltered and supported increasing numbers of cerulean warblers from 1998 to 2006 (R^2=0.64, $F_{1,7}$=8.943, p=0.03); whereas five stands were altered by prescribed

burns or group selection and exhibited a significant decrease in population from 1998 to 2006 (R^2=0.61, $F_{1,7}$=7.875, p=0.038). Cerulean warblers abandoned areas that were burned in 2004. However, males were located in two stands that were burned in 2006. In addition, some of the most dramatic declines occurred in stands that had been group-selected. Only five stands supported cerulean warblers in the Ouachita National Forest from 2004 to 2006, and number of cerulean warblers there declined by 30% from 10 to 7 birds.

Red-eyed vireos (*Vireo olivaceus*), ovenbirds (*Sieurus aurocapillus*), and hooded warblers (*Wilsonia citrina*) were the most common species detected in stands that supported cerulean warblers in the Ozark National Forest. Red-eyed vireos and black-throated green warblers (*Dendroica virens*) were the most common species detected in the Ouachita National Forest.

To evaluate habitat selection, I sampled vegetation in used and unused portions of stands in the Ozark and Ouachita National Forests that supported cerulean warblers to characterize habitat and predict presence/absence of the species. During June of 2005 and 2006, I used playback techniques to delineate territory sizes of cerulean warblers, which enabled me to delineate used portions of the stands. In the Ozark National Forest, territory plots had fewer but larger trees than plots located randomly outside of the territories. Stands that contained cerulean warblers tended to have more northern red oaks (*Quercus rubra*) and hickories (*Carya* spp.) than stands that were not occupied. Comparisons between habitat at random locations and within territories revealed that cerulean warblers were located in areas with large trees, a steep slope and fewer northern red oaks and hickories compared to surrounding areas.

Habitat used by cerulean warblers in the Ouachita National Forest was drastically different from habitat used in the Ozark National Forest. The model developed to predict cerulean presence/absence in the Ozarks only correctly classified 43% of the territories from the Ouachitas. In the Ozark National Forest, cerulean warbler abundance was positively related to presence of a tall subcanopy and large canopy trees (R^2=0.445, $F_{2,14}$=4.810, p=0.029). Hickories were the dominant tree species in territory and reference plots in the Ozarks and in territory plots in the Ouachitas.

How cerulean warblers utilize space was characterized by microhabitat and territory size. Cerulean warblers were observed most often between 6.1 and 12.2 m above ground. Outer portions of trees were used most by cerulean warblers in 2005 and 2006 and cerulean warblers were observed in hickories most often (36.5% of observations in 2005 and 28.6% in 2006). Average size of 41 territories was 1.70 ± 1.23 ha and ranged from 0.24 to 6.64 ha. Territory size was not related to the number of cerulean warblers in a stand (R^2=0.001, $F_{1,41}$=0.034, p=0.855). Habitat loss, either from natural causes or management practices, negatively affected abundance and occurrence of cerulean warblers during my study.

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INTRODUCTION

Cerulean warbler (*Dendroica cerulea*) populations have declined drastically since the early 1900s (Hamel 2000). Breeding populations throughout North America have declined by an average of 3.4% per year, from 1966-1987 (Robbins et al. 1989). However, the greatest rates of decline revealed through analysis of Breeding Bird Survey data have occurred on the Highland Rim in Kentucky and Tennessee and on the Ozark-Ouachita Plateau of Missouri and Arkansas (Robbins et al. 1989). In the Ouachita Mountains of Arkansas, populations were surveyed in the 1990s and 16 birds were located at 8 sites (James et al. 2001). In addition, populations of cerulean warblers in the Ozark National Forest of Arkansas declined by 40% between 1998 and 2001 (Kellner 2002). However, monitoring populations in the Ozarks is difficult because of low site fidelity. Over half (15 of 28) of the groups of cerulean warblers that have been monitored in the Ozarks consisted of 1 to 3 individuals, and small groups were not found consistently among years (Kellner 2002).

The cerulean warbler is currently listed as a species of concern in the U.S. (Evans and Fischer 1997) and a Species of Special Concern in Canada (COWEWIC 2003). A petition was filed with the U.S. Fish and Wildlife Service in October 2000 to add the cerulean warbler to the threatened list of the Endangered Species Act (Hamel et al. 2004); however, cerulean warblers were not listed as federally threatened. Consequently, projects, such as the Cerulean Warbler Atlas Project (CEWAP) have been designed for studying cerulean warbler populations extensively over the last six years to determine whether declines are continuing and how to manage for the species (Rohrbaugh et al. 2001). Another suit has been filed against the USFWS, who now has until November 30,

2006 to decide whether the cerulean warbler merits protection as threatened under the ESA (SELC 2006).

Habitat fragmentation and destruction have played major roles in population declines of cerulean warblers (Oliarnyk 1996; Hamel et al. 2004; Robbins et al. 1989; Robbins et al. 1992). Habitat fragmentation changes large tracts of forested land into small, isolated patches that are not selected by Cerulean Warblers (Oliarnyk 1996; Hamel et al. 2004; Robbins et al. 1989; Robbins et al. 1992). Although cerulean warblers require a minimum tract size throughout their range, the minimum sizes of occupied tracts in western portions of the breeding range are larger than in eastern parts (Hamel 2000). Seventy-four percent of cerulean warblers located in the Southeastern United States were found in tracts greater than 405 ha (1000 acres), with only four percent in areas less than 81 ha (200 acres), whereas over 50% of occupied sites in the Northeastern United States are less than 41 ha (100 acres) probably because there were few large tracts available (Rosenberg et al. 2000). Forested tracts in Arkansas that support cerulean warblers are similar in size to forest tracts in other states in the Southeast and most are greater than 405 ha. However, individual stands that support cerulean warblers are usually smaller than 81 ha. I consider any process that converts suitable habitat into unsuitable habitat for cerulean warblers to be habitat destruction. Thus, to fully evaluate habitat destruction, a complete understanding of the habitat features required by cerulean warblers is necessary. Cerulean warbler habitat is often described as mature deciduous forest with a closed canopy in mesic or floodplain sites (Rosenberg et al. 2000). Cerulean warblers may seek the most mature forest conditions available in each region (Hamel 2000). However, habitat use by cerulean warblers varies across their geographic range, especially with

regards to canopy tree-species composition and understory vegetation composition. However, tree size may be more important than tree species (Rosenberg et al. 2000). Thus, in order to conserve cerulean warbler populations, an understanding of regional habitat requirements and ecological processes that render stands unsuitable are critical.

Rosenberg et al. (2000) suggested that mesic upland forest is an important habitat for cerulean warblers over much of the Southeast and throughout the Appalachians, where large tracts of habitat exist and consist of diverse tree communities that include oaks (*Quercus* spp.) and maples (*Acer* spp.). Seventy-six percent of sites surveyed in Arkansas during the CEWAP were classified as upland habitat and 25% were classified as bottomlands. Oaks (mostly Northern red oaks-*Quercus rubra*) and hickories (*Carya* spp.) were dominant tree species in upland sites whereas sweetgum (*Liquidambar styraciflua*), sycamore (*Platanus occidentalis*), and maples were dominant in bottomland sites. Oaks and hickories were also dominant trees in upland sites in Connecticut, Kentucky, Massachusetts, Michigan, Tennessee, Virginia, Wisconsin, and West Virginia (Rosenberg et al. 2000). Kellner (2002) noted that cerulean warbler habitat in upland hardwood forests of Arkansas included a fairly dense understory with extensive ground cover (> 51 % cover) including pawpaw (*Asimina triloba*). Similarly, in the Roanoake River Basin in North Carolina, spicebush (*Lindera benzoin*), buckeye (*Aesculus sylvatica*), and pawpaw dominated the shrub layer and ground cover was dense (Lynch 1981). Forest stands used by cerulean warblers in the Ozark National Forest are mostly located on north- or east-facing slopes (Kellner 2002).

Disease can alter nesting habitat of cerulean warblers (Robbins et al. 1989; Robbins et al. 1992). Oaks have declined in many states due to oak wilt and gypsy moths

(*Lymantria dispar*; Hamel 2000) and red oak borer (*Enaphalodes rufulus*) in Arkansas. Censuses conducted by Kellner (2002) occurred during a period of rapid oak decline and severe drought that may have contributed to the cerulean warbler population decline in the Ozark National Forest, Arkansas.

Forest management may also negatively impact cerulean warbler habitat. For example, Kellner (2002) found that between 1998 and 2001 populations of cerulean warblers in forest stands of the Ozark National Forest that received group-selection harvests declined by 61%, whereas unmanipulated stands that experienced oak decline and drought only declined by 29%. Harvesting rotations were also too short to allow deciduous trees to grow to maturity. In addition, even-aged management reduces habitat heterogeneity, which is of great importance to cerulean warblers (Hamel 2000; Robbins et al. 1989). Fire suppression is important in managing bottomland hardwood forests for cerulean warblers in the southeastern United States (Evans and Fischer 1997), and may also be important in managing upland hardwood forests in Arkansas (Kellner 2002). Over time, fire can change tree species composition (Evans and Fischer 1997) and may eliminate important tree species preferred by cerulean warblers.

The Ozark National Forest of Arkansas contains one of the largest cerulean warbler populations ($\geq$ 50 pairs; Rosenberg et al. 2000); therefore, population monitoring should continue in these areas. Although populations of cerulean warblers have been intensively studied in the Ozark National Forest between 1998 and 2001, populations have not been intensively monitored in the Ouachita National Forest. The Ouachita National Forest was surveyed during the 1990s (James et al. 2001). However, very few sites were searched, and as a result, few birds were located.

Territory sizes of cerulean warblers have not been studied in the Ozarks as a means of habitat evaluation. Delineating territories would aid in identifying important habitat features within stands used by cerulean warblers. Territory sizes along with population sizes will help determine the amount of hardwood forest needed to manage and potentially maintain stable populations of cerulean warblers.

In chapter one, I determined the population abundance of cerulean warblers in the Ozark and Ouachita National Forests. I compared abundance between years and to estimates from other regions. In addition, I compared avian species diversity between stands that supported cerulean warblers to areas outside those stands that did not support cerulean warblers. I also monitored foraging behavior and tree species used by male cerulean warblers.

In chapter two, I focused on habitat selection and territory size of cerulean warblers. I studied stands that supported cerulean warblers at two levels: habitat within territories of cerulean warblers and habitat outside territories. I compared tree height, diameter-at-breast-height, percent ground cover, distance to nearest snag or other opening, basal area, stem density, presence of pawpaw, proportions of red oak, white oak and hickories, and percent canopy cover between habitat within and outside territories. I determined territory sizes with playback techniques (Falls 1981) and calculated sizes with tools from ArcGIS 9.1.

Objectives:

My research objectives were as follows:

1. Determine population abundance of cerulean warblers in the Ozark and Ouachita National Forests of Arkansas.
2. Evaluate effects of fire on habitat use of cerulean warblers.
3. Determine habitat characteristics of cerulean warblers for the Ozark and Ouachita National Forests of Arkansas.
4. Determine territory sizes of cerulean warblers.

LITERATURE REVIEW

Physical Description

Cerulean warblers are small wood warblers measuring 11.5 cm and averaging 8-10 g (COSEWIC 2003; Hamel 2000; Evans and Fischer 1997; Oliarnyk 1996). Adult males have a distinguishable cerulean blue back and a white underside that is offset by a black necklace. Males in all plumages have streaked backs. Streaking of first year males may be limited to sides of back. Underside of first year males is streaked and adult necklace is either restricted to sides of breast or absent. Females and juveniles have greenish backs with light yellow undersides (Hamel 2000), and a white line above the eye (Bent 1963; Hamel 2000). White tail-spots and two white wing-bars are found on both sexes (Hamel 2000).

Distribution

Breeding Range. Cerulean warblers are found throughout most of the eastern U.S. and parts of Canada, ranging from southern Arkansas, eastern Oklahoma north to central Minnesota and Wisconsin west to New York, Vermont, and southern Ontario south to New Jersey, Maryland, central Virginia, and North Carolina west to Tennessee and northern Alabama (Hamel 2000; Robbins et al. 1992). They are more widespread in some areas, such as, southern Missouri and eastern Kentucky, and extremely local in parts of Illinois and western Tennessee (Hamel 2000). Hamel (2000) suggested that populations in central New York and southern Ontario are increasing. Some individuals have dispersed to Ontario from Arkansas (Jones et al. 2004).

Winter Range. Cerulean warblers occupy areas in the mountains of South America, including the Andes in Columbia, and on eastern slopes of the Andes in Peru,

Ecuador, Venezuela and northern Bolivia, with occasional records on forested foothills in Brazil (Hamel 2000). Cerulean warblers have a narrow elevation range of 500-1,500 m above sea level (SELC 2000).

Migration

Migration takes about 2 months in spring and greater than 4 months in fall; in both cases they fly across the Gulf of Mexico (Hamel 2000; Crawford 1980). Cerulean warblers are medium- to long-distance complete migrants that fly at night (Hamel 2000; Crawford 1980). In spring, the species migrates from late March to mid-May, arriving in Arkansas by late March, Tennessee by mid-April, and Kentucky in May. In fall, migration begins by mid-August to early September in Missouri and late July in Michigan. Individuals may arrive on wintering grounds in South America as early as August (Hamel 2000).

Current Status and Trends

According to data from the Breeding Bird Survey, populations of cerulean warblers declined an average of 3.4% per year, from 1966-1987 (Robbins et al. 1989). Cerulean warblers are currently listed as Species of Special Concern in Canada (COWEWIC 2003) and a Species of Concern in the U.S. (Evans and Fischer 1997). A petition was filed with the U.S. Fish and Wildlife Service in October 2000 to add the cerulean warbler to the threatened list of the Endangered Species Act (Hamel et al. 2004); however, they are currently not listed as federally threatened. Biologists and groups, such as the Cerulean Warbler Atlas Project have been studying cerulean warbler populations over the last four years to determine whether the declines are continuing and how to manage for the species (Rosenberg et al. 2000). Another suit has been filed against the

USFWS, who now has until November 30, 2006 to decide whether the cerulean warbler merits protection as threatened under the ESA (SELC 2006).

Although declines in populations are well documented, ranges in the northeastern United States and southern Ontario are thought to be expanding. Thirty-seven areas, including the Arkansas Ozarks and Ontario, support the largest populations of cerulean warblers (≥50 pairs; Rosenberg et al. 2000). Populations are estimated at 85,000 to 287,000 breeding pairs in North America (COSEWIC 2003).

Foraging

Cerulean warblers eat arthropods primarily by gleaning from leaves and twigs of a variety of tree species (Evans and Fischer 1997; Hamel 2000; Parker 1994). Jones et al. (2000) found that cerulean warblers predominantly gleaned from midstory and canopy foliage on Venezuelan shade-coffee plantations, feeding on flies, lepidopteran larvae, and spiders. Foraging heights ranged from 2 to >45 m (Hamel 2000). In Belize, cerulean warblers have been observed foraging at heights of 9-25 m above the ground (Parker 1994). Species hop along larger branches near the trunk and move out toward the smaller branches (Evans and Fischer 1997; Hamel 2000; Parker 1994). Other foraging behaviors include sallies, lunging and hovering (Jones et al. 2000; Hamel 2000). Poison ivy (*Toxicodendron radicans*) vines appear to be an important foraging species for females among sites in the Mississippi Alluvial Valley (Hamel 2000).

Habitat Requirements

Breeding Range. Cerulean warblers are most often found in large forest tracts that are mature and contain a closed canopy and an open understory (Evans and Fischer 1997; Oliarnyk 1996; Hamel 2000; Robbins et al. 1992). Occupied forests are composed of

broad-leaved deciduous trees that are large (COSEWIC 2003; Hamel 2000; Oliarnyk 1996; Lynch 1981) and well-spaced (Jones and Robertson 2001). Kellner (2002) noted that cerulean warbler habitat in upland hardwood forests of the Ozark National Forest in Arkansas consisted of a mature overstory with a fairly dense understory that usually included pawpaw (*Asimina triloba)* and extensive ground cover (> 51% cover). Lynch (1981) indicated that high densities of cerulean warblers occurred in old-growth, mature floodplain forests on well-drained natural levees located within 330 yards of the Roanoke River. Shrub layer was dominated by spicebush (*Lindera benzoin*), buckeye (*Aesculus sylvatica*), and pawpaw and ground cover was dense (Lynch 1981; Evan and Fischer 1997).

Historically, cerulean warblers were found in old-growth bottomland forests of the Mississippi Alluvial Valley, which are now rare (Hamel 2000). Upland forests are also scarce today due to conversion to agricultural fields (Hamel 2000). Forest-tracts occupied by cerulean warblers vary among different regions of the Eastern U.S. (Rosenberg et al. 2000). Forty-one percent of cerulean warblers in the Midwest were found in tracts greater than 405 ha (1000 acres), while fewer than 10% were in tracts less than 41 ha (100 acres; Rosenberg et al. 2000). In the Southeast 74% were found in tracts greater than 405 ha, with only 4% in tracts less than 81 ha (200 acres; Rosenberg et al. 2000). Forest-tract size in the Northeast was drastically different from the other two regions in that only 19 percent of cerulean warblers were located in areas greater than 405 ha and 57% in areas less than 41 ha (Rosenberg et al. 2000). Lack of large tracts of suitable habitat in the northeast may lead to high-density populations (Donovan et al. 2002) in smaller tracts.

Tree diameter at breast height (DBH), associated with habitat use by cerulean warblers, has been documented as an important factor in habitat selection. Territories are located in forest stands where most trees have large diameters (Evans and Fischer 1997; Robbins et al. 1992; Oliarnyk 1996; Jones and Robertson 2001). Most trees in habitat used by cerulean warblers in Missouri had a DBH greater than 30 cm (Evans and Fischer 1997, Robbins et al. 1992). Oliarnyk (1996) suggested that a dense canopy cover and tall trees are important in selection and success of nest sites. Tall trees are also selected for singing perches in Virginia (Evans and Fischer 1997) and North Carolina (Robbins et al. 1992, Lynch 1981).

Tree-species Preference. Distribution and abundance of birds may be influenced by tree species used for foraging, because tree species may influence prey abundance and availability (Robinson and Holmes 1984). Bird species also have morphological and behavioral adaptations for acquiring food (Gabbe et al. 2002; Holmes and Robinson 1981). Birds that glean prey from leaves have stronger tree species preferences than birds that hover for prey (Holmes and Robinson 1981). Foliage structure may also play a role in tree species selection (Robinson and Holmes 1984; Holmes and Robinson 1981, MacArthur and MacArthur 1961). Different tree species have various branching patterns and leaf positions in relation to branches and twigs that may influence how birds move among the vegetation and capture prey (Holmes and Robinson 1984; Holmes and Robinson 1981). Rare birds that have patchy distributions are more selective foragers than common birds (Gabbe et al. 2002; Holmes and Robinson 1981). Gabbe et al. (2002) indicated that cerulean warblers are selective in their choice of foraging substrate, showing a strong preference for one tree species, kingnut hickory (*Carya laciniosa*),

while avoiding red maples (*Acer rubrum*) in floodplain forests. Cerulean Warblers also showed a preference for bitternut hickory (*Carya cordiformis*) (Barg et al. 2006, Gabbe et al. 2002), green ash (*Fraxinus americana*), silver maple (*Acer saccharinum*), overcup oak (*Quercus lyrata*), and sweetgum (Gabbe et al. 2002). They also appeared to show preference for red oaks, white oaks (*Quercus alba*), and hickories in the Ozark National Forest of Arkansas (C. Kellner, pers. comm.). Rosenberg et al. (1998) noted that tall oak trees are an important component in cerulean warbler habitat. Cerulean warblers in upland sites in West Virginia were observed foraging and singing in oaks, maples, and hickories. Bitternut hickories were preferred song posts in Ontario due to their delayed leaf-out rates which could aid in relaying songs between male cerulean warblers (Barg et al. 2006). At the territory level, canopy trees in Ontario were used in proportion to their availability (Barg et al. 2006).

Winter Range. Cerulean warblers occupy second-growth forests in Ecuador and Venezuela, and shade-coffee plantations (Jones and Robertson 1997, Hamel 2000), while occupying mature, humid evergreen forests in the Andes Mountains of South America at mid-level elevations of 500-1,500 m from Bolivia, Venezuela, and Columbia to Peru (Hamel 2000; Robbins et al. 1992; Jones et al. 2000) and occur in mixed-species flocks (Evans and Fischer 1997; Hamel 2000; Parker 1994).

History of Ozark and Ouachita Mountains

At the time of settlement, the Arkansas Ozarks were dominated by red (subgenus *Erythrobalanus*) and white (*Leucobalanus*) oaks (Smith et al. 2004) and the Ouachitas were dominated by pine (Fitzgerald and Pashley 2000). Between 1880 and 1900, the Ozarks were clear-cut to make railroad ties and the short-leaf pine was harvested in the

Ouachitas (Fitzgerald and Pashley 2000). Today the Ozark forest is a relatively even-aged mixture of hickories, oaks, and other deciduous species, with some pine located in southern portions (Smith et al. 2004). Canopy is closed, ground cover is mainly poison ivy, and little shrub development is present (Smith et al. 2004). Ninety percent of the Arkansas Ozarks are forested and 75% of that is dominated by oaks (Smith et al. 2004, McWilliams et al. 2002). Upland forest occurred between 427 and 518 m (1400 and 1700 ft) in elevation (Foti 2004). Ouachita Mountains have 70% forest cover (Foti 2004) and are dominated by pines mixed with hardwoods (Smith et al. 2004). In 1994, over 2 million acres were pine plantations (Foti 2004).

Behavior

Hamel (2000) indicated that average perching and foraging heights were 15 m above ground in trees that averaged 22 m within bottomland hardwood forests of Tennessee and Arkansas. Cerulean warblers were observed hopping along small branches in the canopy, and females often hopped along poison ivy vines that were wrapped around trees. Flight between trees is often short. Males and females often fight with other cerulean warblers of the same sex. Females were also observed attacking males, including their mates (Hamel 2000).

Territoriality. Males establish and maintain territories by singing and fighting. Oliarnyk and Robertson (1996) stated that cerulean warblers hold small, well-defined territories. In Ontario, mean territory size in breeding sites is 1.04 ± 0.16 ha (SE), with territories ranging in size from 0.38 to 2.4 ha (Hamel 2000; Oliarnyk 1996). Barg et al. (2006) observed clustering of territories at the Queen's University Biological Station (QUBS) in Ontario. Males typically use the tallest trees for singing, which are often used

as nesting sites as well. Singing males can be heard throughout the day, with peaks in the early morning and late afternoon (Lynch 1981). Jones and Robertson (2001) indicate that male cerulean warblers utilize territories consisting of large, well-spaced trees with dense, high canopies in Ontario. Core areas within territories are preferred singing areas for male cerulean warblers at QUBS in Ontario (Barg et al. 2006). Interactions have been observed in Arkansas between cerulean warblers and hooded warblers (*Wilsonia citrina*) and red-eyed vireos (*Vireo carolinensis*), in which the cerulean warblers are displaced (Hamel 2000).

Density. Jones et al. (2000) found that detectability of cerulean warblers at point counts is affected by density. As avian density increases, the ability of an observer to detect differences in numbers and species decreases (Bart and Schoultz 1984). Evans and Fischer (1997) indicated that the density of breeding cerulean warblers varies with habitat type and region. Between 1966 and 1987, concentrations of breeding cerulean warblers were greatest on the Cumberland Plateau of eastern Tennessee, eastern Kentucky, and southern West Virginia (Robbins et al. 1992, Evans and Fischer 1997). The highest breeding density recorded was 290 pairs/km^2 in a climax deciduous forest in Ohio (Robbins et al. 1992). Densities of 206 pairs/km^2 were reported in West Virginia in a mature oak-hickory forest (Evans and Fischer 1997, Robbins et al. 1992).

Avian Community

Red-eyed vireos, Kentucky warblers, and American redstarts (*Setophaga ruticilla*) commonly co-occur with cerulean warblers (Lynch 1981, Hamel 2000). Hooded warblers and white-breasted nuthatches (*Sitta carolinensis*) also occur with cerulean warblers

(Hamel 2000). Kellner (2002) indicated that ovenbirds (*Seiurus aurocapillus*) and scarlet tanagers (*Piranga olivacea*) are common in habitat occupied by cerulean warblers.

Breeding and Nesting

Males often reach breeding grounds before females. The first, and often only, brood hatches in late April to early July in the Mississippi Alluvial Valley of Arkansas and Tennessee, and late May to early July in Ontario (Hamel 2000). Only the female incubates the eggs, however, both parents feed the young (Hamel 2000, Evans and Fischer 1997). Nests are constructed of grass, tree bark, and other plant materials bound by spider silk, forming a shallow, cuplike structure (Evans and Fischer 1997, Harrison 1975). Nests are often placed on lateral limbs of deciduous trees and concealed by leaves (Hamel 2000, Evans and Fischer 1997). Due to difficulty in locating nests in the top of tall trees, nest heights may be underestimated (Evans and Fischer 1997, Robbins et al. 1992). Nests may be located 8 to 12 m high or $\geq$ 30 m high (Evans and Fischer 1997, Robbins et al. 1992).

Reasons for Declines on Breeding Grounds

Serious long-term problems exist for cerulean warblers on breeding grounds, especially along stream valleys. Many potential breeding areas are uninhabitable due to conversion to agriculture, stream channelization, or being located near urban areas (Hamel 2000; Robbins et al. 1989). According to Hamel (2000), when suitable habitat develops, cerulean warblers will use these areas, as seen in the north and east where ranges have recently been expanded. Mountaintop mining in West Virginia has increased the amount of large-scale edge present by clearing forests to mine for coal (Bosworth 2003; Wood et al. 2006).

The remaining mature deciduous forests have become increasingly isolated because of agricultural development (Hamel 2000; Robbins et al. 1989). Cerulean warblers are sensitive to forest tract sizes and do not occupy sites below some critical size. However, this critical size appears to vary and is larger in western portions of the breeding range than in eastern parts (Hamel 2000).

Some silvicultural practices inhibit development and maintenance of habitat for cerulean warblers. Harvesting rotations are too short to allow deciduous trees to grow to maturity. In addition, even-aged management reduces habitat heterogeneity, which is of great importance to cerulean warblers (Hamel 2000; Robbins et al. 1989). Group-selection may be compatible with maintenance of cerulean warbler habitat as long as thinning does not accompany establishment of the groups and also if only one set of groups is cut (Kellner 2002). Wood et al. (2005) suggested that small harvests within mature forests did not affect abundance of cerulean warblers in the remaining forest, but only within the small harvest areas.

Over time, fire can result in a change in tree species composition (Evans and Fischer 1997), which can ultimately eliminate important tree species preferred by cerulean warblers. Fire suppression is important in managing bottomland hardwood forests for cerulean warblers in the southeastern United States (Evans and Fischer 1997), and may also be important in managing upland hardwood forests in Arkansas (Kellner 2002).

Trees used by cerulean warblers have had problems with pollution or disease (Robbins et al. 1989). Oaks have experienced declines due to oak wilt, gypsy moths,

(Hamel 2000), red oak borers (Smith et al. 2004) and drought (Kellner 2002). American chestnuts are lost from chestnut blight and elms from Dutch elm disease (Hamel 2000).

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CHAPTER I
ABUNDANCE AND COMMUNITY STRUCTURE OF CERULEAN WARBLERS IN THE OZARK AND OUACHITA NATIONAL FORESTS OF ARKANSAS

ABSTRACT

Populations of cerulean warblers (*Dendroica cerulea*) have declined throughout their breeding range primarily due to habitat fragmentation and loss. I monitored populations in the Ozark and Ouachita National Forests to determine if populations were changing from 2004 to 2006. I censused 20 stands in the Ozark National Forest and 56 stands in the Ouachita National Forest from 2004 to 2006. I also conducted point count surveys to determine avian community structure within and outside of stands that supported cerulean warblers.

The population of cerulean warblers in the Ozark National Forest increased by 10% in 16 stands censused from 2004 to 2006, and average change per stand was 15.8 ± 77.2%. However, the increasing trend was not statistically significant (R^2=0.80, $F_{1,3}$=3.918, p=0.298). There was also no significant difference between average number of birds per stand between years ($F_{2,54}$=0.07, p=0.936).

Understanding management practices, such as controlled burning, that might alter habitat suitability will aid management of cerulean warbler populations. Eight stands were monitored consistently from 1998 to 2006. Three of those stands were unaltered and supported increasing numbers of cerulean warblers from 1998 to 2006 (R^2=0.64, $F_{1,7}$=8.943, p=0.03); whereas five stands were altered by prescribed burns or group selection and exhibited a significant decrease in population from 1998 to 2006 (R^2=0.61, $F_{1,7}$=7.875, p=0.038). Cerulean warblers stopped using areas that were burned in 2004 along Beindorf Road and Pain Ridge. However, males were located in two stands that

were burned in 2006. Only five stands supported cerulean warblers in the Ouachita National Forest from 2004 to 2006. In those stands, populations declined from 10 to 7 between 2005 and 2006.

Red-eyed vireos (*Vireo olivaceus*), ovenbirds (*Sieurus aurocapillus*), and hooded warblers (*Wilsonia citrina*) were the most common species detected in stands that supported cerulean warblers in the Ozark National Forest. Red-eyed vireos and black-throated green warblers were the most common species detected in the Ouachita National Forest.

INTRODUCTION

Cerulean warbler (*Dendroica cerulea*) populations have declined drastically since the early 1900s (Hamel 2000). Breeding populations throughout North America have declined by an average of 3.4% per year, from 1966-1987 (Robbins et al. 1989). Breeding Bird Survey data revealed the greatest rates of decline occurred on the Highland Rim in Kentucky and Tennessee and on the Ozark-Ouachita Plateau of Missouri and Arkansas (Robbins et al. 1989). In the Ouachita Mountains of Arkansas, populations were surveyed in the 1990s and 16 birds were located at 8 sites (James et al. 2001). In addition, populations of cerulean warblers in the Ozark National Forest of Arkansas declined by 40% between 1998 and 2001 (Kellner 2002). However, monitoring populations in the Ozarks is difficult because birds nesting there exhibit low site fidelity. Over half (15 of 28) of the groups of cerulean warblers that have been monitored in the Ozarks consisted of 1 to 3 individuals, and small groups were not relocated consistently among years (Kellner 2002). Declines led to a petition in 2000 to list the cerulean warbler as threatened under the Endangered Species Act (ESA; Rohrbaugh et al. 2001, Hamel et al. 2004). The U. S. Fish and Wildlife Service (USFWS) failed to meet deadlines. Another suit has been filed against the USFWS, who now has until November 30, 2006 to decide whether the cerulean warbler merits protection as threatened under the ESA (SELC 2006).

Forest management may negatively impact cerulean warbler habitat. For example, between 1998 and 2001 forest stands in the Ozark National Forest that received a group-selection harvest had a higher rate of population decline by cerulean warblers than did unaltered stands (Kellner 2002). Also, timber harvest rotations that are too short do not

allow deciduous trees to grow to maturity. In addition, even-aged management reduces habitat heterogeneity, which is of great importance to cerulean warblers (Hamel 2000; Robbins et al. 1989). Fire suppression is important in managing bottomland hardwood forests for cerulean warblers in the southeastern United States (Evans and Fischer 1997), and may also be important in managing upland hardwood forests in Arkansas (Kellner 2002). Over time, fire can change tree species composition (Evans and Fischer 1997) and may eliminate important tree species preferred by cerulean warblers.

My objectives were to monitor populations of male cerulean warblers in the Ozark and Ouachita National Forests of Arkansas from 2004 to 2006 and evaluate effects of fire on habitat use. I also determined avian species diversity of stands.

METHODS

Study Area

Study sites were located in the Ouachita and Ozark National Forests in Arkansas and included 25 forest stands that supported cerulean warblers. Such stands averaged 16-20 ha (40-50 acres) in the Ozark National Forest (Kellner pers. obs.) and were characterized by a mature overstory, dominated by Northern red oaks (*Quercus rubra*), white oaks (*Quercus alba*), and several species of hickories (*Carya* spp.), and pawpaw (*Asimina triloba*) usually present in the understory (Kellner 2002). Stands were located between 427 and 700 m (1400 and 2300 ft) in elevation and on north-, northeast-, and east-facing slopes. Stands in the Ouachitas were located on northern slopes of dry ridgetops and were characterized by a mature overstory dominated by hickories. Cerulean

warblers were located in 20 stands from 2004 to 2006 in the Ozark National Forest (Figure 1.1) and five stands in the Ouachita National Forest (Figure 1.2).

Avian Censusing

I conducted censuses for male cerulean warblers in the Ozark and Ouachita National Forests in Arkansas from 2004 to 2006. In the Ozark's, I censused 15 of the known locations of cerulean warbler populations as reported by James et al. (2001) and Kellner (2002) and censused 4 new locations that supported the birds. I did not search 11 stands that were monitored from 1998 to 2001, which only contained 1 to 2 birds per stand. In the Ouachitas, I censused two locations where birds had been previously reported (see James et al. 2001 for locations) and also 56 locations in 2004 and 2005 as potential habitat, based on elevation, aspect (north- and northeast-facing slopes), and correct habitat structure based on stand age of 90 years, site index of 70, and tree species composition (i.e. oak-hickory stands).

I walked quietly through each stand and listened for singing males. Upon locating a singing male, I flagged the position and used a Global Positioning System (GARMIN 12 XL; Magellan Meridian Gold) to georeference each location. Each stand was visited at least three times, from mid-May to late-June, to account for warblers that may have been quiet on a particular day and also to determine whether birds remained throughout the breeding season or migrated out of the area.

Point counts were conducted between 6 am and 12 pm at each forest stand supporting cerulean warblers and at least 250 m outside these stands to make sure no birds were counted twice. All species heard or seen during a ten minute period were

recorded (Dawson et al. 1995). Birds were censused from early May to late June in the spring of 2004, 2005, and 2006.

Population Abundance

In NCSS, linear regression was used to evaluate population trends of male cerulean warblers between 1998 to 2006 and 2004 to 2006. I calculated percent changes between years for each stand. I also calculated a mean percent change for each year. I used an Analysis of Variance (ANOVA) to determine population differences between 2004 and 2006. Two sample t-tests were used to determine population differences between 2001 and 2004. Level of significance for all tests was set at 0.05.

Avian Community

Abundance of bird species among sites that supported cerulean warblers was compared between the Ozark and Ouachita National Forests. Abundance of bird species outside the areas that supported cerulean warblers was compared to those that supported cerulean warblers in the Ozark National Forest.

Avian diversity among stands that supported cerulean warblers and stands that did not in the Ozark National Forest were compared using the Shannon-Wiener function [$H=-E(p_i)(\log_2 p_i)$], where p_i is the proportion of the i^{th} species in the total sample; Krebs 1985), which measures the degree of uncertainty. According to Krebs (1985), the degree of uncertainty is greater as H becomes larger because it is difficult to predict the identity of an individual randomly picked from a community, thus the species diversity is greater. Equitability ($E = H/H_{max}$) is calculated as a measure of evenness of species among samples. With an increasing number of species and evenness, comes an increase in species diversity (Krebs 1985). Species diversity in stands that supported cerulean

warblers, measured using the Shannon-Wiener function, was compared between the Ozark National Forest and the Ouachita National Forest.

RESULTS

Population Abundance

Ozark National Forest. I censused male cerulean warblers in twenty stands from 2004 to 2006. Populations varied from 1 to 15. Five stands contained 1 to 3 birds in 2004, while nine stands in 2006 contained three or fewer birds (Table 1.1). I located and searched three new sites in 2005 and two new sites in 2006 that contained 1 to 4 male cerulean warblers.

Total change in population between 2004 and 2005 was 1.1%; whereas, average change per stand was -2.4 ± 39.5%. Four stands had no change, 5 stands had a positive change and 6 stands had a negative change (Table 1.1). Total change in population between 2005 and 2006 was 8.3%; whereas, average change per stand was 18.8 ± 59.8%. Four stands had no change in population, 7 stands had a positive change, and 6 stands had a negative change (Table 1.1). Four stands doubled in size from 2005 to 2006 but contained small numbers of birds and represented a small portion of the total population.

Population of cerulean warblers increased by 10% in 16 stands censused from 2004 to 2006, and average change per stand was 15.8 ± 59.8%. However, the increasing trend was not statistically significant (R^2=0.80, $F_{1,3}$=3.918, p=0.298) (Figure 1.3). Eight stands had a positive change and 8 stands had negative change. Numbers of cerulean warblers in 11 of the 16 stands changed by 1-2 birds, and the biggest change was an

increase of seven birds (Table 1.1). There was no significant difference between average number of birds per stand between years ($F_{2,54}$=0.07, p=0.936).

Populations in eight stands that were censused from 1998 to 2006 decreased from 1998 to 2001 and had begun to recover after 2001(Figure 1.4). Sixty-three singing males were counted in 1998 in those eight stands while I only detected fifty-five birds in those stands in 2006. Only three of those eight stands had a higher population in 2006 than in 1998. Although populations declined by 40% from 1998 to 2001, populations of cerulean warblers increased by 26% for 12 stands monitored during 2001 and 2004; however the increase was not statistically significant (Mann Whitney U, Z=-0.817, p=0.414). Average change in population per stand, however, was 46%. Three stands more than doubled but contained small numbers of birds and represented a small portion of the population.

Controlled burning and timber harvest appeared to degrade cerulean warbler habitats. Three stands that supported increasing numbers of cerulean warblers from 1998 to 2006 were unaltered (R^2=0.64, $F_{1,7}$=8.943, p=0.03; Figure 1.5); whereas the five stands that exhibited a decrease were altered by prescribed burns or group selection (R^2=0.61, $F_{1,7}$=7.875, p=0.038; Figure 1.5). Distribution of cerulean warblers in two areas burned early in 2004 was similar in 2005 and 2006 (Table 1.1). Birds along Beindorf Road and Payne Ridge no longer occupied areas that were burned in 2004. One side of Beindorf Road was burned in 2004 after which birds were only located on the unburned side of the road. East Payne Ridge was logged in early 2005 and I noted a decline of two birds between 2004 and 2006. Two stands were burned in early 2006 a few weeks prior to summer surveys and cerulean warblers continued to use both locations. In fact, East

Solly's Knob supported eight birds after the burn, which was an increase of four birds from 2005.

Ouachita National Forest. I searched 56 stands in 2004 and 2005, and 5 stands in 2006. However, only five stands supported cerulean warblers from 2004 to 2006. Populations varied from 1 to 5 birds (Table 1.2). Population in the five stands decreased from ten birds in 2005 to seven birds in 2006.

Avian Community

Ozark National Forest. I conducted 32 point counts within stands used by cerulean warblers. Forty species (excluding cerulean warblers) were censused among the points (Table 1.3); however, no species was detected at every point. Red-eyed vireos (*Vireo olivaceus*) were detected at 30 of 32 points and hooded warblers (*Wilsonia citrina*) were detected at 25 of 32 points. Red-eyed vireos, ovenbirds (*Sieurus aurocapillus*), and hooded warblers accounted for 32% of birds detected (Table 1.3) (Compare Tables 1.3 and 1.4 for a list of avian species in territory and random points).

Avian species diversity did not vary among stands. Stands that supported cerulean warblers had a diversity index of 3.147 and equitability value of 0.842, while stands that did not support cerulean warblers had a diversity index of 3.037 and equitability value of 0.812 ($p=0.152$).

Ouachita National Forest. I conducted eight point counts within stands used by cerulean warblers. Twenty-five species (excluding cerulean warblers) were censused among the points (Table 1.5); red-eyed vireos were detected at every point. Red-eyed vireos, black-throated green warblers (*Dendroica virens*), and Carolina wrens (*Thryothorus ludovicianus*) accounted for 40% of birds detected (Table 1.5). Avian

diversity did not vary among stands. Stands that supported cerulean warblers had a diversity index of 2.860 and equitability value of 0.868 and stands that did not support cerulean warblers had a diversity index of 2.489 and equitability value of 0.747 ($p=0.323$). Stands that supported cerulean warblers in the Ozarks had a similar diversity index and equitability value to stands that supported cerulean warblers in the Ouachitas ($H=2.860$, $E=0.756$, $p=0.258$).

DISCUSSION

Population Abundance

Ozark National Forest. Stands that were monitored from 2004 to 2006 showed an increasing population trend. However, the increase was not statistically significant probably due to low power of the statistical test associated with a small sample of stands. Populations may have increased as forest stands recovered from drought and oak decline in the late 1990s. Similarly, populations in other regions, such as Ontario, have remained stable and possibly increased. Queen's University Biological Station (QUBS) in Ontario has one of the few populations that have remained stable at approximately 250 pairs (COSEWIC 2003, Jones et al. 2000). Oliarnyk (1996) noted that density of cerulean warblers might be as high as 96 prs/km^2 in eastern portions of Ontario. Densities of 206 pairs/km^2 were reported in West Virginia in a mature oak-hickory forest (Evans and Fischer 1997, Robbins et al. 1992).

I continued to locate new stands that supported cerulean warblers in 2005 and 2006. Thus, more stands need to be searched, especially in the western portion of the Ozarks where I did little searching due to time constraints.

Stands that were managed by prescribed burning or group-selection cuts showed a significant decrease in population from 1998 to 2006. Prescribed burning resulted in a shift in habitat use by male cerulean warblers. Cerulean warblers returned to two stands burned in 2006, but did not return to other burned stands and may have moved to more suitable habitat nearby. Although the population at East Solly's Knob increased after a burn I don't know whether successful breeding occurred. I also did not observe females in any of the male's territories, nor did I locate a nest at East Solly's Knob. Males at East Solly's Knob sang frequently throughout the season, leading me to believe that they did not find mates. Lein (1981) noted that singing rates of male ovenbirds dropped by over 50% when females arrived and became more sporadic once males were mates. It is also unknown whether successful breeding occurred at Deer, which was also burned in 2006. In other stands, I observed females foraging or gathering nesting material in the understory, thus females may not be attracted to sites with no understory. In Ontario, cerulean warblers exhibited high site fidelity and seemed unable to recognize habitat degradation (COSEWIC 2003). Thus, birds remained in unsuitable habitat (COSEWIC 2003). Cerulean warblers appear to be semicolonial (Oliarnyk 1996, Barg et al. 2006) and may be attracted to less suitable habitat because other males are already present, consequently increasing the probability of attracting a mate (Oliarnyk 1996). Therefore, stands at East Solly's Knob and Deer should be monitored next year to see if the birds return and if females are present.

Group selection also degraded cerulean warbler habitat leading to population declines. Payne Ridge and two sites at Pelsor underwent group-selection cuts in the 1990s. During the first few years after the timber harvest cerulean warblers continued to

use stands that had been cut. However, between 1998 and 2006, populations at 2 group-selected stands near Pelsor declined from 26 birds to 2 birds, which is the largest decline documented (Kellner 2002). Rodewald and Smith (1998) also noticed that cerulean warblers were often absent in plots treated with understory removal or with selective logging and understory removal in the Ozark National Forest. Payne Ridge supported 5 birds in 1998 including 3 birds that used the areas among the group cuts. However, by 2000 none of the territories were located among the groups. Payne Ridge has since been burned and no longer supports cerulean warblers. Nevertheless, group selection alone may not have been the cause of degradation to cerulean warbler habitat because during the period in which the population declines took place drought and oak decline (a syndrome that involves two lined oak borers, armillaria root rot, and hypoxilon canker), which is fatal to oaks, may have interacted with group selection to render the habitat unsuitable for cerulean warblers (Kellner 2002). At Pelsor, oak decline killed a substantial number of oaks, which reduced canopy cover and increased the size of some of the group cuts. In West Virginia, two-age harvesting and clearcutting also resulted in a decreased abundance of cerulean warblers (Wood et al. 2005). Cerulean warblers in Ontario had a decline in reproductive success during 1998 where an ice storm destroyed much of the canopy foliage (COSEWIC 2003). However, reproductive success increased the following year when cerulean warblers shifted nest-site locations and increased territory sizes, suggesting that cerulean warblers can recover from certain disturbances (COSEWIC 2003).

Severe drought occurred during 1999 and 2000 and may have caused the decline in populations in 2001 (Kellner 2002). Drought may have decreased reproductive success

of cerulean warblers from 1999 to 2001 (Kellner 2002). Drought in Arizona reduced the availability of insects, thus reducing the density of birds in the community (Erhlich et al. 1988). Birds that were found in moist, higher elevations moved away (Ehrlich et al. 1988). Populations of cerulean warblers exhibited a decrease in 1999 and 2000, and then decreased significantly in 2001 (Kellner 2002). The decrease in population in 2001 may have been a lag response which songbirds are known to exhibit as a result of habitat disturbance (Jones et al. 2004, Brooks et al. 1999). Populations may have been increasing in 2002 and 2003, as forest stands were recovering from drought, and by 2004 populations had increased by 26% in stands censused in 2001 and 2004.

Nest parasitism may also play a role in declines of cerulean warblers. Stands that are cut or harvested remove large portions of trees creating more edge habitat. Brown-headed cowbirds thrive in edge habitat and lay their eggs in other species' nests (Ehrlich et al. 1988) and may be an important factor in the decline of cerulean warblers (Robbins et al. 1992, Hamel 2000). However, it may be difficult to estimate the amount of brood parasitism that occurs because cerulean warbler nests are high in the canopy (Hamel 2000, Ehrlich et al. 1988).

Ouachita National Forest. I censused 56 stands from 2004 to 2006; however, only five of those stands supported cerulean warblers. In 2006, due to the low number of birds found for total hours searched, I only censused the five stands that had previously supported cerulean warblers. All stands, except Rich Mountain, were located within one mile of each other. I speculate that this area has the best habitat available for cerulean warblers in the Ouachita National Forest.