Cerulean Warbler *Dendroica cerulea*

Species Account
And
Cumberland Habitat Conservation Plan (HCP)
Survey Results

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This document was created during the development phase of the Cumberland HCP. Specific species surveys were sent electronically and manually to experts on the 6 focal species suggested by the SAC to be included in the Cumberland HCP. Results of the surveys are discussed in both sections of this document.

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SECTION 1: SPECIES ACCOUNT

Taxonomic Status

The Cerulean Warbler (*Dendroica cerulea)* is a small songbird belonging to the Phylum Craniata, Class Aves, Order Passeriformes, and Family Parulidae (AOU checklist 2008). Alexander Wilson originally described Cerulean Warblers as two separate species. He named the male Sylvia cerulea (Wilson 1810), and the female Sylvia rara (Wilson 1811). For 90 years, *Dendroica cerulea* has been the only Latin name used for this species. This species is considered monomorphic, meaning it has no subspecies.

Amadon (1950) noted a female in Lyons, NJ, that built a nest and laid eggs that did not hatch. This was considered an example of a situation where a bird might hybridize with another species when outside its breeding range. Hybridization of this species with another was supported in 1954 when a hybrid individual Cerulean Warbler x Black-and-white Warbler (*D. cerulea* x *Mniotilta varia*) was collected during spring migration in Cameron Parish, Louisiana (Parkes 1978).

Conservation Status

The Cerulean Warbler (*Dendroica cerulea*) is a species of the highest conservation concern (Birdlife International 2004, Rich et al. 2004) because it is declining faster than any other North American warbler (Veit et al. 2005). According to Rosenberg and Wells (1995, 2000), "The Cerulean Warbler is among the highest priority landbirds for conservation in the United States. It ranks as extremely high priority on the national Watchlist based on Partners in Flight (PIF) prioritization scores. Rich et al. (2004) stated, "The Cerulean Warbler is among the most specialized and threatened birds of the deciduous forest and is in need of focused conservation attention throughout its range."

In October 2000, there was a petition received by the U.S. Fish and Wildlife Service (USFWS) to ask that the Cerulean Warbler be listed as threatened and for the designation of critical habitat. On September 24, 2002, the USFWS made its 90-day finding, which was published on October 23, 2002 in the Federal Register (USFWS 2002). A status assessment including biological data and a description of past, present and likely future threats to the Cerulean Warbler was published by Paul Hamel in 2000 to aid in the decision to be made by the U.S. Fish and Wildlife Service to designate this species as threatened under the Federal Endangered Species Act. Unfortunately the USFWS was unable to fund additional work on the petition until late in the fiscal year 2005, due to budget shortfalls (USFWS 2006a).

A decision was made by the U.S. Fish and Wildlife Service on November 8, 2006 not to list this species. The following are direct statements from the Federal Register supporting their decision not to list Cerulean Warblers as threatened (2006a), "The Cerulean Warbler population is decreasing by approximately three percent per year across its breeding range. A combination of habitat losses and structural changes and fragmentation in remaining forest habitats across the species' annual range are most likely the primary causal factors contributing to this decline. The available information on potential causal factors indicates these threats are, for the most part, both already operating and will continue to operate in the foreseeable future. Hence, we anticipate continued, gradual decline of this species. We also conclude, however, that abundance will remain high enough that the species effectively is in no danger of extinction in the near term, and that, if the historical trend continues, tens of thousands of Cerulean Warblers will remain in 100 years". The USFWS indicated other support behind their decision, which can be found in the Federal Register (2006a). The USFWS asked the public to submit to them any new information about the status or threats to this species (USFWS 2006a).

The Cerulean Warbler is globally ranked as G4, which indicates a species that is apparently secure, uncommon but not rare; some cause for long-term concern due to declines or other factors. It is a concern for some however; that the last time that this status was reviewed or changed was in 1996. This species is ranked in the state of Tennessee as S3 indicating that it is vulnerable, in the state due to a restricted range, relatively few populations (often 80 individuals or fewer), recent and widespread declines, or other factors making it vulnerable to extirpation. It is ranked in the state of Kentucky as S4S5, indicating that its category is undetermined. S4 indicates a species is apparently secure, uncommon but not rare; there is some cause for long-term concern due to declines or other factors. A species that is ranked as S5 is considered secure, common, widespread, and abundant in the nation or state/province. The Cerulean Warbler breeds in both Tennessee and Kentucky (NatureServe 2006).

Identification

Cerulean Warblers are small, neotropical migratory birds that have relatively long, pointed wings and short tails. There are statistically different characters between males and females, however considerable overlap exists. Both sexes average 10.2cm in length and weigh approximately 8-10 grams. They both exhibit plumages with two white wing bars and white tail spots. Males in breeding plumage are blue above, white below with a bluish black necklace across the breast. Females exhibit breeding plumage of bluish green above and whitish yellow below with a white or yellow line over their eyes. Male non-breeding plumage is similar to that of breeding, however the back may be slightly greenish and neck ring may be less visible. Female non-breeding plumage is simply duller than her breeding plumage. First fall males have plumage similar to non-breeding females, but have streaks on their backs. First fall females have plumage similar to non-breeding females, but their backs are more olive green and they exhibit a yellow color on their underparts and line over their eyes (Hamel 2000a). For juvenile and hatchling identification refer to Hamel's description in The Birds of North America (Hamel 2000a).

This species is not usually confused with other species, with the exception of the Blackburnian Warbler *Dendroica fusca*. Please see Hamel's (2000a) description of the similarities and differences between the two in The Birds of North America.

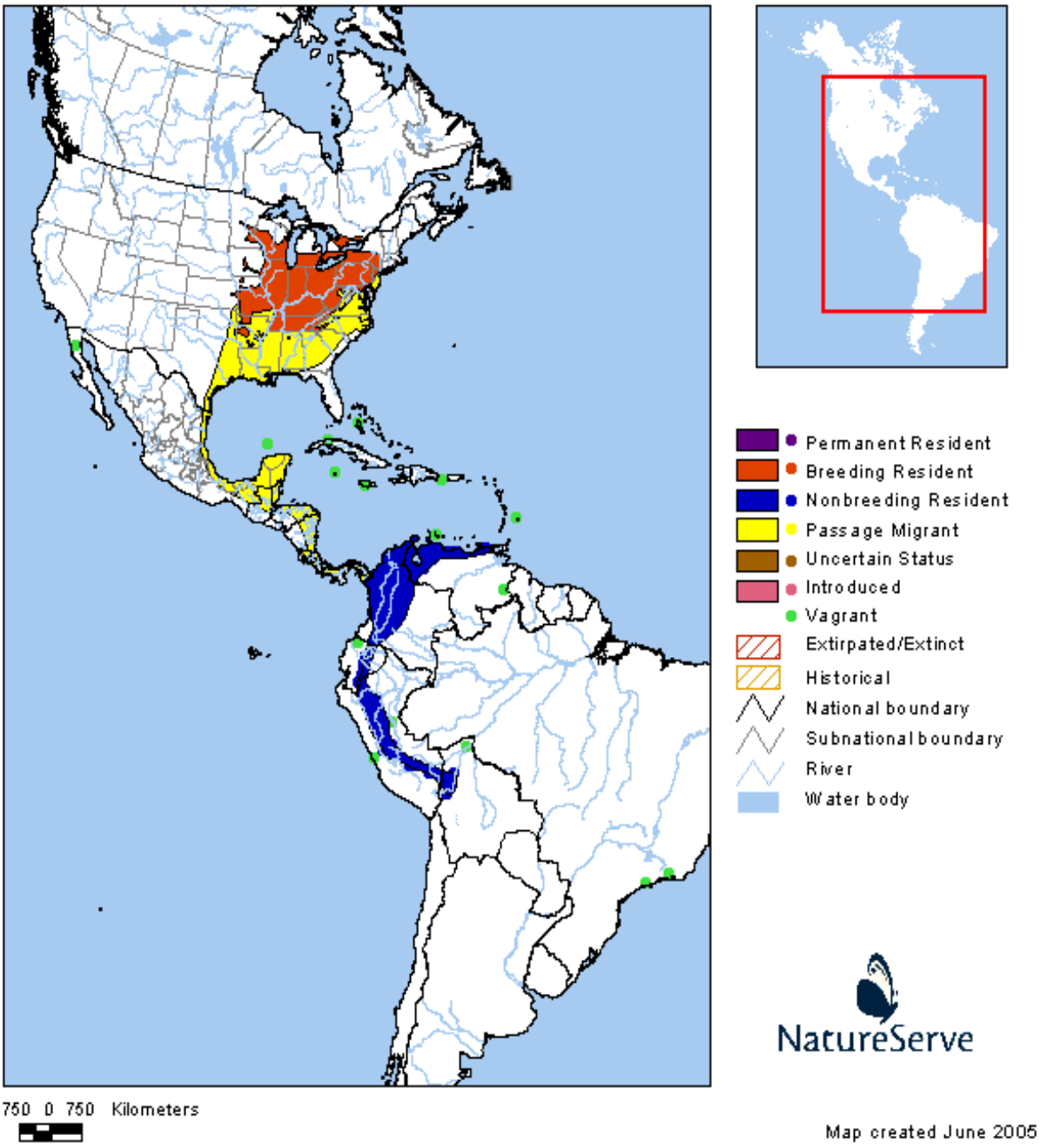
Singing of Cerulean Warblers has been studied by Woodward (1997), and has only been documented in males. They sing not only for mate attraction, but also during intrasexual communication. They tend to sing all day long; while foraging, preening, occasionally in flight, as well as sitting on an exposed perch. Songs can be described as ZHEE ZHEE ZIZIZIZI zzzeet, ZEE ZEE ZEE ZIZIZIZI zeet, or zz ZI ZI ZI zeeet; with capitalization indicating more heavily stressed syllables (Woodward 1997). Rogers (2006) reported four distinct nonsong vocalizations of adult ceruleans. (1) A metallic, buzzy *zzee* call note, singly or in series of 1-6 notes was heard from males and females. (2) Both sexes exhibited a series of sweet, nonmetallic *chip* notes when Rogers was near a nest with nestlings or fledglings. (3) An alarm *tchip* was heard recorded. (4) Territorial males with females gave a "whisper song".

Distribution

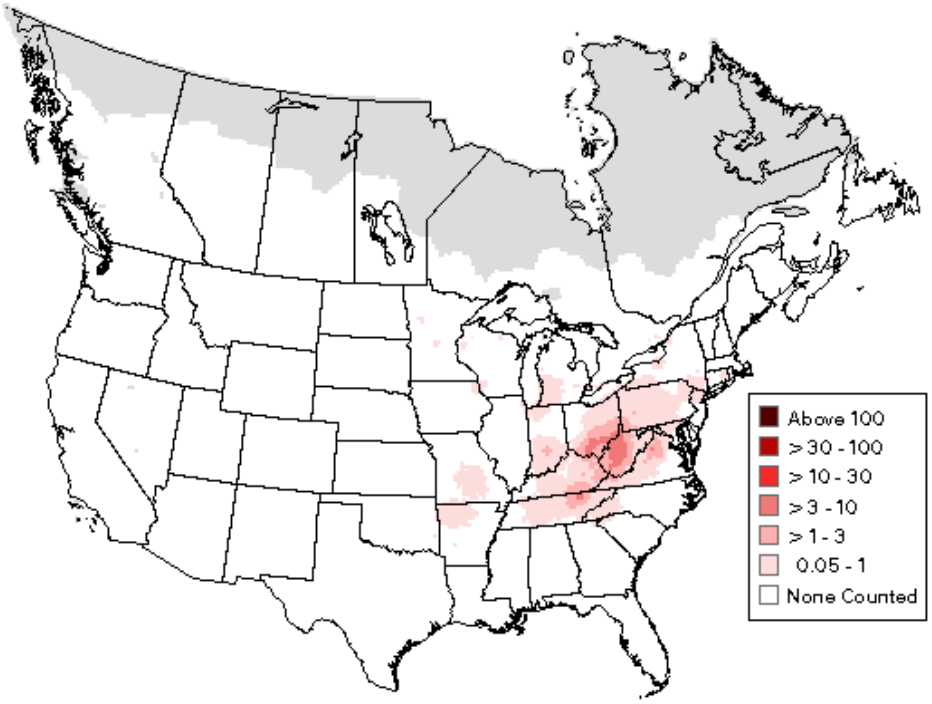
According to the Federal Register (USFWS 2006):

> It breeds in mature deciduous forests primarily within the central hardwood region of eastern North America, primarily in the Ohio and Mississippi River Valleys and adjacent areas east of the Appalachians, in New England and southern Canada, and in the Great Lakes region (Hamel 2000a). The breeding range generally extends from the eastern Great Plains, north to Minnesota, east to Massachusetts, and south to North Carolina and Louisiana (Hamel 2000a), encompassing 33 States and 2 Canadian Provinces. The core area of the breeding range is currently within the Cumberland Plateau and Ohio Hills physiographic regions in eastern Tennessee, eastern Kentucky, southern and western West Virginia, southeastern Ohio, and southwestern Pennsylvania (Villard and Mauer 1996, Sauer et al. 2005a). This species undertakes a long migration compared to many other warblers and passerines of similar size (Hamel 2000b), covering a distance of approximately 4,000 kilometers (km) (2,500 miles (mi)) between the central latitudes of North America and northern latitudes of South America. The migratory pathway between the breeding and wintering grounds is not well known, but for most individuals, it likely includes a flight across the Gulf of Mexico and stops at a limited number of locations in Central America and northern Colombia or Venezuela (Hamel 2000b). The fall migration to South America might be along a more easterly path than that of the northward migration in the spring (Dunn and Garrett 1997). Cerulean Warblers winter in broad-leaved evergreen forests within a relatively arrow band of middle elevations (500 to 1,800 meters (m); 1,650 to 5,900 feet (ft)) in the northern Andes Mountains in Venezuela, Colombia, Ecuador, Peru, and Bolivia and possibly in the Guayana Highlands of southeastern Venezuela, especially the tabletop mountains (tepuis) of this ecoregion (Robbins et al. 1992, Moreno et al. 2006).

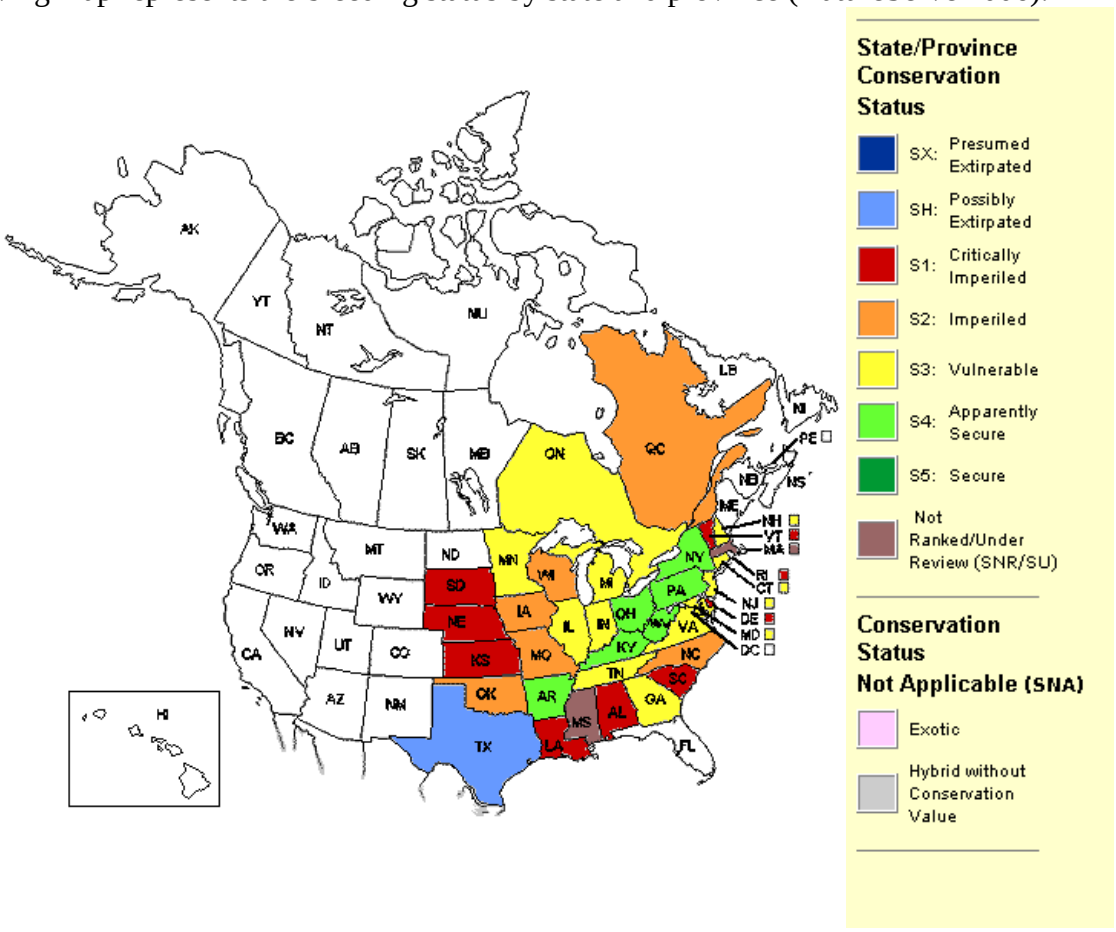
The following maps show the distribution and range of this species in states and provinces in the U.S. and Canada and state statuses (NatureServe 2006). For more information visit the website at: http://www.natureserve.org/explorer/

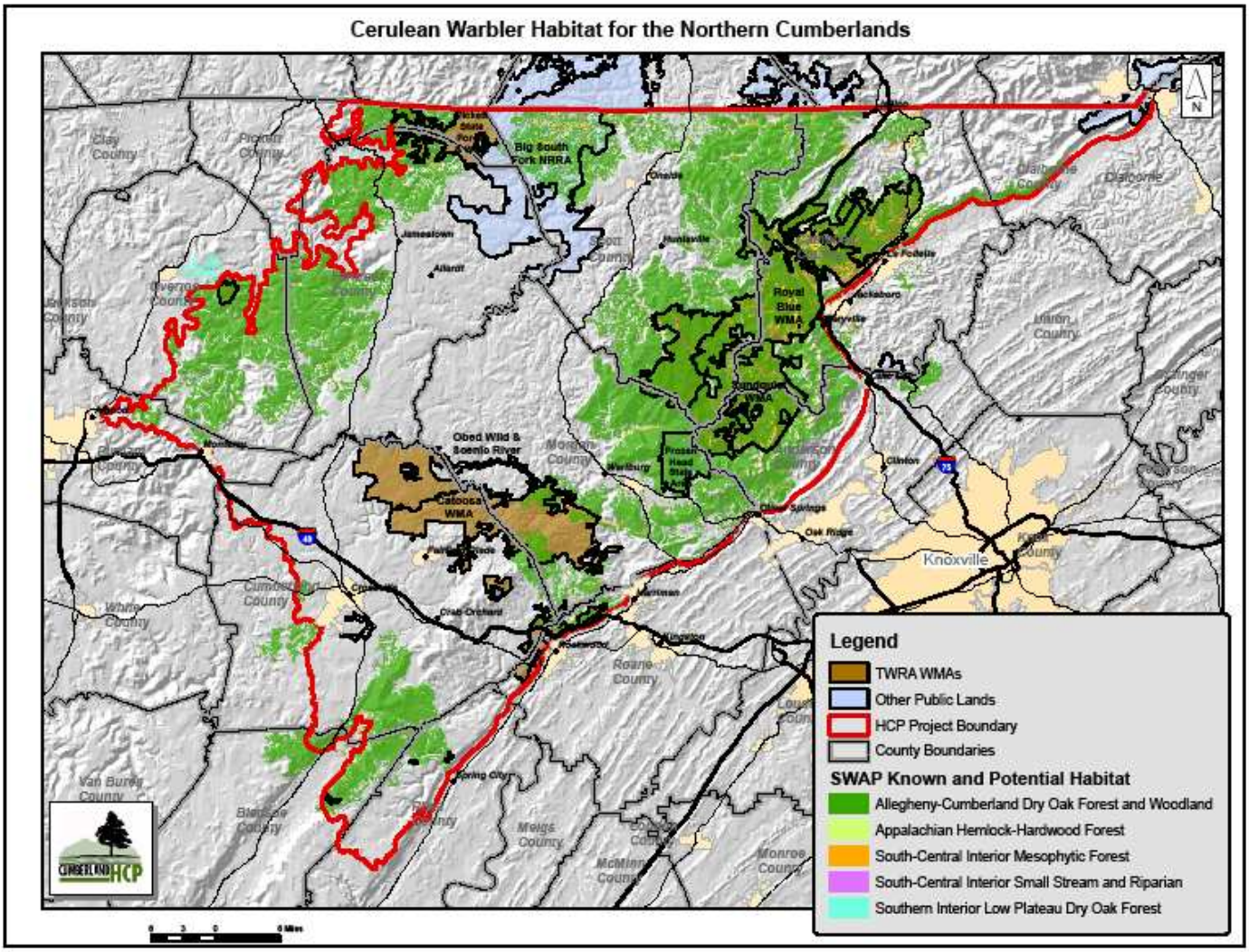


The following map is the summer distribution from Breeding Bird Survey (BBS) data (Sauer et al. 2005b).



The following map represents the breeding status by state and province (NatureServe 2006).





North American Breeding Bird Survey (BBS) data indicate a significant population decline in eastern North America, 1966-1994; decline was 49.5% between 1966 and 1993, and 17.2% between 1984 and 1993 (Price et al. 1995). The decline has been most pronounced in the core of the breeding range (Robbins et al. 1992). The cerulean's population size has declined across its range in eastern U.S., but it has expanded its range, particularly in the Northeastern U.S. and Ontario, perhaps in response to forest maturation (Hamel 1992) and has shown declines in areas converted from forested to residential areas (Friesen et al. 1995). See Hands et al. (1989) for information on status in the north-central U.S. See the COSEWIC report (2003) for information on its status in Canada (fairly stable). http://dsp-psd.pwgsc.gc.ca/Collection/CW69-14-326-2003E.pdf

Abundance

Rich et al. (2004) estimate the population of Cerulean Warblers in North America to be 560,000 individuals. Global abundance is estimated at 2,500 to > 1,000,000 individuals (NatureServe 2006). North American populations are estimated to range from 85,000 to 287,000 breeding pairs (Rosenberg et al.

2000). The Canadian estimate is 500 to 1,000 breeding pairs (COSEWIC 2003). The Partners in Flight (PIF) landbird population estimate of Cerulean Warblers is 560,000, and should be considered the most current and accurate estimate to date (2008). Please refer to the following link for future population estimates. http://www.rmbo.org/pif_db/laped/about.aspx

Wood et al. (2006) recently determined in a study in southwestern West Virginia that, "Cerulean Warbler abundance was positively associated with more productive sites, higher snag density, large blocks of mature deciduous forest, and low amounts of edge in the landscape".

Habitat Requirements

The Cerulean Warbler requires large tracts of mature forest (Hamel 2000a), and often prefers forests with structural complexity caused by small forest gaps (Weakland and Wood 2005) in its breeding range. The Tennessee State Wildlife Action Plan (TN SWAP) determined preferred habitats for ceruleans in Tennessee. The following are terrestrial habitats in the HCP project area that are recognized by this TN SWAP report. In the Interior Low Plateau terrestrial ecoregion, Southern Interior Low Plateau Dry Oak Forests were considered marginal habitat. In the Cumberland Plateau and Mountains ecoregions, Allegheny-Cumberland Dry Oak Forest and Woodland, Appalachian Hemlock-Hardwood Forest, and South-Central Mesophytic Forests were all considered suitable habitat; whereas South-Central Interior Small Stream and Riparian habitat was marginal. In the Ridge and Valley ecoregions, Allegheny-Cumberland Dry Oak Forest and Woodland, Appalachian Hemlock-Hardwood Forest, and South-Central Mesophytic Forests were all considered suitable habitat.

The habitats during migration and winter season are poorly known (Hamel 2000b). They have been spotted during spring migration in Belize (Parker 1994), Honduras, and Guatemala, and southern Mexico (Welton et al. 2007). The hypothesis is that they may fly non-stop during their fall migration from the southern U.S. to the northern coast of South America (USFWS 2006). They are known to winter in broad-leaved evergreen forests in a narrow band of middle elevations 500 to 1,800 meters (1,650 to 5,900 feet) in the northern Andes Mountains (Robbins et al. 1992, Moreno et al. 2006), however they have also been found wintering in second-growth forests and shade-grown coffee plantations (Hamel 2000b, Jones et al. 2000).

In the Cumberlands, Cerulean Warblers appear to be choosing areas with larger trees providing them with more overstory cover. Beachy (2008) compared cerulean habitat selection and densities in Royal Blue Wildlife Management Area (WMA) with Sundquist WMA in Tennessee. Her results showed that ceruleans were found in higher densities in Royal Blue WMA where in recent decades much less large-scale habitat disturbances have occurred. They also are most commonly found on north-to east-facing slopes on steep ridges (Beachy 2008). Buehler et al. (2006) created a habitat model that showed 80,000 ha of potential cerulean habitat distributed throughout the Cumberlands, with an estimated 44,804 breeding pairs.

Ecological Interactions

Food preferences were summarized in the Federal Register (USFWS 2006a):

> Insects are the primary food source of Cerulean Warblers throughout the year. During the breeding season, their diet has been observed to consist primarily of

> Homoptera and Lepidoptera but also may include small amounts of Coleoptera, Hymenoptera, Diptera, Hemiptera, Araneae, and other arthropods (Hamel 2000b). While no detailed studies of diet have been completed during the non-breeding period, Cerulean Warblers appear to use nectar resources, as well as insects, during at least some period of their residency on their non-breeding grounds in South America (Jones et al. 2000, USFWS 2006b) and have also been observed eating small amounts of plant material during migration (Hamel 2000b). Their primary foraging mode for capturing insects is gleaning prey from the upper and lower surfaces of leaves. They also use sallying and hover-gleaning to a lesser extent (Hamel 2000b).

Hamel (2000b) documented interspecific aggressive interactions between Cerulean Warblers and Blue-gray Gnatcatchers, American Redstarts, Northern Parulas and others. Intraspecific interactions occur frequently between males and possibly at the same time between females of breeding pairs. Females have been seen attacking males and vice versa (Hamel 2000a).

Predators of this species have not been studied; however personal accounts of predatory activity and response to potential predators indicate that Blue Jays, snakes, and Mississippi Kites are predators (Hamel 2000a). While researching ceruleans in the Cumberland Mountains of Tennessee, Beachy observed red-bellied woodpeckers eating chicks from cerulean nests and saw a sharp-shinned hawk go to a nest that he had possibly just predated (pers. comm. T. Beachy 2007).

Brown-headed Cowbirds have been documented as nest parasites and in some cases had been thought as being an important factor in the decline of this species (Robbins et al. 1992). 54% of survey participants agreed with this thought, although further research is needed because the effect from cowbird parasitism is likely regional. At the Queen's University Biological Station (QUBS), only 2 cases since 1994 of Brown-headed Cowbird parasitism has been documented in over 200 nests (pers. comm. J. Jones). There are no other documented cases of parasitism on this species (Hamel 2000a).

Behavioral Patterns

Migration of Cerulean Warblers was described in the Federal Register (USFWS 2006a):

> Cerulean Warblers are nocturnal migrants. Little is known about habitat preferences and other ecological aspects of this bird's migration. Several stopover locations for spring migration have been found in Belize (Parker 1994), Honduras, and Guatemala (Welton et al. 2005), but records of this species during migration elsewhere are scarce. To explain this, one hypothesis is that Cerulean Warblers could migrate in pulses of large groups of individuals that make relatively long flights between stops (for example, northern South America to middle Central America and then across the Gulf of Mexico to southern United States). Even fewer records exist for Cerulean Warblers during the southward migration in the fall, prompting the suggestion that these birds might fly non-stop from the southern U.S. all the way to the northern coast of South America. Isotope analyses indicate some level of migratory connectivity for this species (USFWS 2006b), suggesting that individuals residing in the northern portions of the breeding range tend to go to more northerly portions of the wintering range and birds from the southern portions of the breeding range go to the more southerly portions of the wintering range.

Currently, 2 manuscripts are under review based on new research which refines the isotopic analysis which was the basis of the previous information in the Federal Register (2006a). The following is a description from Jason Jones of new information derived from new research (pers. comm. J. Jones).

> Dispersal –A conservative estimate of adult male dispersal between breeding seasons is 28%, implying that we could be underestimating survival by at least that amount. There are considerable regional differences in both the tendency to produce dispersing individuals and to receive dispersing individuals. In contrast to adults, we detected very little natal dispersal, contrary to most migratory songbirds.
>
> Connectivity – Adult male Cerulean Warblers exhibit a parallel migration system rather than the chain system reported earlier. Birds breeding in western populations (e.g. Illinois, Tennessee) tend to winter in southwestern areas (e.g. Ecuador and Peru) while birds breeding in eastern populations (e.g. Ontario, West Virginia, Pennsylvania) tend to winter in northeastern areas (e.g. Venezuela and Colombia). There also appears to be connection between strength of migratory connectivity and population declines; the breeding populations that showed the strongest migratory connectivity experienced the strongest population declines over the past 40 years.

Reproduction

The core of the Cerulean Warbler breeding range is in the southern Appalachian region, specifically in West Virginia, Ohio, Kentucky, and Tennessee. Cerulean warblers occur at high densities in some areas across this region. For example, the Cumberland Mountains of eastern Tennessee can support an estimated 40,000+ breeding pairs (Buehler et al. 2006).

This species is commonly monogamous; however several bigamous males have been documented. The nest is built by females. It is made of brown bark covered with gray plant material such as lichens and mosses and lined with mosses (Bent 1953, Harrison 1984), and placed on a large lateral branch in a tree, a considerable distance from the bole of the tree. There has been a range of heights documented from 5-20 meters high by Bent (1953), Harrison (1984), and Hands et al. (1989), however the typical height is probably above the middle of this range (NatureServe 2006). Preferences on nest site placement are fairly unknown and Hamel (1992) suggested that the relationship between site selection and canopy gaps as a research priority. This species can raise 2 broods per season, however this is thought to be a rare occurrence (Barg et al. unpublished data and Hamel 2000a).

Nicholson (2004) studied the reproductive activities of ceruleans from 1995-1999 in the Cumberland Mountains of east Tennessee. In his observations, nest building began on 5 May and the last fledgling left the nest on 7 July. During a recent study in the Cumberland Mountains of Tennessee, nest building began as early as 30 April (pers. comm. T. Beachy 2007). Also in her study, she documented that, the most commonly used nest tree species on Royal Blue WMA in 2005 was sugar maple (*Acer saccharum*) and white oak (*Quercus alba*) in 2006. Other nest trees included northern red oak, black cherry, tulip tree, American basswood, red maple and yellow buckeye, northern red oak, black cherry, black gum, hickory, and cucumber magnolia. The most commonly used nest tree species on Sundquist WMA in 2005 was tulip tree and sugar maple and black locust and tulip tree in 2006. The average DBH of the nest trees found on Royal Blue in 2005 was 40.6 cm and 41.5 cm in 2006. Please refer to Beachy (2008) for a more complete

list of nest trees and Cerulean Warbler nesting information in the Cumberland Mountains of Tennessee. Data such as this can aid managers and private land owners in determining best management practices on their land to aid in the conservation of Cerulean Warblers.

Early Life History

This aspect of Cerulean Warbler ecology is very difficult to study because females, fledglings, and independent young are hard to locate and capture. Distinguishing between more than two age classes is also challenging due to our minimal understanding of plumage variability and gender-specific diagnostic features (Hamel et al. 2004). It is very difficult to locate and observe Cerulean Warbler nests; which has led to our limited knowledge in this aspect of Cerulean Warbler ecology. This was the aspect of life history that we know the least about based on survey results. It was rated by 69% of survey participants as the aspect of life history that is poorly known or completely unknown.

Adult Life History

Knowledge of Cerulean Warbler life history is not well known. Survey participants rated it second behind early life history when asked to rate levels of knowledge. 54% of participants agreed that information is poorly known about adult life history of Cerulean Warblers. Other information regarding adult life history can be found in other areas of this document such as in reproduction and ecological interactions.

Survival rates are uncertain for Cerulean Warblers with only one study by Jones et al. (2004) that has published estimates of minimum survival rates. Annual male survival over the period of 1995 to 2001 was reported at a rate of 0.49, or 0.54 in "normal years" and 0.40 following an ice storm in 1998. The estimates are also minimum values due to the fact that they do not account for adult dispersal and emigration between breeding seasons (Jones et al. 2004).

Threats and Reasons for Decline

Degradation of habitat through land use change is the major threat to this species throughout its entire range. According to Hamel (2000a), "Conversion of mature deciduous forest to agricultural or urban areas, fragmentation and increasing isolation of remaining mature deciduous forest, the change to shorter rotation periods and even-aged management, and loss of key tree species to disease are all breeding season constraints. Wintering habitat is also threatened by conversion to other land uses such as pastureland and farms, and is converted into coca plantations, which have a detrimental effect on suitable primary forest habitat. Attempts to eradicate coca plantations will also potentially damage forests".

The Tennessee's Statewide Action Plan (SWAP) listed nine threat sources and corresponding threat stresses for the Cerulean Warbler:

1. Incompatible forestry practices - Altered physical habitat structure
2. Forest type conversion - Altered physical habitat structure
3. Incompatible mining practices - Altered physical habitat structure
4. Agricultural conversion - Altered physical habitat structure
5. Construction of roads, railroads, utilities - Altered physical habitat structure
6. Commercial or industrial development - Altered physical habitat structure

7. Primary residential development - Altered physical habitat structure
8. Secondary home or resort development - Altered physical habitat structure

Only one survey participant listed other sources of stress not covered by the TN SWAP. This survey participant believed that lack of forest management, loss of disturbance regimes, and wind energy development are sources of stress that also may cause altered physical habitat structure. One survey participant stated the following, "Cerulean Warblers can tolerate (and potentially benefit from) some small scale disturbance such as tree-fall gaps and the resultant increased forest structure. In general though, Cerulean Warblers require large expanses of mature forests. Therefore, incompatible forestry and mining practices that create very large forest disturbance will remove currently suitable habitat from the landscape. Specifically, the size and frequency of timber harvests and the size, frequency, and reclamation of coal mines are all specific stresses for Cerulean Warblers in this region. Unlike an aquatic organism that dies immediately from contaminated water, the potential threats of the above forest disturbances on Cerulean Warblers will likely be cumulative. In other words, a threshold may be met where fragmentation begins to have marked effects on Ceruleans that may not be detectable during the first years of increased disturbances in the region. Furthermore, this species steep population declines and the fact that the Cumberland Mountains are the core of this species range makes it worthy of increased conservation attention" (CW1).

Conservation Actions

The Cerulean Warbler Atlas Project (CEWAP) was developed by The Cornell Lab of Ornithology to aid in the conservation of this species, by linking volunteer birders and professional biologists in an attempt to survey and map all known breeding populations. Rosenberg et al. (2000) submitted a report to the USFWS in 2000.

American Bird Conservancy (ABC) is also taking a stand to help protect this species. The ABC has teamed with Fundación ProAves in Colombia and Fundación Jocotoco in Ecuador to establish two important reserves that protect wintering ceruleans as well as other migrants in the High Andes. These organizations are not only raising money to aid in this quest, but are managing shade coffee plantations on these species wintering grounds and working with agencies, universities, industry representatives, and private landowners throughout the U.S. to protect much needed habitat.

Cerulean Warbler Technical Group (CWTG) is a partnership of biologists, managers, and scientists from the forest-products industry, Federal and State agencies, nongovernmental organizations, and academia that was formed in 2001 to develop a broad-based, technically sound approach to conservation of the Cerulean Warbler. The CWTG seeks to keep the focus on identifying meaningful and proactive conservation solutions through sound science, clear communication, and trust. A similar committee that was highly successful, the Louisiana Black Bear Conservation Committee, formed in the early 1990s provides a model for this group. A Steering Committee charged to spur action and chart future activities and directions has been assigned. There are currently 72 CWTG participants working on several committees to support this group's mission (USFWS 2006a). Hamel et al. (2004) provides a thorough discussion on the history, organization, and objectives of this group. There are many other groups such as this who are interested and are actively pursing the conservation of the Cerulean Warbler. A list of these groups is found in the Federal Register (2006a).

Likelihood of Take

Based upon survey results, 62 percent of the 13 survey participants agreed that mining is currently the most threatening landuse practice and is causing take of the Cerulean Warbler. Thirty-one percent of participants agreed that forestry is the most threatening, while 8 percent chose all of the above. One survey participant commented, "It's quite hard to choose one of forestry and mining given the pervasiveness of both threats. Focusing on one and not the other will greatly limit the effectiveness of habitat management plans" (CW5). Survey participants were given the choice of forestry, mining, water development, all of the above, none of the above, or unable to answer. Although there are other possible causes of take of the Cerulean Warbler such as agriculture related issues, we focused on these three because they are being proposed for inclusion in the Cumberland HCP.

Survey participants were also asked which landuse practice is the most threatening and has the greatest potential to cause take over the next 10 years. Again, 62 percent of the 13 survey participants agreed that mining has the greatest potential to cause take. Twenty-three percent agreed forestry has the greatest potential, while 8 percent agreed that all three, forestry, mining, and water development have the greatest potential in the next 10 years to cause take. One survey participant was unable to answer the question.

The Science Advisory Committee (SAC) for the Cumberlands Habitat Conservation Plan (HCP) met at Cumberland Mountain State Park near Crossville, Tennessee on September 14, 2006. The committee, consisting of 19 attendees, divided into three groups (one for terrestrial plants and animals, a second for mussels, and a third for fishes and crayfishes) to assess the likelihood of take of imperiled species as a result of forestry, mining, or water development activities within the HCP project area. For the Cerulean Warbler the likelihood was rated "very high" for all three land uses; water development, forestry, and mining.

The following table is based upon the SAC meeting and received surveys. Options for likelihood of take were: very high, high, moderate, low, none, or unknown.

X indicates high or very high likelihood of take.

Species	**Common name**	**Forestry**	**Mining**	**Water Development**
Dendroica cerulea	Cerulean Warbler	X	X	X

Strategies for Minimizing Take

Suggested strategies from surveys range from limiting the width of contour surface mines where possible, to avoiding large-scale mining activities. Specific suggestions for land use practices are:

Forestry

- Harvest fewer than 1000 acres of timber per year (CW1).
- Forestry management practices to benefit the species are currently being investigated, but the general consensus is that habitats need some form of management that promotes mature hardwood forest, with canopy gaps or other structural complexity, and that may favor development of super-emergent canopy trees (often along ridgelines) (CW9).

Mining

- Reclaim mines to native forests rather than non-native dominated scrub/grasslands (CW4).

- Surface Mining: A designation of Lands Unsuitable for Mining for areas of high CERW breeding density would be the only means of avoiding take. A legal requirement to reforest mine sites that were formally CERW breeding habitat could theoretically provide habitat for CERW in 60 to 100 years or more. While reforestation would not replace breeding habitat in a reasonable amount of time, it would have the advantage of reducing the impact that the mine site would have on the breeding density of the CERW in the adjoining forest (Weakland and Wood 2002). Reforestation would also reduce the threat of BHCO parasitism in the adjoining forest by removing potential foraging habitat (CW10).

Other

- Effective landscape planning could minimize take (CW3).

Refer to Section II for a detailed list of all of the suggestions from survey participants.

Strategies for Mitigating Take

Suggested strategies from surveys range from restricting any mountain-top removal mining that causes large openings; to preserving current habitat through an easement or purchase. Specific suggestions for land use practices are:

- Home development should proceed in low impact ways …. retention of native trees and habitats in developments and homesites . . . minimized clearing; minimal roads, trails, lake development, etc. Land developers should be required to alter plans if CERW habitat is to be impacted (CW9).
- Mitigation could also take the form of modifying mining or forestry plans where significant breeding populations might be impacted; creating buffers around existing breeding habitat, etc. Mitigation or assessment of impacts needs to consider that even if forests that currently don't have CERW are impacted, that the future potential of those areas is now lost in supporting conservation of the species (CW9).
- Providing incentives to mine companies to reclaim to diverse hardwood forests without severe compaction of soils (CW7).
- Require timber management companies and state entities to follow the forest management prescriptions recommended by the Breeding Season Research Group of the CERW in high breeding density habitat in the Cumberland Mountains (CW10).

Refer to Section II for a detailed list of all of the suggestions from survey participants.

Coexisting Imperiled Species

Indiana bat *Myotis sodalis* [Federal status LE; State status (TN & KY) E; S1, G2], **Golden-winged warbler**, *Vermivora chrysoptera* [State status D ("Deemed in need of management") S3B (breeds in TN) and G4], and **Swainson's Warbler** *Limnothlypis swainsonii* [State status D ("Deemed in need of management") S3B (breeds in TN) and G4] are proposed by survey participants to be coexisting with the Cerulean Warbler in the proposed Cumberland HCP area. These species are affected by some of the same threats and stresses as Cerulean Warbler. Indiana bat was the most common species listed by survey participants.

All statuses are from NatureServe (2006) and 'A Guide to the Rare Animals of Tennessee' (May 2004). http://www.state.tn.us/environment/na/nhp.shtml

Other coexisting imperiled species not covered in the Cumberland HCP listed by survey participants to be coexisting include Louisiana Waterthrush, Worm-eating Warbler, Kentucky Warbler, Wood Thrush, Yellow-throated Vireo, Acadian Flycatcher, and blue shiners. Others were generally suggested such as several shrew species and amphibians), as well as small mammals, and listed mussels and fishes.

Survey Methods

Methods suggested by survey participants include point count or transect surveys, as well as searching for nests during the breeding season. Other methods included spot mapping to determine the number and relative size of territories in an area. One survey participant commented, "Distance-based surveys that allow estimation of detection probability. However, without complementary studies examining reproductive success, one cannot be sure that areas of high density are in fact of high quality (CW12)."

Monitoring Recommendations

NatureServe (2006) provides monitoring requirements based on suggested monitoring guidelines from Hands et al. (1989):

1) Surveys should be conducted annually at selected sites throughout the northcentral U.S., with the same sites being sampled each year. Annual surveys are justified if multiple species in the same habitat are targeted. If annual surveys are not possible, the same sites should be surveyed for several (three) consecutive years. After this, surveys should be conducted once every three years.
2) If a decline is detected, studies of breeding success and productivity should be initiated at selected sites throughout the northcentral U.S. These studies should be repeated annually until the reasons for the decline are understood.
3) For maximum efficiency, state or regional surveys should be coordinated, for example by the U.S. Fish and Wildlife Service, Office of Migratory Bird Management. By setting up such a clearinghouse, the OMBM could prevent duplicative surveys and standardize methodology.

Population status can only be assessed with more data on population trends, nest success, productivity, and mortality rates (Hands et al. 1989). Mortality rates will be difficult to estimate; recaptures and/or resightings of marked individuals may be the only method possible. Capture of these birds requires the use of canopy mist nets (see Greenlaw and Swinebroad 1967, Humphrey et al. 1968).

Currently, monitoring of breeding populations by the BBS provides useful information. However, this monitoring is too imprecise to document trends accurately and to relate trends to causes. The requirement of the National Forest Management Act of 1976 that National Forest lands be monitored for populations of native vertebrates could be used to justify Cerulean Warbler monitoring. The warbler is an excellent candidate for an indicator species for mature hardwood forests, particularly on floodplain sites, but also in mesic upland types as well. Further monitoring of breeding populations will also be required, i.e., monitoring that can document the actual distribution at the landscape scale in regions that are primarily forested and in those that are not. This warbler is an excellent bird to use as the vehicle for a thorough documentation of the operation of the forest fragmentation effect (Hamel 1992).

Monitoring of winter habitat can be done by utilizing remote sensing technology for large-scale examinations of trends. Later, more detailed monitoring of the numbers and distribution of the birds in winter will be required.

Survey participants also provided the following monitoring recommendations:

1) Habitat can be modeled and monitored through remote sensing in most cases, especially if you can account for new disturbances from some baseline point (CW2).
2) By assessing changes in populations over time alongside changes in forest habitat quality (CW4)
3) Follow and monitor bird populations. The reproductive success of populations will tell you if your habitat strategies are working. It is not enough to count the number of singing males (CW5).
4) In addition to surveying populations and reproductive success, conduct a series of randomly located, fixed radius vegetation plots that can be revisited from year to year to assess changes; compare these conditions to habitat characteristics of territories and nest sites (CW6).
5) Multi-scale approach: look at rangewide changes in forest distribution, regional scale at a higher resolution, and local scale habitat plots (CW7).

Refer to Section II for more specific recommendations.

Recovery

Restoration of old forest habitat that has been removed may be a method to recover lost habitat. This would take a period of 80 years and a long- term commitment (Hamel 1992), and vast expanses of land. In a study in West Tennessee, Cerulean Warblers were not found in tracts less than 1,600 ha in extent (Robbins et al. 1992). Hamel (1992) provided a summary of breeding ground preserve design. One such suggestion is arranging tracts of land at least 4,000 ha in size with minimal perimeter distance. There is no proof that doing this type of restoration will secure the future for the Cerulean Warbler, but failure to attempt it may result in an insecure future for this species (NatureServe 2006).

Securing wintering ground is also a necessity for the conservation of this Neotropical migrant. Protection of breeding habitat will not gain long-term security if its wintering ground is not secure. Hamel (1992) provided a summary of preserve design on wintering grounds.

Uncertainty Regarding Species Ecology

Based upon survey results; early life history and adult life history are the aspects of the Cerulean Warbler that we are most uncertain about. Fifty percent or more of participants rated this as either poorly known or completely unknown. The highest level of uncertainty fell into the category of early life history with 69 percent of survey participants agreeing that information is poorly known or completely unknown. Almost half of the survey participants agreed that behavioral patterns and reproduction are other aspects that we are uncertain about. One survey participant commented that, “We still lack a good way of getting to and banding juveniles to follow them post-fledging” (CW6). See Section II for all categories regarding uncertainty about Cerulean Warbler species ecology rated by survey participants.

Survey participants also suggested the following as research needs:

1) How the distribution, reproduction and abundance of the Cerulean will be affected by different types of timber management (CW1).
2) Data on survival is lacking for the Cumberlands (CW2).
3) What is a "viable population"? Do we have a source-sink situation (CW3)?
4) What are fine scale habitat requirements on breeding grounds and distribution/habitat use in the tropics during winter (CW4)?
5) Female survival and demography, post-fledging behavior and demography, intrinsic limits to fecundity, natal and breeding dispersal, migration routes (CW5).

Conservation Recommendations

The Cumberland Mountains of Kentucky and Tennessee play a vital role in the conservation of Cerulean Warblers. The Appalachian Bird Conservation Region (BCR 28) supports 80% of its breeding population. This region stretches from PA to GA, but the Cumberlands have some of the highest breeding densities of anywhere in the breeding range. (Rosenberg et al. 2002, Buehler et al 2006). This region has reported high numbers of ceruleans and has documented high breeding densities, however the population on the Cumberland Plateau declined 4% from 1966-2004 based upon Breeding Bird Survey data (Robbins et al. 1992, Sauer et al. 2005, Buehler et al. 2006). The Cumberland Plateau also has a higher proportion of interior forest and low level of fragmentation compared to other parts of the cerulean's range (Hamel 2000b, Wear and Greis 2001). Thus, these two areas have become very important to this species and research is currently underway to better understand the demographics, reproductive success, and habitat use of ceruleans and to create models to determine the effects of future land use activities on the Cumberland Plateau.

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Petition to List CERW under ESA: http://www.southernenvironment.org/lawlibrary/forests/2000-10-31_cerulean_petition.pdf

Southern Research Station: http://www.treesearch.fs.fed.us/pubs/2305

USFWS Ecological Services Site with Species of Concern: http://www.fws.gov/midwest/eco_serv/soc/birds/cerw/index.html

SECTION II: SURVEY RESULTS:

1. Threat rating of each of Tennessee's State Wildlife Action Plan (SWAP) threat sources by survey participants: severe=3, moderate=2, mild=1, unsure=U

Threat Source	Threat Stress	Threat Rating	Mean
Incompatible forestry practices	Altered physical habitat structure	2,2,3,2,3,3,2,3,2,3,3,2.5	2.5 (N=12)
Forest type conversion	Altered physical habitat structure	2,1,2,2,3,2,2,3,2,2,U,2.5	2.1 (N=11)
Incompatible mining practices	Altered physical habitat structure	2,3,3,2,3,3,3,3,3,3,3,3	2.8 (N=12)
Agricultural conversion	Altered physical habitat structure	2,1,1,U,1,1,2,1,2,1,3,1	1.5 (N=11)
Construction of roads, railroads, utilities	Altered physical habitat structure	1,2,1,2,1,2,3,1,1,1,3,1	1.6 (N=12)
Commercial or industrial development	Altered physical habitat structure	1,2,1,2,2,2,2,3,1,1,3,U	1.8 (N=11)
Primary residential development	Altered physical habitat structure	1,2,1,2,2,2,3,3,2,1,3,U	2.0 (N=11)
Secondary home or resort development	Altered physical habitat structure	1,2,1,2,1,2,3,1,1,2,3,1	1.7 (N=12)
Lack of Forest Management [a]	Altered physical habitat structure [a]	2 (CW7)	
Loss of Disturbance Regimes [a]	Altered physical habitat structure [a]	2 (CW7)	
Wind Energy Development [a]	Altered physical habitat structure [a]	1 (CW9)	

[a] –Additional threats added by survey participant.

Comments by survey participants:
Incompatible forestry practices - Altered physical habitat structure

- Agree (CW1, CW4, CW7, CW13)
- As it currently applies to the Cumberland HCP project area and known cerulean range- same for all of the other sources below (CW2).
- ie. clearcutting of large areas (CW6)
- May take decades for habitat to recover (CW8).
- There are a multitude of forestry practices (including no action) that might negatively impact CERW through altered physical habitat structure; it is difficult to offer an accurate threat rating. Accuracy in the threat rating hinges on which specific forestry practices (or lack of certain forestry practices) are at play in the Cumberlands. Obviously, clearcutting in large patches of the most suitable of habitats will have a severe immediate impact, whereas small clearcuts or group selection are likely to favor forest stand conditions desirable to the birds. Roads may help improve stand

conditions by creating caps and adding canopy complexity, but then too dense of a road system could degrade the overall suitability of habitat. Thus this threat source is too general to be able to meaningfully assign a single threat rating (CW9).

- Most forest management practices in TN remove the very trees that CERW are attracted to for breeding habitat (CW10).
- Moderate (breeding) and severe (wintering) (CW12)

Forest type conversion - Altered physical habitat structure

- Agree (CW1, CW4, CW7)
- Also- there is the question of intensity of the activity. For example, when forest-ag conversion occurs, it has the ability to destroy cerulean habitat but in the Cumberlands, this isn't happening (ag conversions) at present, so I therefore rank it as a mild threat (CW2).
- This is a problem in areas where pine plantations or other species are planted that weren't originally there; or where fescue and other non-native species are planted on food plots or strip benches, rather than hardwoods (CW6).
- Ceruleans use many tree species, but some are very unsuitable (CW8)
- Depends on what is meant by "forest type conversion." I'm assuming this refers to conversion of otherwise suitable hardwood forest stands to, say, softwoods?? However, it could also mean conversion of suitable forest to other habitats . . . e.g., early successional habitats, food plots, etc?? The per/acre severity of each of these is probably quite similar . . . the real "severity of threat" would be based on the likelihood of each form of conversion, and the acreage impacted. Given that conversion to softwoods probably occurs in bigger blocks, this form of conversion would have a relatively higher threat severity than conversion to food plots, etc (CW9).
- Conversion of hardwood forest to pine plantations seems to have slowed in recent years (CW10).
- Moderate (breeding) and severe (wintering) (CW12)
- Unsure (CW13)

Incompatible mining practices - Altered physical habitat structure

- Agree (CW1, CW4, CW7, CW13)
- Huge areas disturbed; see comments above (CW6)
- Especially Mountaintop Removal Valley Fill Mining. To the extent this type of mining practice occurs in the Cumberlands, the threat rating would be severe (total immediate devastation of habitat). Other mining practices (e.g., strip/bench) result in habitat conversion/loss, but can also offset losses by creating gaps, edges that in certain areas might improve forest structure for CERW. I would rate threats from these mining practices as moderate. If reclamation is included in 'incompatible mining practices", then the treat rating goes up . . . this would assume that reclamation is to some non-forest habitat resulting in permanent loss of CERW habitat (CW9).
- This is the number one threat that the CERW faces (CW10).
- Especially if increased (CW11).
- Agricultural conversion - Altered physical habitat structure
- Agree (CW1, CW7)
- Conversion of forest to ag would be a moderate threat if lost forest area was in late successional stages preferred by the species. Conversion of ag to forest without proper management would lead to forests that may never display the habitat qualities preferred by CERW. Non-managed forest stands may be subject to invasion by non-natives species that may lead to mature forest structure that is unsuitable (CW4).
- There isn't as much agric in the Cumberlands as in west TN, along the MAV; CERWs occur in higher elevations here, where there isn't much agric (CW6).

- To the extent it occurs, Ag conversion would result in loss of habitat, thus severe impacts. As with other threat sources, the real severity of threat is tied more to the acreages impacted by such activities in the Cumberlands (CW9).
- There is little agricultural conversion going on in the breeding range of the CERW in TN (CW10).
- Already important (CW11)
- Unsure (CW13)

Construction of roads, railroads, utilities - Altered physical habitat structure

- Agree (CW1, CW7, CW13)/Agree-Due to direct habitat loss and general forest fragmentation effects on area-sensitive NTMBs (CW4)
- Roads associated with mining, logging, etc (CW6)
- Commercial or industrial development - Altered physical habitat structure
- Agree (CW1, CW7)/ Agree-Due to direct habitat loss and general forest fragmentation effects on area-sensitive NTMBs (CW4)
- Land in the mountains is purchased by developers, etc, that bring commercial and industrial dev. to support more residents (CW6).
- Threat rating is mild assuming such activities are moderated. Continual expansion and growth of industry/commercialism will "nickel and dime" habitats over periods of time. Here, cumulative impacts are the key to the severity rating . . . more cumulative impacts obviously = higher threat ratings (CW9).
- Unsure (CW13)

Primary residential development - Altered physical habitat structure

- Agree (CW1, CW7)/ Agree-Due to direct habitat loss and general forest fragmentation effects on area-sensitive NTMBs (CW4)
- See above comments; expansion of Mt. communities (CW6).
- As with the comment 5 above, cumulative impacts are key. On a "per activity" basis, residential development is likely to have a higher threat rating given that residential development often results in total land clearing, subdivision or larger sized developments, and more associated human encroachment issues. Though not always, secondary home development can be done compatibly . . . at lower densities, smaller acreages, and with homes nestled in among existing habitats, etc. Home sites can also act as surrogates for forest management practices that would otherwise improve canopy complexity (beneficial for the birds). However, secondary home development typically occurs in areas more likely to be prime CERW habitat. Too much of it can begin to cause problems, and as is typical, once development pressures start, they don't stop until problems do occur (CW9).
- Unsure (CW13)
- Secondary home or resort development - Altered physical habitat structure
- Agree (CW1, CW7)/ Agree-Due to direct habitat loss and general forest fragmentation effects on area-sensitive NTMBs (CW4)
- Rarity Ridge; vacation homes; retirement communities (CW6)
- But it encourages further eventual development (CW8).
- As with the comment 5 above, cumulative impacts are key. On a "per activity" basis, residential development is likely to have a higher threat rating given that residential development often results in total land clearing, subdivision or larger sized developments, and more associated human encroachment issues. Though not always, secondary home development can be done compatibly . . . at lower densities, smaller acreages, and with homes nestled in among existing habitats, etc. Home sites can also act as surrogates for forest management practices that would otherwise improve canopy complexity (beneficial for the birds). However, secondary home development typically occurs in areas more likely to be prime CERW habitat. Too much of it can begin to cause

problems, and as is typical, once development pressures start, they don't stop until problems do occur (CW9).

- This is becoming more of an issue in the Cumberland Mountains (CW10).
- Unsure (CW13)

Lack of Forest Management - Altered physical habitat structure

- Agree (CW7)

Loss of Disturbance Regimes - Altered physical habitat structure

- Agree (CW7)

Wind Energy Development – Altered physical habitat structure

- Wind development could pose a future risk to the species, especially in montane portions of its range (like the Cumberlands). It's unclear what the wind development potential is at this time for the Cumberlands, but migratory bird impacts (direct and habitat related) are a growing concern (still probably better than mining though) (CW9).

Additional Comments

- Cerulean Warblers can tolerate (and potentially benefit from) some small scale disturbance such as tree-fall gaps and the resultant increased forest structure. In general though, Cerulean Warblers require large expanses of mature forests. Therefore, incompatible forestry and mining practices that create very large forest disturbance will remove currently suitable habitat from the landscape. Specifically, the size and frequency of timber harvests and the size, frequency, and reclamation of coal mines are all specific stresses for Cerulean Warblers in this region. Unlike an aquatic organism that dies immediately from contaminated water, the potential threats of the above forest disturbances on Cerulean Warblers will likely be cumulative. In other words, a threshold may be met where fragmentation begins to have marked effects on Ceruleans that may not be detectable during the first years of increased disturbances in the region. Furthermore, this species steep population declines and the fact that the Cumberland Mountains are the core of this species range makes it worthy of increased conservation attention (CW1).
- My habitat loss and fragmentation comment would only apply when there is loss of suitable habitat. In most cases, in the Cumberlands, when forest habitat is lost due to these threats, that habitat is not in the mature forest stages or structure preferred by CERW; it has probably not been allowed to revert to such suitable mature stages. These comments assume that the habitat is potentially suitable or nearly to an age class/structure that would be (CW4).
- I assumed that I was supposed to answer the threat level relative to the current and future situation in the Cumberlands, TN. For example, I consider agriculture to be a severe threat in other states….most agriculture in this region is practiced at lower elevations where the Ceruleans populations are less dense. In Indiana, agriculture is a more feasible industry on the flatter ground where Ceruleans are found there (CW8).
- I am thinking here that forest removal to provide cleared space for agriculture, urbanization, and exurbanization is itself a (pre-development) forestry practice. More generally, although the Cerulean Warbler has declined significantly since 1966, avian biologists remain unsure of what has caused the decline. Therefore we do not know how the species would respond to future landscape alterations that are listed in the above table, and my entries should be regarded as hypotheses. An exception is mining practices, which in some cases remove entire mountains and the forests that cover them (CW11).
- Given the distribution of CERW in more mountainous areas of the state, I suspect that there is relatively little agricultural and primary residential development and therefore I rated those as lower. I could be wrong (CW12).

2. SWAP threat course scale stresses rated by survey participants at the fine scale threat stress level:

Threat Source	Coarse Scale Threat Stress	Fine Scale Threat Stress
Incompatible forestry practices	Altered physical habitat structure	1. Make forest structure unsuitable (loss of big trees and full or partial canopies) (CW2) 2. Loss of mature deciduous forest (CW3)/ Loss of mature age classes (CW4)/ Lack of thinning to create small canopy gaps, removal of large dbh trees(CW13) 3. Loss of large forest patches (CW3) 4. Microclimate changes where warmer temperatures permeate into the interior forest (CW4). 5. Loss of canopy heterogeneity and suitable song post trees and nest trees (CW5) 6. Fragmentation of large forested landscape by creating large patch cuts which are unsuitable for CERWs (CW6) 7. Loss of dominant/codominant oaks (CW7) 8. Loss of mature trees, loss of critical canopy cover, overall fragmentation of forest (CW8) 9. Loss of super-dominant (emergent) trees. Heavy cutting that reduces basal areas to the point where forest stands become "too open" (something akin to a seed tree cut). Shelterwood cuts and small group selection might be the best practices. Alternatively, lack of management results in canopies with little structural complexity. Canopy gaps seem to be important components in defining CERW breeding habitats (CW9) 10. Loss of diverse canopy structure can be caused by removing large diameter trees (CW10). 11. Increased nest predation, brood parasitism from forest fragmentation (CW11) 12. Loss of large dbh, emergent canopy trees, Stands that are too even-aged and lack complex canopy structure (CW12) 13. Unsure (CW1)
Forest type conversion	Altered physical habitat structure	1. Pines are unsuitable for cerulean habitat (CW2) 2. Loss of mature deciduous forest (CW3) 3. Conversion of mesophytic hardwood forests to timber crop monocultures (CW4). 4. The obvious loss of intact forest expanses preferred by CERW (CW4). 5. Loss of canopy heterogeneity and suitable song post trees and nest trees (CW5) 6. Creates unsuitable breeding and foraging habitat, whether it's pines or grass (CW6) 7. Loss of forest diversity (CW7) 8. Some tree species unsuitable (CW8) 9. Conversion of hardwoods to softwoods. Results in permanent or long term loss of current or potential hardwood breeding habitat. As per comments above, cumulative

		acreages impacted by such conversion is the key to how significant a threat this is (CW9). 10. Direct loss of breeding and foraging habitat (CW10). 11. Possibly formation of monoculture; Possibly loss of oaks (CW11) 12. Loss of oak component; loss of mature forest and forested landscapes; (CW12) 13. Unsure (CW1)
Incompatible mining practices	Altered physical habitat structure	1. Direct clearing (loss) of mature forest habitat- big trees (CW2)/ Loss of mature deciduous forest (CW3) 2. Loss of nesting habitat and fragmentation of remaining habitat leading to edge effects (CW5) 3. The coal seams in the Cumberlands are exactly where the best CERW habitat is, therefore large-scale disturbances remove large areas of suitable habitat until native vegetation is allowed to grow back (CW6). 4. Habitat fragmentation thru large-scale loss of forest; creation of hard 'edges' along forested habitat reduces density of CERW around edges (CW7) 5. Loss of mature trees, removing topography for selection, forest fragmentation (CW8) 6. Especially Mountaintop Removal Valley Fill Mining. To the extent this type of mining practice occurs in the Cumberlands, the threat rating would be severe (total immediate devastation of habitat). Other mining practices (e.g., strip/bench) result in habitat conversion/loss, but can also offset losses by creating gaps, edges that in certain areas might improve forest structure for CERW. I would rate threats from these mining practices as moderate. If reclamation is included in 'incompatible mining practices", then the treat rating goes up . . . this would assume that reclamation is to some non-forest habitat resulting in permanent loss of CERW habitat (CW9). 7. Direct loss of breeding and foraging habitat (CW10) 8. Mountain (forest) removal (CW11) 9. Complete habitat loss in mountain-top mining, which overlaps with distribution of CERW (not really fine-scale) (CW12) 10. Clearing for mining, loss of larger forest tracts (CW13) 11. Unsure (CW1) 12. None (CW4)
Agricultural conversion	Altered physical habitat structure	1. Direct clearing (loss) of mature forest habitat (CW2)/ Loss of mature deciduous forest (CW3) 2. Conversion of mature hardwood forest to agriculture could potentially decimate existing forested habitats for CERW in terms of suitable area (CW4). 3. Loss of nesting habitat and fragmentation of remaining habitat leading to edge effects (CW5) 4. Conversion of mature forest to agriculture removes suitable

		habitat (CW6). 5. Loss of mature hardwood forests for breeding (CW7) 6. Loss of mature trees, loss of critical canopy cover, overall fragmentation of forest (CW8) 7. Permanent loss of forest breeding habitat through conversion of hardwoods to pasture or rowcrop (CW9) 8. Direct loss of breeding and foraging habitat as well as forest fragmentation (CW10). 9. Increased nest predation, brood parasitism (CW11) 10. Loss of habitat (not really fine-scale) (CW12) 11. Unsure (CW1)
Construction of roads, railroads, utilities	Altered physical habitat structure	1. Direct clearing (loss) of mature forest habitat (CW2) 2. Loss of large forest patches (CW3) 3. In cases where large mature forest expanses are bisected, edge effects could decrease suitability of habitat due to decreases in area of intact forest (CW4) 4. In cases where large mature forest expanses are bisected, introduction of non-native and/or invasive plant species into the native vegetation structure (CW4) 5. In cases where large mature forest expanses are bisected, shifts in microclimate in the ecotones. 6. These impacts may be greater in a 512 kV transmission line corridor than in a small private road. 7. Secondary impacts to surrounding forests due to negligence in adhering to aquatic resource BMPs may also degrade forest habitat quality (CW4). 8. Forest fragmentation and exposure of remainder to edge effects (CW5) 9. Removes suitable habitat (CW6) 10. Habitat fragmentation; increase permeability for predators, cowbirds, and invasive plants (CW7) 11. Increases fragmentation (CW8) 12. Obviously, construction of interstates thru the core hardwood breeding habitats would present a severe threat, whereas lower density secondary or tertiary road construction represents a much lower risk, and in some instance can probably be viewed as even helping . . . by creating some of the structural characteristics needed by the birds (CW9). 13. Degradation of forest habitat by fragmentation (CW10) 14. Increased nest predation, brood parasitism (CW11) 15. Allow penetration of forested landscapes by predators and brood parasites. Facilitate movement of exotic species (plants) (CW12). 16. Logging for such purposes (CW13) 17. Unsure (CW1)
Commercial or industrial development	Altered physical habitat structure	1. Direct clearing (loss) of mature forest habitat (CW2) 2. Loss of large forest patches (CW3) 3. Same edge effects as mentioned above would apply to the footprint of such development as well (CW4).

		4. Forest fragmentation and exposure of remainder to edge effects (CW5) 5. Removes suitable habitat (CW6) 6. Habitat fragmentation and direct loss of mature forest habitat (CW7) 7. Loss of mature trees, loss of critical canopy cover, overall fragmentation of forest (CW8) 8. Threat rating is mild assuming such activities are moderated. Continual expansion and growth of industry/commercialism will "nickel and dime" habitats over periods of time. Here, cumulative impacts are the key to the severity rating . . . more cumulative impacts obviously = higher threat ratings (CW9). 9. Direct loss of breeding and foraging habitat (CW10) 10. Increased nest predation, brood parasitism (CW11) 11. Allow penetration of forested landscapes by predators and brood parasites. Facilitate movement of exotic species (plants) (CW12). 12. Unsure (CW1)
Primary residential development	Altered physical habitat structure	1. Direct clearing (loss) of mature forest habitat (CW2) 2. Loss of large forest patches (CW3) 3. Same edge effects as mentioned above would apply to the footprint of such development as well (CW4). 4. Forest fragmentation and exposure of remainder to edge effects (CW5) 5. Removes suitable habitat (CW6) 6. Habitat fragmentation and direct loss of mature forest habitat (CW7) 7. Loss of mature trees, loss of critical canopy cover, overall fragmentation of forest (CW8) 8. As with number 5 above, cumulative impacts are key. On a "per activity" basis, residential development is likely to have a higher threat rating given that residential development often results in total land clearing, subdivision or larger sized developments, and more associated human encroachment issues. Though not always, secondary home development can be done compatibly . . . at lower densities, smaller acreages, and with homes nestled in among existing habitats, etc. Home sites can also act as surrogates for forest management practices that would otherwise improve canopy complexity (beneficial for the birds). However, secondary home development typically occurs in areas more likely to be prime CERW habitat. Too much of it can begin to cause problems, and as is typical, once development pressures start, they don't stop until problems do occur (CW9). 9. Direct loss of breeding and foraging habitat as well as forest fragmentation (CW10). 10. Increased nest predation, brood parasitism (CW11) 11. Allow penetration of forested landscapes by predators and

		brood parasites. Facilitate movement of exotic species (plants) (CW12). 12. Unsure (CW1)
Secondary home or resort development	Altered physical habitat structure	1. Direct clearing (loss) of mature forest habitat (CW2) 2. Loss of large forest patches (CW3) 3. Same edge effects as mentioned above would apply to the footprint of such development as well (CW4). 4. Forest fragmentation and exposure of remainder to edge effects (CW5) 5. Removes suitable habitat (CW6) 6. Habitat fragmentation and direct loss of mature forest habitat (CW7) 7. Loss of mature trees, loss of critical canopy cover, overall fragmentation of forest (CW8) 8. As with number 5 above, cumulative impacts are key. On a "per activity" basis, residential development is likely to have a higher threat rating given that residential development often results in total land clearing, subdivision or larger sized developments, and more associated human encroachment issues. Though not always, secondary home development can be done compatibly . . . at lower densities, smaller acreages, and with homes nestled in among existing habitats, etc. Home sites can also act as surrogates for forest management practices that would otherwise improve canopy complexity (beneficial for the birds). However, secondary home development typically occurs in areas more likely to be prime CERW habitat. Too much of it can begin to cause problems, and as is typical, once development pressures start, they don't stop until problems do occur (CW9). 9. Direct loss of breeding and foraging habitat as well as forest fragmentation (CW10). 10. Increased nest predation, brood parasitism (CW11) 11. Allow penetration of forested landscapes by predators and brood parasites. Facilitate movement of exotic species (plants) (CW12). 12. Unsure (CW1)
Lack of Forest Management [a]	Altered physical habitat structure [a]	1. No canopy gaps or oak regeneration; lack of vertical heterogeneity to forest (CW7)
Loss of Disturbance Regimes [a]	Altered physical habitat structure [a]	1. No canopy gaps or oak regeneration; lack of vertical heterogeneity to forest (CW7)

[a] –Additional threats added by survey participant.

Comments by survey participants regarding their answers:
(Threat Source - Coarse Scale Threat Stress - ***Fine Scale Threat Stress – Comments***)

(CW1)

- Additional comments regarding fine-scale threat table-***Not much is known about the fine-scale needs of Cerulean Warblers. They need mature forests with diverse structure. This structure is often not present in forests post harvest for many years.***

(CW4)

- Incompatible mining practices - Altered physical habitat structure- none - ***Mining itself probably with no direct impacts on CERW. The habitat loss if forested slopes are newly mined would have negative impacts as mentioned earlier.***
- Additional comments regarding fine-scale threat table- ***General impacts to area-sensitive Neotropical migratory songbirds via habitat fragmentation would apply to CERW in any of these landuses. These impacts are generally summed up in:***

  Robbins, C. S., D. K. Dawson, and B. A. Dowell. 1989. Habitat area requirements of breeding forest birds of the middle Atlantic states. Wildlife Monographs No. 103.

  And there is a plethora of other more recent papers on fragmentation and edge effects. In general, on their breeding grounds, areas-sensitive species, when forced to breed in sub-optimal habitat due to fragmentation and edge effects, are subjected to direct habitat loss, habitat structural shifts, competition with non-area-sensitive bird species, brood parasitism by Brown-headed cowbirds, to name a few. CERW would be affected in these ways as well as others that may be more species-specific.

(CW6)

- Incompatible forestry practices - Altered physical habitat structure - ***Fragmentation of once largely forested landscapes by creating many large patch cuts - CERWs can tolerate (and may even benefit from) patches up to a certain size, but continued removal of mature forest across an important breeding area like the Cumberland Mts may introduce more problems with predators, nest parasitism, resource availability, and overall lack of suitable habitat.***
- Incompatible mining practices- Altered physical habitat structure - ***The coal seams in the Cumberlands are exactly where the best CERW habitat is, therefore large-scale disturbances remove large areas of suitable habitat until native vegetation is allowed to grow back - CERWs can use old strip benches to an extent, if they are not too wide; cross-ridge mining, however, and the practice of extracting several widely-spaced seams along a very wide contour are most likely not compatible***.
- Construction of roads, railroads, utilities - Altered physical habitat structure - ***Removes suitable habitat - CERWs often locate territories on roads, as long as the gap created isn't too wide.***
- Commercial or industrial development - Altered physical habitat structure - ***Removes suitable habitat - These stresses alter the largely forested landscape where CERWs occur, possibly making unusable a larger area than just the area where the disturbance occurred.***

(CW8)

- Incompatible forestry practices - Altered physical habitat structure - ***Loss of mature trees, loss of critical canopy cover, overall fragmentation of forest - Habitat loss coupled with increased predators and parasites.***
- Forest type conversion – Altered physical habitat structure - ***Some tree species unsuitable - This is detrimental especially when forest becomes largely monotypic (ex. Evergreens).***
- Construction of roads, railroads, utilities - Altered physical habitat structure - ***Increases fragmentation - Edge effects: predators and parasites.***

(CW10)

- Incompatible forestry practices - Altered physical habitat structure - ***Loss of diverse canopy structure can be caused by removing large diameter trees - Cerulean Warblers (CERW) breed in large forested tracts of mature tall trees with a structurally diverse canopy structure. Current and past timber management practices in Tennessee often remove the mature trees within a tract, a practice called "high-grading". These are the very trees that the CERW require. I have observed***

CERW abandon a breeding area the year after the tract was high-graded. Obviously clear cutting is another incompatible forestry practice because it removes all potential breeding habitats.

- Forest type conversion - Altered physical habitat structure - ***Direct loss of breeding and foraging habitat - Forest conversion in TN replaces hardwood forest with pine. CERW avoid pines.***
- Incompatible mining practices- Altered physical habitat structure - ***Direct loss of breeding and foraging habitat - In upland sites CERW prefer to nest on ridgetops (Wood et al. 2006, Buehler et al. in press). Mountaintop and cross-ridge mining completely removes this highest quality CERW habitat. Unfortunately, even if the site is reforested after mining, there is no empirical evidence that it will again become CERW breeding habitat. Reforestation research is in its early stages and it will take many decades before these planted trees reach a maturity that could produce acceptable CERW breeding habitat. In addition, Wood et al. (2006) found significantly reduced densities of breeding Cerulean Warblers in forest fragmented by mining and in forest adjacent to mine edges. This indicates that the impact of surface mining on CERW breeding habitat is greater than the footprint of the mine itself.***

(CW11)

- Incompatible forestry practices - Altered physical habitat structure - ***Increased nest predation, brood parasitism from forest fragmentation - Major factors affecting reproduction***
- Forest type conversion - Altered physical habitat structure - ***Possibly formation of monoculture; Possibly loss of oaks - Nesting birds would avoid monoculture – not vertically or horizontally heterogeneous; few gaps; Possible food loss***
- Incompatible mining practices- Altered physical habitat structure - ***Mountain(forest) removal - Loss of all trees***
- Agricultural conversion - Altered physical habitat structure - ***Increased nest predation, brood parasitism - Loss of large forest tracts (exposure to previous agents)***
- Construction of roads, railroads, utilities – Altered physical habitat structure - ***Increased nest predation, brood parasitism - Loss of large forest tracts (exposure to previous agents)***
- Commercial or industrial development - Altered physical habitat structure - ***Increased nest predation, brood parasitism - Loss of large forest tracts (exposure to previous agents)***
- Primary residential development - Altered physical habitat structure - ***Increased nest predation, brood parasitism - Loss of large forest tracts (exposure to previous agents)***
- Secondary residential development - Altered physical habitat structure - ***Increased nest predation, brood parasitism - Loss of large forest tracts (exposure to previous agents)***
- Additional comments regarding fine-scale threat table- ***I measure Cerulean Warbler reproduction in southwest Michigan. Nest predation, and to some extent brood parasitism, are high there EVEN IN THE LARGEST FORESTS IN THAT PART OF THE STATE I WHICH CERW BREED. These areas are increasingly surrounded by nest predators and brood parasites that prosper in agricultural land, and areas converted to urbanization and exurbanization. What is less known is how such land conversion affects food supply of breeding CERW.***

(CW13)

- Construction of roads, railroads, utilities – Altered physical habitat structure - ***Small roads, etc. can be beneficial in that CERW often utilize forests along roads (e.g. forest service roads).***

3. *Confidence values based on SWAP threats and threats added by survey participants: very high=4, high=3, moderate=2, low=1, none=0, U=unknown*

Threat Source	Threat Stress	Confidence Values (Regarding Take)	Mean	Mode
Incompatible forestry practices	Altered physical habitat structure	3[b],4,4,3[b],4,4,2,3[f],4,4,3,2,3	3.3 (N=13)	4.0
Forest type conversion	Altered physical habitat structure	3[b],1,3, 3[b],4,4,U,U[g],2,2,4,1[j]	2.7 (N=10)	3.0-4.0 tie
Incompatible mining practices	Altered physical habitat structure	3[b],4,4,0[c],4[d],4,4,3,4,4,4,3[k],4	3.5(N=13)	4.0
Agricultural conversion	Altered physical habitat structure	3[b],1,1,3[b],2,2,2,1[h],2,1,4,2[l]	2.0 (N=12)	2.0
Construction of roads, railroads, utilities	Altered physical habitat structure	1,4,2,2[b],2,3,3,2,3,1,4,1,2	2.3 (N=13)	2.0
Commercial or industrial development	Altered physical habitat structure	1,4,1,2[b],3,2,U,3,4,1,4,1[m]	2.4 (N=11)	1.0
Primary residential development	Altered physical habitat structure	1,4,2,2[b],3,2,2,3,3,1,4,1	2.3 (N=12)	2.0
Secondary home or resort development	Altered physical habitat structure	1,4,1,2[b],2,3,3,3,3,2[i],4	2.5(N=11)	3.0
Lack of Forest Management [a]	Altered physical habitat structure [a]	3[e] (CW7)		
Loss of Disturbance Regimes [a]	Altered physical habitat structure [a]	3[e] (CW7)		

[a] -Additional threats added by survey participant.
[b]- At high elevations (CW4)
[c]- Mining itself probably with no direct impacts on CERW, but preparation of forested areas for mining would have detrimental impacts and this aspect of mining I would rate as "high", especially at higher elevations (CW4).
[d]- Mountain top removal coal mining (CW5)
[e]- Not really a take but large-scale habitat quality issue (CW7).
[f]- Mature forest is critical (CW8).
[g]- Some tree species unsuitable, but how prevalent is conversion in TN (CW8)?
[h]- Most birds at greater elevations than agriculture in TN (CW8).
[i]- In Cumberland Mountains (CW10)
[j]- Conflicting evidence about CERW reliance on oak (CW12).
[k]- I can't see how the current plans for mountain top removal mining would NOT be a disaster(CW12).
[l]- Seems like agricultural conversion rates are down. Urban/residential seem to be increasing (CW12).
[m]- I don't know TN development patterns/trends (CW12).

Additional comments regarding this table:

- Cerulean Warblers typically occupy forests > 2000 ft in elevation. Therefore, these stresses occurring at lower elevations are not causing take in the Cumberland region. Furthermore, there is very little agriculture, private or industrial development occurring at these high elevations. At high elevations there is a good bit of timber harvesting and clearing for coal mining that is directly removing Cerulean Warbler habitat (CW1).
- I responded to this table assuming that these practices would result in a substantial net loss of mature (at least 60 year old) forest in the affected Cumberlands region, but I have not specifically researched the future of these practices in this area. My responses would change slightly for areas outside the Cumberlands…i.e. greater agricultural impact (CW8).
- See note regarding all threat sources: – it's unclear whether we are to consider this question with respect only to the Cumberlands, or just generally? I answered the question considering the breeding range of CERW (CW9).
- These ideas must be regarded as hypotheses. Again, we know relatively little abut CERW responses to habitat factors. It is difficult to predict the future with so few data. One thing that is certain: reproduction, even in large forests, is low, based on a current manuscript in revision for Journal of Wildlife Management (data from MI, Ontario, OH, WV, MS, and TN). Whether or not this is caused by any of the factors in the above table awaits further study (CW11).

4. Which landuse currently is most threatening and is causing take of the focal species?

Numbers are percents of the total survey participants and are rounded to the nearest whole number.

Species	Forestry	Mining	Water Development	All of above	None of above	Unable to answer
Cerulean Warbler (N=13)	31	62		8		

Comments by survey participants regarding their answers:

Forestry

- Forestry is currently removing the most Cerulean Warbler habitat on an annual basis (1000-3000 acres/year) in the Cumberland Mountains region (CW1).
- I don't know that anyone has formally documented "take" of CERW relative to mining, or forestry for that matter (here "take" being defined based on the MBTA, because CERW is not an ESA protected species). Take of birds can only be inferred based on the land use changes and impacts posed by these activities. Mining is most likely to result in "active take" of the species and of its habitat– that is, take of birds and habitats results from the direct action of mining interests. Loss of habitats may be permanent. Forestry is more likely to result in "passive take" – that is, individual birds may be less likely to be taken, but long term lack of management results in habitat degradation and eventual population level impacts to the species. There is more potential to promote appropriate CERW habitats in areas subjected to improper forestry (or no management) versus those impacted by large-scale mining operations (CW9).
- I am not familiar with the location of most water development activities for TN and, therefore, don't know if ranges of activities and CERW distribution would overlap much. Forestry at local scales definitely causes takes, but its impact at regional scales can be lower (or higher) depending on the cumulative size/distribution of harvests. Forest conversion in winter habitats is a big concern. With the price of coffee dropping, many farmers in the Andes are converting shade-coffee plantations (which support CERWs) to pasture, which are not used by CERW. Andean forests

continue to be heavily fragmented as well. On the breeding grounds, mountain-top mining is the number one serious threat in my mind right now. I think it has the potential to devastate CERWs (CW12).

Mining

- Mining is most threatening because all trees must be removed before removing the coal, and because it covers such large areas and affects the hydrology of an area (CW6).
- A model to predict CERW breeding habitat availability and populations in the Cumberland Mountains of eastern Tennessee was completed in 2005 (Buehler et al. in press). The model was applied to the 21,609-ha state-owned Royal Blue Wildlife Management Area to evaluate the potential effects of coal surface mining. The model suggests coal surface mining could remove 2,954 ha of cerulean habitat on Royal Blue Wildlife Management Area and could displace 3,161 breeding pairs (23% of the Royal Blue population). The Tennessee Valley Authority owns the mineral rights under Royal Blue and has indicated an interest in leasing these rights in the near future (CW10).
- Forestry is also important in that often logging companies log an area first where they know a mining permit will soon be submitted (CW13).

All of the Above

- Here I assume that water development can mean housing being built along riparian zones (CW11).

Both forestry and mining

- It's quite hard to choose one of forestry and mining given the pervasiveness of both threats. Focusing on one and not the other will greatly limit the effectiveness of habitat management plans (CW5).
- A (forestry) and B (mining) are the most threatening, but I am unsure which will affect the most landscape. Mountaintop removal mining would appear to have the longest ill-effects as it even changes the topography of habitat, which has already been demonstrated to be an important habitat-selection characteristic for Ceruleans in the mountains (CW8).
- I am not familiar with the location of most water development activities for TN and, therefore, don't know if ranges of activities and CERW distribution would overlap much. Forestry at local scales definitely causes takes, but its impact at regional scales can be lower (or higher) depending on the cumulative size/distribution of harvests. Forest conversion in winter habitats is a big concern. With the price of coffee dropping, many farmers in the Andes are converting shade-coffee plantations (which support CERWs) to pasture, which are not used by CERW. Andean forests continue to be heavily fragmented as well. On the breeding grounds, mountain-top mining is the number one serious threat in my mind right now. I think it has the potential to devastate CERWs (CW12).

5. Which landuse practice is most threatening and has the greatest potential to cause take over the next 10 years?

Numbers are percents of the total survey participants and are rounded to the nearest whole numbers.

Species	Forestry	Mining	Water Development	All of above	None of above	Unable to answer
Cerulean Warbler (N=13)	27	65		8		

Comments by survey participants regarding their answers:

Mining

- Mining has the most potential to cause take for Ceruleans. This is mainly because of the increased size and frequency of mines in the region and the current reclamation procedures that reclaim areas to open grasslands. Not only will thousands of acres of forest be lost to mining, but the poor soils and thick herbaceous cover planted to prevent soil erosion cause the succession of these areas back to mature forest to be extremely slow. It is also possible that the increased grassland habitat will lead to increased nest parasitism by the Brown-headed Cowbird (CW1).
- While unsustainable forestry practices may have posed the greatest threats to CERW thus far, increased mining seems more imminent. Furthermore, if this mining is concentrated on surface mining operations, where large amounts of forest are razed and locked in early successional stages via reclamation practices that rely on non-native vegetation, mining may turn out to be the greatest threat in the next ten years (CW4).
- The rate of CERW habitat loss to surface coal mining in Tennessee is likely to increase substantially in the next 10 years. There is an anticipated increase in future demand for Appalachian coal due to the planned construction of flue gas desulphurization units (scrubbers) at some of the existing coal-fired generating plants owned by the Tennessee Valley Authority (TVA 2002) and other electric utilities in the region. This increase in mining activity has already begun in Tennessee. Between 1992 and 2002 the Office of Surface Mining issued permits for 3,704 hectares of surface mines. Between December 2002 and October 2003, over 2,023 hectares of surface mining permits had already been approved (Siddell 2003) (CW10).
- As I understand it, the most profitable areas to mine overlap substantially with the current distribution of CERWs and there is the potential to see a quick and tremendous increase in mining activity. Although forest practices/fragmentation on wintering grounds remains a cause for serious concern, I see less potential for dramatic changes in land use practices compared to mountain-top removal mining (CW12).

Both forestry and mining

- It's quite hard to choose one of forestry and mining given the pervasiveness of both threats. Focusing on one and not the other will greatly limit the effectiveness of habitat management plans (CW5).
- Still uncertain about the extent to which these will be undertaken over time, but in a given area I would undoubtedly expect mountaintop removal to cause more take on a 100 acres of land than a 100 acre timber harvest would (the extent of this likely depends greatly on the type of timber harvest to be done, which was not specified). I do not believe clear cutting is the only incompatible type of timber harvest (CW8).
- Forestry and mining collectively have potential to be of great risk to CERW and its habitat. Though mining may represent a higher threat in terms of a "per-operation" impact, forestry (lack of proper management) arguably impacts greater acreages. It would be difficult with current data to ascertain which is greater . . . the location of actual mine sites would play into this assessment. Obviously those planned for core CERW breeding areas represent significant potential for harm to the species (CW9).

6. Are you aware of any landuse activities other than logging, mining, or water development that are causing take of the Cerulean Warbler now, or are likely to cause take in the next 10 years?

- Natural gas pipelines and pumps (?) are being installed in increasing numbers in the Cumberland Mountains. The disturbance area created by these activities is quite small (~1

acre at each pump and wide roads for access), but there are quite a few being installed, and the effects should be monitored. At least the footprint (e.g. acreage) should be estimated and considered as part of the cumulative impact of forest disturbances in the region (CW1).

- Human development in the area- commercial, industrial, residential, and transportation (CW2).
- No (CW3, CW13)
- No, these, especially forestry, and then maybe mining, are the major landuses that impact areas of forest large enough to support this species, whether presently or in the future (CW4).
- Wind farm development, depending on density of windmills and their placement (CW5)
- Increased development as people realize the quality of the area as a place to live; land is still relatively cheap up there (CW6)
- I am not familiar with the entire Cumberland area, but in the rangewide scheme of things for Ceruleans anything that disturbs forested habitat may be causing take (residential development, agricultural expansion, etc) (CW8)
- Again, though I don't think that anyone can document take of an actual bird, its apparent that residential development and urban expansion will impact CERW and its habitat through cumulative degradation and loss of forested habitats required by the species. There is no doubt that home construction and urban growth chew up forest habitat, some of which is very likely to be used (or could have been used) by CERW (CW9).
- The potential impact of wind turbines on CERW is unknown (CW10).
- See above description in 2. of Michigan studies (CW11).
- Possibly wind farms along migratory pathways. Of course, we don't have a good understanding of their migratory routes. Window/tower/building collisions during migration. One could speculate about cumulative impacts from climate change and the anthropogenic activities that contribute to that climate change, but I have no empirical evidence to support those speculations (CW12).

7. If not answered in the tables in questions 1-3, specifically how is take of the Cerulean Warbler linked to the landuse practices that you selected in questions 4-6?

[A hypothetical (fabricated) example of the detail needed for this question follows: clear cut logging practices remove large (give minimum dbh) trees that adult Cerulean Warblers need for establishing breeding territories, etc.]

- As stated above, the fine scale habitat needs are not exactly known for this species (at least by me). It is the sheer loss of mature forests that will have great future impacts on this species. Ceruleans that occur in less forested regions (i.e. Mississippi Alluvial Valley) have much lower nest survival rates than those observed in this region currently (CW1).
- Clear cut logging practices remove large (60 cm dbh) trees that adult Cerulean Warblers need to establish breeding territories. Inadequate landscape planning of silvicultural activities result in forest fragmentation, isolating breeding populations into smaller patches possibly creating source-sink situations (CW3).
- See comments above and throughout tables (CW4).
- See above comments in tables (CW6)
- Incompatible forestry and mining remove mature trees (60+ years old) that breeding Cerulean Warblers require to establish breeding territories. Mountain top removal mining

alters and removes the topographical variation in the Cumberlands that has been demonstrated to be selected for by breeding Ceruleans. Both of these practices can increase the presence of nest predator species and brood parasites in the remaining habitat surrounding the harvested areas, thereby reducing productivity for this species (CW8).

- I think the above comments explain the mechanisms (CW9).
- Forestry – (CW12)
    - Even-aged management practices (clearcut, seed tree, or very low density shelterwood) remove large trees and mature forest structure that CERW require.
    - Single-tree harvesting that approximates high-grading removes large trees that CEWR require for breeding.
    - Conversion to non-forest habitat – is not viewed as habitat by CERW.
    - Fragmentation of forest, which allows predators and brood parasites to have greater impact on reproduction.
    - Reduced patch size of mature forest areas might reduce number of CERW that can occupy a site. In Ohio, we suspect that CERW may show strong conspecific attraction, which might be one mechanism of a preference for large forest blocks
- Mining – (CW12)
    - Removes forest habitat and CERW cannot breed there (no trees = no CERW)
    - Fragments remaining mature forest habitat in unparalleled way, which can increase presence/impact of predators and parasites.

8. Is take of the Cerulean Warbler occurring in ways not related to any particular landuse activity?

[For example, low levels of take occasionally occur when fishermen unwittingly collect blackside dace (a federally listed fish species) in minnow traps while collecting minnows as fishing bait. This type of take would not be related necessarily to a particular landuse (unless road/trail development afforded greater access to blackside dace streams).

- Not that I know of (CW1)/ No (CW3)/ Not to my knowledge (CW4)/ Not that I'm aware of (CW6)/ If I understand your definition of land use here, then I do not believe any recreational (non-landuse activities) are causing take (CW8)/ Unaware of any; most take is going to be proximately or ultimately related to human-induced land-use alteration (CW9)
- Natural disturbance cycles may take habitat and birds on occasion- catastrophic winds (tornados) and fire (CW2).
- Attraction to lighted structures (e.g. communication towers) during nocturnal migration (CW5)/ In TN there is likely take caused by collisions with communication towers (CW10).
- Perhaps through control of forest pest species (i.e., reduction in food resources), or maybe on wintering grounds through various means; unsure if definition of "landuse" includes collisions with towers, wind turbines, buildings, but if not, then include those as take (CW7)
- Unsure (CW12)

9. Are you aware of any strategies that could be used to either (a) minimize take or (b) completely avoid take of individuals or habitat?

- Do not carry out mountain-top removal mining that creates very large openings (CW1).
- Limit the width of contour surface mines where possible (CW1).
- Reclaim mines to forests (CW1).
- Harvest fewer than 1000 acres of timber per year (CW1).

- For this species, habitat loss from anthropogenic and natural sources is going to happen all the time- the real question is how do we maintain a sustainable supply of suitable habitat over time given the land uses that occur today and are likely to occur in the future- a major question for the HCP to address. Take can be managed in a reasonable way with careful planning in terms of what land uses are permitted and where they can operate and over what time frames (CW2).
- Effective landscape planning could minimize take (CW3).
- Avoid large-scale mining activities (e.g. mountain top removal) (CW4).
- Reclaim mines to native forests rather than non-native dominated scrub/grasslands (CW4).
- Single-tree selection silvicultural methods, if used more often, would reduce the amount of forest area loss and reverting early-successional habitat. These strategies could be employed especially at higher elevations (CW4).
- Stop mountain top removal mining - a pipe dream, I know (CW5).
- Foster development of habitat mitigation strategies following mining operations (CW5).
- Adopt silvicultural practices that generate canopy heterogeneity while leaving sufficient basal area for song post and nesting trees (CW5).
- Ideally, timber companies and land managers would be restricted to such silvicultural practices that are compatible with CERW conservation in areas where they are abundant. This may include smaller patch cuts that leave a certain percentage of the dominant trees (CW6).
- Also, it would be very helpful to be able to ban strip and cross-ridge mining and encourage management of existing strip benches to regenerate hardwood forest. Unfortunately, this level of legislation would only be possible if the CERW were to be listed as an Endangered Species (CW6).
- To minimize take a very selective timber harvest may be the best option. Studies are under way to attempt to assess the effect on these birds. It remains uncertain whether a low level of harvest can occur, without negatively affecting reproduction. The degree of harvest that may be able to occur w/o damaging reproduction likely is also dependent on the surrounding landscape (forest patch size, fragmentation, development, etc). The only way to avoid take is likely to refrain from pursuing the detrimental activity (CW8).
- Forestry management practices to benefit the species are currently being investigated, but the general consensus is that habitats need some form of management that promotes mature hardwood forest, with canopy gaps or other structural complexity, and that may favor development of super-emergent canopy trees (often along ridgelines) (CW9).
- Regarding mining, I don't think its real promising yet, but people are exploring ways to improve reclamation practices to promote regrowth of "native forest" as opposed to cool-season grasses, conifers, etc. Best way to improve MTRVF mining is to stop it . . its devastating (CW9).
- Forest Practices: Dr. David Buehler, UTK, is currently involved in a 5-state research project initiated by the Cerulean Warbler Technical Group (CWTG) to determine what forest management practices are beneficial or the least damaging to CERW breeding habitat. The goal of this research is the development of forest management guidelines. Voluntary adherence to these guidelines could reduce take. Legislative requirements to follow these guidelines in areas of high CERW breeding density would minimize and potentially avoid take (CW10).
- Surface Mining: A designation of Lands Unsuitable for Mining for areas of high CERW breeding density would be the only means of avoiding take. A legal requirement to reforest mine sites that were formally CERW breeding habitat could theoretically provide habitat for CERW in 60 to 100 years or more. While reforestation would not replace breeding habitat

in a reasonable amount of time, it would have the advantage of reducing the impact that the mine site would have on the breeding density of the CERW in the adjoining forest (Weakland and Wood 2002). Reforestation would also reduce the threat of BHCO parasitism in the adjoining forest by removing potential foraging habitat (CW10).

- Forestry – Local: favor retention of large diameter trees and creating complex canopy structure; Landscape: Plan harvests at landscape scales to ensure the maintenance of large forested blocks of mature forest. If necessary, don't allow harvesting in certain key/ideal habitats (CW12).
- Mining - Avoid mountain-top removal mining. Reduce footprint of mine when possible. Avoid placing mine in areas known to have CERW or within high-quality CERW habitat (CW12).
- Work with Surface Mining to have trees cleared outside the nesting season and develop post-mining landuse of forestry with proper reforestation guidelines (CW13).

10. What mitigation strategies might be appropriate to offset take, if an incidental take permit were to be issued for some particular landuse activity?

- Do not carry out mountain-top removal mining that creates very large openings (CW1).
- Limit the width of contour surface mines where possible (CW1).
- Reclaim mines to forests (CW1).
- Harvest fewer than 1000 acres of timber per year (CW1).
- I think that if a landowner was to ensure a certain amount of habitat would be maintained in a state suitable for Cerulean Warblers, then land use on other acres or land use compatible with ceruleans on dedicated acres would be permissible (CW2).
- All of the example strategies: (preserving current habitat through an easement or purchase, restricting access to lands, creating buffers around existing habitats, restoring degraded areas to provide suitable habitat, creating new suitable habitats, and modifying landuse practices) some combination of these would probably be most effective (CW3) would be useful but their utility will be very site and context specific (CW5,CW6).
- The Cumberland Mts. make up a unique physiographic province that includes a large percentage of the quality breeding habitat for the CERW worldwide. For this reason, habitat altered in the Cumberlands (due usually to mining and logging) would have to be mitigated by purchasing other land in the Cumberlands, protecting it, restricting access, and using only such management practices that would be compatible with their conservation. This land would also need to be only in suitable CERW habitat within the mountains, which includes high elevation ridges in mixed mesophytic forest (right where the coal is). Purchase of such property would be incredibly expensive because the mineral rights are worth more than the surface, timber, or wildlife rights combined on any of these lands (CW6).
- Providing incentives to mine companies to reclaim to diverse hardwood forests without severe compaction of soils (CW7).
- Protecting current habitat/adding buffers/ and restricting destructive access might be the most appropriate actions. Quality Cerulean habitat cannot be created quickly…..it may take 60 plus years to create an appropriately aged forest….where do the birds breed in the meantime (CW8)?

- Mitigation through easements and acquisition would have to focus on creating new habitat. Purchasing X acres of existing habitat to destroy Y acres of some other existing habitat still results in a loss of habitat. Unless those X acres are under a very real threat of development or loss, mitigation needs to focus on restoration and management of habitats (CW9).
- Mitigation could also take the form of modifying mining or forestry plans where significant breeding populations might be impacted; creating buffers around existing breeding habitat, etc. Mitigation or assessment of impacts needs to consider that even if forests that currently don't have CERW are impacted, that the future potential of those areas is now lost in supporting conservation of the species (CW9).
- Home development should proceed in low impact ways …. retention of native trees and habitats in developments and homesites . . . minimized clearing; minimal roads, trails, lake development, etc. Land developers should be required to alter plans if CERW habitat is to be impacted (CW9).
- Preserve as much of the high breeding density habitat in the Cumberland Mountains as possible through easement and direct purchase of mineral rights (CW10).
- Require timber management companies and state entities to follow the forest management prescriptions recommended by the Breeding Season Research Group of the CERW in high breeding density habitat in the Cumberland Mountains (CW10).
- Require surface coal mines in high breeding density habitat in the Cumberland Mountains be reforested with a diverse mix of native hardwood species (CW10).
- Top two: Protection of mature forested areas, creating low/no development buffers around high quality existing protected areas (CW12).
- Others – manipulate forest structure to (hopefully) improve quality for CERW (this has not yet been demonstrated to be successful) (CW12).
- Setting aside other tracts of land where CERW are known to nest as mitigation, reforesting, or using silvicultural practices on existing forests to improve CERW habitat (CW13).

11. What are the major natural/ecological sources of stress or mortality for the Cerulean Warbler that may only be indirectly related to human activities?

[For example, altered physicochemical conditions might favor a predator or competitor (either native or nonindigenous) that displaces the Cerulean Warbler.]

- Increased predator abundance near edges. Increased nest parasitism by Brown-headed cowbirds as forest cover declines in a region (CW1).
- Gypsy moth mortality to oaks, sudden oak decline, or other pathogens impact on other deciduous trees could account for additional habitat loss (CW2).
- Decrease in forest patch size and increase in forest fragmentation could result in higher incidence of nest parasitism by brown-headed cowbirds (CW3).
- In general, on their breeding grounds, areas-sensitive species, when forced to breed in sub-optimal habitat due to fragmentation and edge effects, are subjected to direct habitat loss, habitat structural shifts, competition with non-area-sensitive bird species, brood parasitism by Brown-headed cowbirds, to name a few. These impacts all negatively affect reproductive success of CERW in the region. CERW may also be affected in other ways that are more species-specific (CW4).

- Migration pressures (e.g. suitable stopover habitat to facilitate energy acquisition), perturbations during the non-breeding season (both habitat and non-habitat related factors), unpredictable weather events (e.g. ice storms, hurricanes during fall migration) (CW5).
- Climate change or large storms that destroy nests, kill adults; late frosts that kill insects, their primary source of food on the breeding ground; large mast crops which promote higher squirrel density, (potential nest predators) (CW6).
- Increasing permeability {through road construction, habitat fragmentation, etc.} of forest tracts to predators, cowbird parasitism, and invasive species (CW7)
- Cerulean Warblers may be negatively impacted by increased predator populations (American crows, Blue Jays, etc) resulting from habitat fragmentation by agriculture, development, etc. Nest parasites (Brown-headed cowbirds) now have easier access to nests now that many forests are highly fragmented. Roads and the creation of habitat edges likely facilitate the dispersal of both predators and parasites to nesting areas that were historically isolated from these pressures. Habitat fragmentation and silviculture have been shown to increase the presence of nest predators and parasites (CW8)
- Depends on where you draw the line for direct/indirect impacts. Home development, urbanization and agriculture – even if not directly impacting birds of their immediate habitat – can bring things like increased recreation and disturbance, cats/feral cats, brown-headed cowbirds, higher populations of raccoons, chipmunks and other possible predators, etc. These are the most likely sources (CW9).
- The Brown-headed Cowbird (BHCO) is a known nest parasite of the CERW. When forest is fragmented or when forest cover drops below 75-80% then the occurrence of cowbirds will likely increase. For instance, the Cumberland Mountain region is ~80% forested but BHCO have been observed on larger surface coal mine sites revegetated with grasses (CW10).
- I hypothesize that reducing forest size exposed CERW to food and perhaps nesting competition with socially dominant warbler species, e.g. Yellow Warbler (Dendroica petechia), Chestnut-sided Warbler (D. atricapilla), and American Redstart (Setophaga ruticilla) (CW11).
- Soil chemistry? At the last Cerulean summit, someone mentioned that CERW in their state (VA or NC?) corresponded to limestone outcrops. That makes me wonder if they might be sensitive to soil pH via impacts on arthropods (as shown with Wood Thrush by the Hames et al. at Cornell Lab of Ornithology). Natural Disturbances – windstorms/windthrows/ice storms all change forest structure. Storm events during migration (CW12).
- Possibly clearing patches and allowing Brown-headed cowbirds to more easily parasitize nests (CW13)

Natural/ ecological source of stress or mortality	Brown-Headed Cowbird Parasitism	Increase in Natural Predators (Squirrels, Blue Jays, Crows, etc.)	Un-predictable Weather Events	Migration Pressures	Gypsy Moth/Oak decline	Competition with more dominant Warblers/American Redstart	Soil Chemistry / soil ph impacts on arthropods
Percent of survey participants (N=13)	54	23	23	8	8	8	8

12. For the Cerulean Warbler, what is the best way to survey individuals or populations of this species?

- Point count or transect surveys during the breeding season (May-June) (CW1)
- Identify and delineate suitable habitat and monitor how that changes over time. Determine the densities of birds occupying suitable habitat (breeding bird censuses) and determine population trend over time (CW2).
- Individuals – Point Counts (territorial male song surveys in breeding season (CW3).
- Population – Same as above and nest searching (productivity) (CW3)
- Population-level assessments via point counts or transects. Habitat quality assessments via forest structure monitoring efforts (CW4).
- In increasing order of information gathered: point count surveys, spot mapping, nest searching and monitoring, marking of individuals to document site fidelity and adult survival (CW5).
- Combination of spot mapping and point counts. You can get an estimate of CERW presence by doing point counts and encounter surveys along transects, but I believe that intensive spot mapping is the best way to gauge the number and relative size of territories in an area. This method is very labor-intensive, but very informative (CW6).
- Focal species approach, similar to methods of Cerulean Warbler Atlas project (CW7)
- There is no great answer for this species. I have used the following method for learning about a localized population. We used plots containing survey transects 200 meters apart. These need to be surveyed once it is believed most birds have completed migration and are somewhat settled into territories. This is easier once you have worked a study area for a season. The key is also completing multiple surveys before the breeding season begins to wind down and detection rates plummet. The problem with this type of data is that it may be difficult to extrapolate over a larger study area as Ceruleans often appear to have a "clumped" distribution and may not use all habitat….at least what we think is habitat. Because of this it may be beneficial to supplement with point counts spread out over a larger area to get an idea of the variation in distribution (CW8).
- Standard Point Counts on breeding habitat. Protocols well described and documented (CW9).
- That would depend on what you are trying to do with the surveys. The BBS yields trend data but on a fairly coarse scale. The survey techniques employed by Weakland and Wood (2002) and by the 5-state forest management study, being conducted by the CWTG, allow assessment of population response to management and land use activities as well as yielding trend data (CW10).
- Point counts on the breeding grounds (CW11).
- Distance-based surveys that allow estimation of detection probability. However, without complementary studies examining reproductive success, one cannot be sure that areas of high density are in fact of high quality (CW12).
- Some sort of line transect or point count method where the area is surveyed during the breeding season (CW13).

13. What is the best way to monitor its habitat and habitat conditions?

- I am unsure (CW1).
- Habitat can be modeled and monitored through remote sensing in most cases, especially if you can account for new disturbances from some baseline point (CW2).

- Remotely via GIS, habitat modeling, etc. (CW3)
- By assessing changes in populations over time alongside changes in forest habitat quality (CW4)
- Follow and monitor bird populations. The reproductive success of populations will tell you if your habitat strategies are working. It is not enough to count the number of singing males (CW5).
- In addition to surveying populations and reproductive success, conduct a series of randomly located, fixed radius vegetation plots that can be revisited from year to year to assess changes; compare these conditions to habitat characteristics of territories and nest sites (CW6).
- Multi-scale approach: look at rangewide changes in forest distribution, regional scale at a higher resolution, and local scale habitat plots (CW7).
- I believe remote-sensing is the most valuable tool known that many ground-based projects have been completed. Ground-based data collection should still be utilized to complement data gathered remotely. Advances in better resolution and new types of data gathered remotely hold the most promise for better understanding the habitat in the future (CW8).
- Currently under development. Remote sensing can provide gross information on amount/extent of habitats available or under threat. At some point, stand-level information from forests becomes necessary to determine if appropriate forest structure exists. To a large degree, presence/absence/abundance/density information of the warblers themselves is the best determinant if habitats are "correct" (CW9).
- Measure nest success under varied forest condition, and in different geographic regions. Determine vegetation structure (canopy, subcanopy) st different spatial scales, and determine tree species richness in preferred habitat (CW11).
- Lydar might be promising as a way to monitor remotely, given its ability to detect subtle features of canopy. Otherwise, probably ground-based surveys of basal area, tree size distribution, canopy structure. As said above, what determines habitat “condition” ultimately is the ability of birds to survive and reproduce. This ability is determined partly by interactions with other species (predators/brood parasites) and will never be completely captured by habitat-only surveys (CW12).
- Vegetation measurements such as percent canopy/shrub cover, dbh, spp. composition (CW13).

14. Are you aware of other imperiled species that are immediately syntopic or sympatric with the Cerulean Warbler on the Cumberland Plateau?

- Indiana Bat. On a completely unrelated note, have there been recent surveys for Green Salamanders in the Cumberland Mountains? There are lots of exposed, damp rocks up there and this species listed as “vulnerable” in TN. I doubt that much is known about its abundance in the region (CW1).
- The only other listed species that might be associated with ceruleans is the Indiana Bat. At this point, we don’t know enough about the distribution and habitat use of Indiana Bats in the HCP area to know to what extent the two spp. might be correlated (CW2).
- Indiana Bat. Yes, I presume this species would suffer negative impacts of losses of the same forest types, but a bat expert would shed more light on how and when (CW4).
- As far as I know, the Indiana bat occurs in very similar areas to the CERW, and would also be at risk for the same reasons (habitat loss, alteration). In addition, many species of mature

forest birds, herps, and mammals would be adversely affected by permits for logging, mining, etc. Protection of habitat for species such as the Indiana Bat and Cerulean Warbler can enable them to act as umbrella species for many others that are affected (CW6).

- Indiana bat, Louisiana Waterthrush, Worm-eating Warbler, Kentucky Warbler, Wood Thrush, Yellow-throated Vireo, Acadian Flycatcher, numerous salamanders —loss of diverse upland forests and alteration of structural diversity would impact these species as well. It would eliminate or reduce quality of breeding, foraging, and roosting sites. Impacts to watershed would impact streams with endangered mussels and fishes too (CW7).
- Plenty of other non-birds (mussels, bats) . . . several other priority species of birds that inhabitat similar habitats. Golden-winged warbler would be one (CW9).
- The entire suite of mature forest birds of high conservation concern share breeding habitat with the CERW. The Louisiana Waterthrush, Worm-eating Warbler, Kentucky Warbler, Wood Thrush, Yellow-throated Vireo, Acadian Flycatcher are all at or nearly at their maximum breeding density within the Cumberland Mountain portion of the Cumberland Plateau (USGS 2003). They are all listed as priority species by Partners in Flight and all are also classified as Birds of Conservation Concern by the U. S. Fish and Wildlife Service (USFWS 2002) within the Appalachian Bird Conservation Region, which includes the Cumberland Plateau. These species would also be at risk of take if the Cerulean Warbler were to be covered by an incidental take permit for logging or mining (CW10).
- Not sure on Cumberland, but in Ohio they strongly co-occur with Yellow-throated Vireo. YTVI also favor habitats with open canopy structure (CW12).
- Several interior forest bird species would be covered. Also several shrew species and herps (particularly amphibians) (CW3)
- Best answered by those working there…I have never worked with some of the other species there (CW8).
- No (CW11).
- CERW habitat is very similar to that of Indiana Bat (CW13).

15. Uncertainty Regarding Species Ecology: Our current state of Cerulean Warbler knowledge rated by survey participants.

Values are percentages that are rounded to the nearest whole numbers.
Highest percentages are in shaded boxes.

	Well Known	Moderately Known	Poorly Known	Completely Unknown
Identification N=13	85	15		
Distribution N=13	54	46		
Abundance N=13	15	69	15	
Habitat requirements N=13	15	62	23	
Ecological interactions N=13	8	46	39	8

Behavioral patterns N=13	23	31	46	
Reproduction N=13	23	31	46	
Early life history N=13		31	46	23
Adult life history N=13	39	8	54	
Migration/stopover ecology N=1 (CW12)				100[a]
Wintering ground ecology, survival, distribution [b] N=1 (CW7)			50 [a]	50 [a]

[a] -Not enough values to be a significant percentage.
[b]-Participant did not rate this aspect of life history.

Comments from survey participants based upon levels of uncertainty:

Distribution

- We still need to study their migration/wintering range more closely (CW6).
- Finer-scale approach to CERW Atlas project (CW7).
- Well known for breeding, poorly for wintering (CW12).

Habitat requirements

- We're working on fine-scale preferences, such as canopy gaps, tree species/structure, proximity to large edges, etc (CW6).
- Generally known would be a better way of describing this (CW9).

Reproduction

- Canopy cameras at nests (CW7)
- Fledgling/Juvenile stage and habitat requirements needs study (CW13).

Early life history

- We still lack a good way of getting to and banding juveniles to follow them post-fledging (CW6).
- Post-fledging telemetry (CW7)
- Survival ??(CW8)
- May even be completely unknown (CW12).

Adult life history

- Winter habitat use and distribution may be less well-understood than the breeding habitat (CW4).
- Survival ??(CW8)
- Winter habitat not well known although is currently being studied (CW13).

Wintering ground ecology, survival, distribution

- I would put this somewhere between poorly known (we know some of the winter distribution and survival info) but wintering ecology is almost completely unknown and there's not enough known about the others to really bump it up too much (CW7).

16. For the Cerulean Warbler, would it be better (or more practical) to set biological goals and objectives and design monitoring protocols that are individual-based or habitat-based, or both?

- I would say **individual-based**, but this is a tough question. It would be much cheaper and easier to simply try and maintain the predominant cover of mature forests in the region. To specifically survey for this species would provide a great deal more knowledge about the true abundance of this species before, during and after disturbances as well as make known any of the indirect effects of forest disturbance that may occur (CW1).
- **Both**- the habitat base can be readily monitored but the actual population levels may continue to decline because of wintering grounds limitations. Therefore, you really need to know both (CW2).
- **Habitat-based** – we have good information on where populations of these birds are; we need to design monitoring protocols that monitor landscape change over time (CW3).
- For population-level monitoring of an area-sensitive songbird, **habitat-based** monitoring protocols (CW4).
- You have to do **both**. There's no point monitoring birds if there isn't a habitat mandate. No point managing habitat if you're not tracking the birds' response (CW5).
- I think **individual-based** monitoring will give you a good idea of the abundance of the CERW in an area, which can be assessed from year to year to see if they are increasing or decreasing in abundance due to management. However, **habitat-based** monitoring can also be useful to characterize suitable CERW habitat in other areas and to target areas for purchase or protection (CW6).
- **Both**: problems may not be limited solely to breeding habitats so need to set goals based on the species and monitor success, but also on the habitats to monitor responses on breeding grounds (CW7).
- **Habitat** monitoring would likely be more practical…especially when remotely-sensed. However, I do not believe that the habitat requirements are well-enough understood to forgo population monitoring (population estimates and productivity). My experience with my work and the literature leads me to believe that habitat patch size may be a critical aspect of reproductive success, but we have not arrived at a minimum patch size for this species. This value may also vary regionally (see Ontario research), possibly as a result of differences in predator/parasite populations (but that remains unknown) (CW8).
- Typically, those involved in setting goals and objectives relative to Cerulean Warbler and similar bird species use an approach that attempts to link populations to **habitat**. That is, establish population-based goals/objectives and tie these to habitats so that quantitative habitat goals/objectives are achieved. This is done usually because its easier to estimate and track habitats and habitat characteristics than it is to estimate/track populations of birds (CW9).
- What is ideal is to measure reproduction (**individuals**) under variable habitat conditions (**habitat**), to determine factors affecting reproductive success (CW11).

- **Both** used together. Habitat-based ones are tricky because there are a lot of anecdotal reports of places that "look great" for Ceruleans, but the birds just aren't there. So habitat-based work will likely overestimate how effective practices are. That requires that we have some information about the actual distribution of birds (CW12).
- Probably **habitat** based since enough research has been conducted to know the general conditions needed for nesting/fledgling habitat (CW13).

	Individual-based	Habitat-based	Both
Percent of survey participants (N=12)	8	42	50

17. In your estimation, what aspects of Cerulean Warbler biology/ecology/status are we most uncertain about? What would be the best way to obtain such knowledge?

- We are not sure how the distribution, reproduction and abundance of the Cerulean will be affected by different types of timber management. There is currently a research project occurring to assess this in the Cumberland Mountains (CW1).
- Data on survival is lacking for the Cumberlands (CW2).
- What is a "viable population". Do we have a source-sink situation (CW3)?
- Fine scale habitat requirements on breeding grounds and distribution/habitat use in the tropics during winter. More research, more costly research, unfortunately (CW4).
- Female survival and demography, post-fledging behavior and demography, intrinsic limits to fecundity, natal and breeding dispersal, migration routes. Put money into basic research as well as habitat management; require land users to collect more than occupancy data when assessing the effects of management or mitigation (CW5).
- See comments above. The CWTG study will be helpful in determining CERW habitat preferences across their breeding range (replicates in TN, WV, OH, KY and PA). One goal of this project is to characterize suitable CERW breeding habitat and be able to recommend compatible silvicultural management treatments after assessing the effects of the experimental treatments on cerulean populations and reproductive success. To learn more about their migration and wintering ecology, more large-scale studies need to be conducted in Central America northern S. America. I'm not sure how to develop an effective, safe way to catch females and juveniles, without harming either the researcher or the birds. In some areas of the breeding range, they don't nest quite so high (ON), so researchers are often able to extract and band nestlings (CW6).
- Responses to forestry practices, post-fledging ecology, and wintering ecology. Regional collaborative projects for both—pooling resources is key to study species broad-scale (CW7).
- In areas where productivity is poor, specific and direct causes of nest failures are seldom documented. The best remedy would include intensive infrared camera monitoring coupled with close and direct monitoring of nest contents. We also know virtually nothing about the survival of juvenile and adult birds, which is critical in estimating population viability (CW8).

- Juvenile dispersal patterns. Habitat use and ecology on the wintering grounds. Don't have a good handle on overall population size, and may also be unaware of certain breeding populations.
- Don't know what factors are most limiting on the breeding grounds. Despite the uncertainties, one thing is clear. To the degree we can preserve and manage significant chunks of habitat, we don't need to be certain about all these things. Pushing the warbler to a place where we are forced to micromanage it necessitates a detailed ecological understanding. Creating dynamic, functional ecosystems and not managing on a species-by-species basis is where the answer lies (CW9).
- Female and post-fledging ecology (CW10)
- We are unsure about why reproduction seems to be below sustainability everywhere in the breeding range. Why is reproduction always so poor? Unfortunately the CERW remains largely an enigma is this important regard (CW11).
- Demography. Especially how survival and reproduction are related to habitat characteristics. This is critical piece of info needed to identify causes of CERW declines. Winter ecology. Especially what are their requirements in winter, where are the most important areas for them, and how they respond to land use changes on wintering grounds. Migration ecology. We don't know important migratory pathways and stopover areas. It's possible that mortality during migration is the driver of declines. We don't know. Both require ecological research (CW12).
- Once young fledge – what are the important habitat characteristics needed? - could radiotag young; What is CERW survival on wintering grounds? (CW13)

Acronyms used in this document

- BBS - Breeding Bird Survey
- BHCO - Brown-headed cowbird
- BMPs - Best Management Practices
- CERW - Cerulean Warbler
- DBH - diameter at breast height
- GIS - Geographic Information System
- HCP - Habitat Conservation Plan
- MAV - Mississippi Alluvial Valley
- NTMBs - Neotropical Migratory Birds
- Spp - Species
- WMA - Wildlife Management Area

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-Trisha Johnson