

Dendroica cerulea: *Biology, Distribution,* *and Demography*



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[+CERW Technical Group!](#)



This talk represents the synthesis of our knowledge to date contributed by many of the CERW experts, most of whom are in the audience today. I am going to summarize what we know about the status of Cerulean populations including the most current info about distribution, population trend and size, and then summarize our general knowledge of breeding habitats at different geographic scales. In the talks that will follow we'll hear more details about specific habitat relationships and also the little that we know about demographics.....

Cerulean Warbler: Biology

- Wood Warbler (Parulidae)
- Neotropical migrant
- 8-10 g
- Single-brooded
- Canopy-nester
- PIF Watch List
- USFWS Focal Species



Cerulean Warbler: distribution

- Breeds in eastern North America
- Winters on east slopes of the Andes in northern South America
- Migrates through Central America and Gulf Coast of U.S.

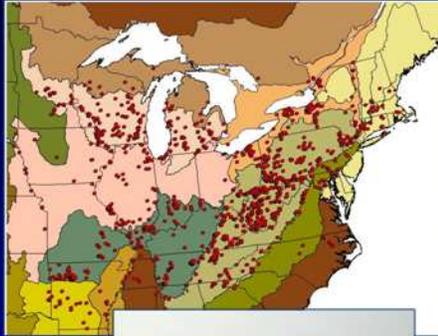


As you probably know, the breeding range of the Cerulean is throughout most of eastern US and southeastern Canada and wintering primarily on the east slopes of Andes of Northern South America. We know very little at present about migration pathways and concentration areas. This will be the subject of a later talk in this symposium and we will also hear several presentations on wintering ground information.

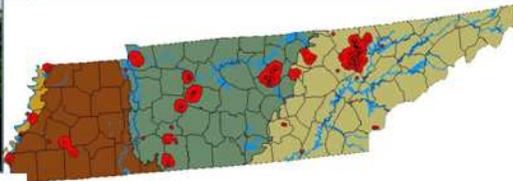
Cerulean Warbler Atlas

(1997 - 2001)

3,000 sites surveyed, range-wide



<u>No. pairs</u>	<u>State/Prov</u>	<u>Site</u>
430	TN	Royal Blue Wildlife Management Area
325	NY	Montezuma Wetlands Complex
300	IL	Kaskaskia River
240	TN	Center Hill Lake, Edgar Evins State Park
200	IN	Big Oaks NWR
200	IL	Shawnee National Forest
200	OH	Queens Univ. Biological Station
175	MI	Kalamazoo River, Allegan St. Game Area
165	NY	Alleghany St. Pk. And vicinity
145	TN	Frozen Head State Park



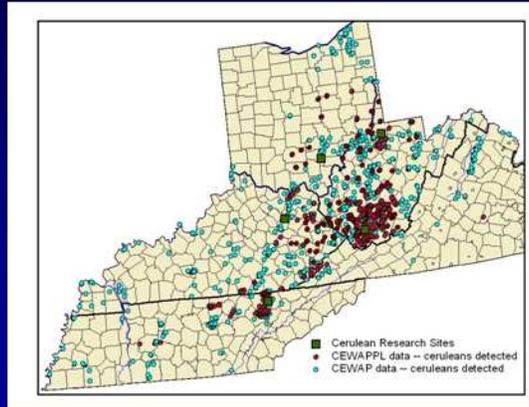
QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

TN -- 1,100 pairs at 530 sites

Surveys on Private Lands (2003-2007)

Proactive partnership with industry – NFWF grant to NCASI

- Surveys conducted at roughly 2,800 sites.
- Ceruleans were located at 30% of all sites surveyed.
- 581 Stratified random samples in core of range for habitat model.



To fill in gaps within the core of the range, which includes vast areas of private lands, we have been partnering with forest industry groups and the NFWF to engage private landowners in surveying for Ceruleans in these areas. This work is ongoing and is designed to inform habitat modeling and forest management research.

Figure 3: Cerulean Warbler Atlas Project for Private Lands (CEWAPPL) data from all years overlaid with Cerulean Warbler Atlas Project data, positive occurrences of ceruleans only.

We collected data at a total of 581 points, with one or more Cerulean Warblers detected at 169 points (29%; see Figure 4.) These sites were distributed across Kentucky, Ohio, Tennessee, and West Virginia, with the bulk in Kentucky (150) and West Virginia (240).

CEWA Population Estimates

Extrapolate from BBS relative abundance

Each stop = 400m
radius "point count"

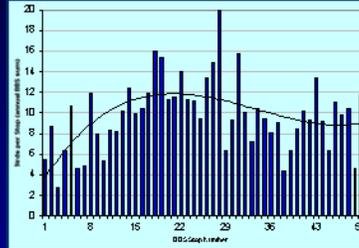


50 stops = 25.1 km²

Cerulean Warbler detection class = 120m;

BBS route = 2.5 km²

Pair correction = 2.0



Time of day correction = 1.38

**Total "BBS" population estimate for
Cerulean Warbler = 570,000 individuals**

So switching now to pop size...As part of the development of the North American Landbird Conservation Plan, PIF derived the first estimates of total pop size for all north American land bird species. Relative abundance data from the BBS was used to extrapolate to population size. By treating a BBS route as a series of point counts with a 400 meter radius the total potential area surveyed by each route is 25 square Kilometers. We applied a series of correction factors that accounted for the detection distance of each species – so for Cerulean the detection distance is 120 m reducing the area surveyed by the BBS route to 2.5 square kilometers. We also applied a time of day correction accounting for the peak period of singing in the morning and assumed that each bird counted on the BBS represented 1 member of a breeding pair. Using this method to estimate a population for each BCR and then summing across the range of the species, we derived a population estimate for Cerulean of roughly 570,000 individuals or 285,000 pairs.

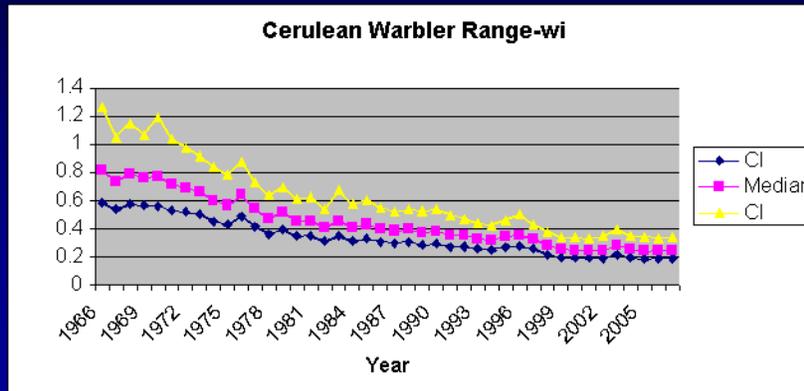
Population Estimates by BCR

Appalachian Mountains (BCR28)	80% = 230,000 pairs
Central Hardwoods (BCR24)	12% = 34,500 pairs
Great Lakes/St. Lawrence (BCR13)	4% = 11,500 pairs
Prairie Hardwood Transition (BCR 23)	2% = 5,700 pairs
Eastern Tallgrass Prairie (BCR22)	1% = 2,300 pairs
Lower Mississippi Valley (BCR26)	<1% = 200 pairs?
New England/Mid-Atlantic (BCR30)	<1% = 100 pairs?
Piedmont (BCR29)	< 1% = 100 pairs?

Population Trend (BBS –2008)

N = 405 BBS routes survey-wide

-2.8% per year



Hierarchical Model analysis courtesy of John Sauer

Now lets talk about pop trends. Pretty much our only information on long term pop trends comes from BBS which now gives us roughly 40 years of data. This graph represents the latest and most sophisticated analysis from the BBS provided by John Sauer. Basically this puts confidence limits, referred to as credible interval in this analysis, around the trend line which indicates an annual rate of decline of 2.8 percent between 1966 and 2008. The magnitude of this declining trend is consistent with almost all the previous BBS analyses and is consistent across major portions of the species range.

Reconstructing Time Series

- Ratio of index in 1995 to index at time t

1995	0.348	560000.0	1.000
1996	0.367	590341.3	1.054
1997	0.336	540079.0	0.964
1998	0.290	466786.7	0.834
1999	0.261	419557.9	0.749
2000	0.257	412438.0	0.736
2001	0.253	406499.6	0.726
2002	0.255	409745.3	0.732
2003	0.281	451212.6	0.806
2004	0.260	417685.1	0.746
2005	0.243	390954.4	0.698

If we accept that this pop estimate represents the mid 1990s then we can project a time series based on the BBS trends to estimate the current pop right now. If we assume that the pop has continued to decline at the rate of 2.8% per year since the 1990s then there are roughly 390,000 Ceruleans today. So we've lost another 30% of the population just since 1995.

Population Status

- 70% population loss since 1966
- Declines in core of range
- Historic expansion to Northeast – but recent declines
- Among smallest global population of Neotropical migrant songbirds



(something about what trend and population means) (WORK on this slide!)

So to summarize what we've got so far regarding population status...

- 1.
2. Especially troubling are declines in core of range
3. Recent declines – BBA data is telling us
4. Population estimates are reasonable and can help us set conservation objectives

birds declining, historic

(Knowing something about pop size tells us how threatened the pop might be and gives us an idea of how many birds we're dealing with and ultimately how much habitat needs to be provided)

General Habitat Relationships

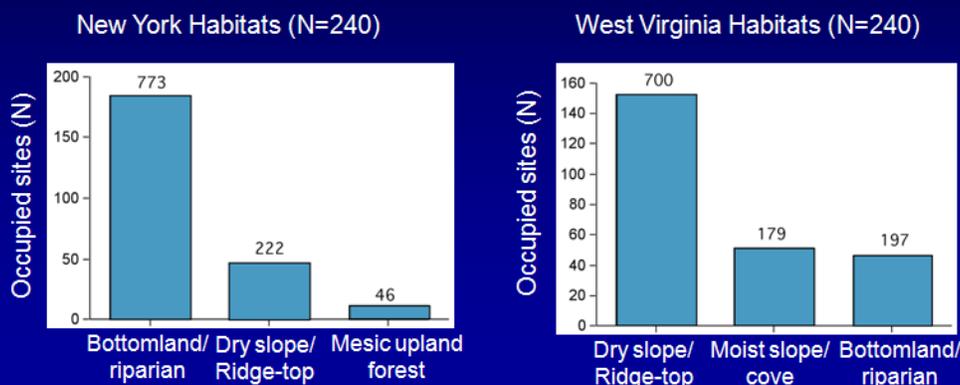
- Large tracts of mature deciduous forest
- Ridge tops, floodplain and mesic cove forests.
- Common denominator = emergent, structurally diverse canopy



Switching gears, I'll now talk about habitats. There is broad consensus that the CERW requires large tracts of mature deciduous forest. Throughout its range, however, this species occupies seemingly very different habitat types including dry ridge tops, riparian floodplains, and mesic cove forests throughout the Appalachian Mountains. The common denominator for all of these habitat types seems to be the presence of an emergent, structurally diverse canopy layer.

Geographic Variation in Habitat Use

Within a region, Cerulean Warblers are often specialized or show bimodal distribution.



(There's a lot of variation from region to region within specific habitats. In any given region they are usually quite specialized and often show a bimodal distribution occurring in bottomlands and adjacent ridge tops, but not in-between. For example in NY the majority of birds were found in bottomland habitats but with a fair number on dry ridge tops and very few birds found in the vast areas of other forest throughout the state. In WV the majority were found on ridge tops which was not the traditional habitat that CERW have been associated with in the literature.)

Cerulean Warblers are more likely to occur on upper slopes and ridge-tops

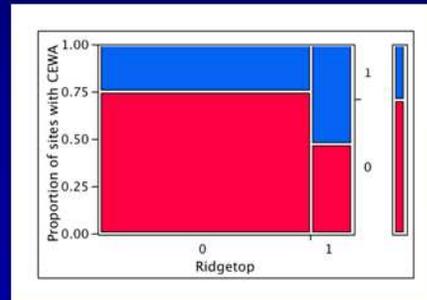
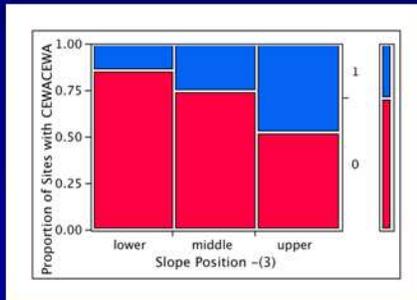


Figure 15: In a highly significant pattern (Likelihood Ratio $\chi^2 = 46.70$, $df = 2$, $p < 0.0001$), ceruleans were detected at < 26% of points at lower and middle slope positions (blue shading), but were detected at nearly half (47.45%) of points on upper slopes.

Figure 13: Ceruleans were detected significantly more often at sites situated on ridge tops ($\chi^2 = 27.554$, $df = 1$, $p < 0.0001$) and the threshold classified cerulean presence correctly at 21% better than chance (Cohen's kappa = 0.2111).

The odds-ratio of 3.42 (95% CI = 1.673 – 2.744) indicates that the odds of having a territorial cerulean at a site are increased over three-fold when sites were situated on ridge tops than other slope positions (Figure 13).

Habitat Relationships: Landscapes

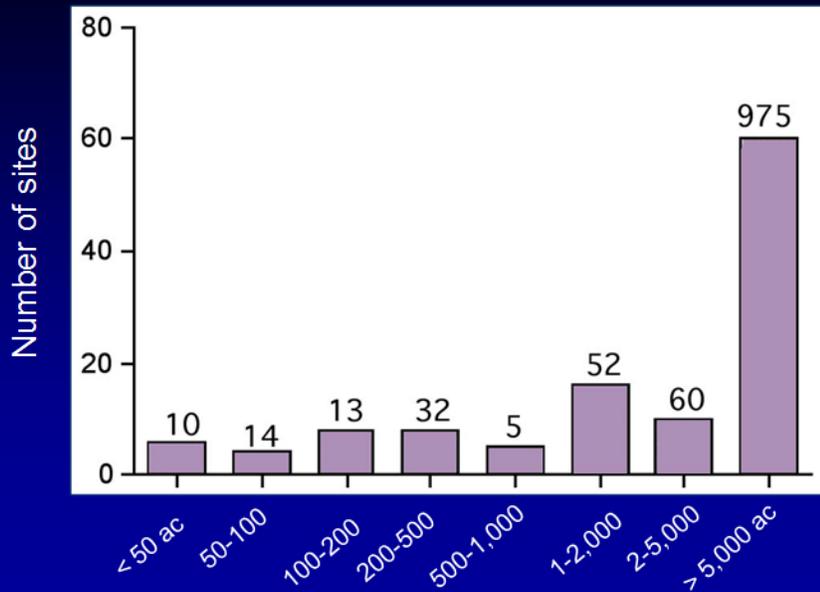
- Area sensitivity
 - 1,780 ac (Robbins et al 1992)
 - 4,000 ac in MAV (Hamel)
- Edge avoidance
- Regional variation in sensitivity



(Robbins data from where?)

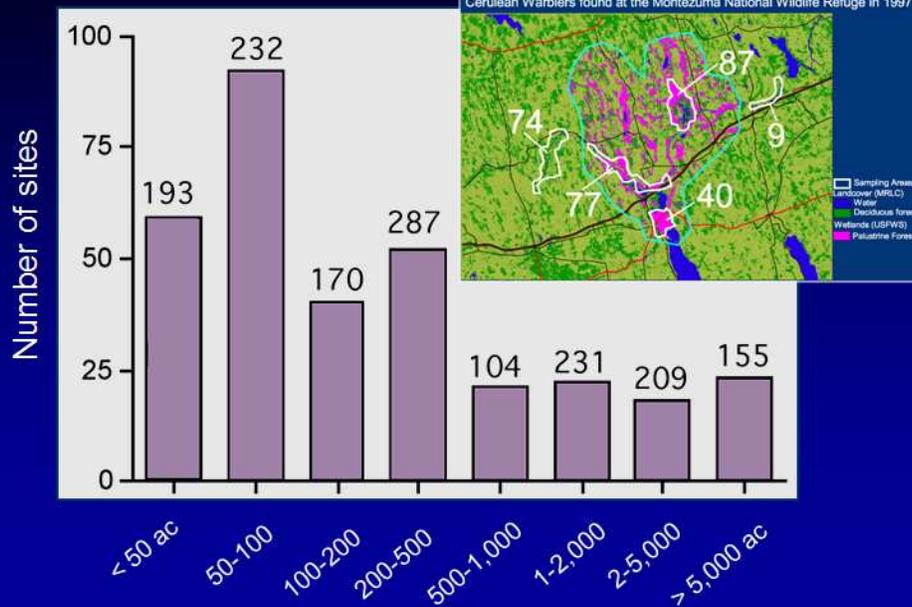
Ceruleans are typically considered an area sensitive species. Published data from Robbins and from Hamel in the Mississippi Alluvial Valley, indicate large minimum tract size. We also have evidence that the Cerulean is a forest interior bird and avoids hard edges of forest such as large open mine lands. However we also are accumulating data indicating regional variation in area sensitivity.

Forest tract size -- Southeast



For example from the Cerulean Atlas the vast majority of sites with Cerulean in the SE were in very large tracts of forest that corresponds with the large tract sizes described by Robbins and by Hamel.

Forest tract-size – Northeast



However in the NE region many CEWA were found in much smaller tracts of forest. For example around the Montezuma NWR in upstate NY, Ceruleans occupy small, fragments of bottomland surrounded by agriculture as shown by the pink areas in the inset map. We are currently in the process of investigating area and habitat requirements in this region to test whether the pattern that we found during the atlas project is really true.

Habitat Relationships: Forest stand structure

- **Stand age distribution**
 - Prefer later succession; mature sawtimber or greater
- **Tree size and height**
 - Larger than average diameter; stand and nest tree
 - Relatively tall trees for diameter class
- **Importance of canopy gaps?**
 - Canopy heterogeneity vs. canopy gaps; vines



At the scale of the forest stand, we know that Cerulean Warblers occur in higher densities in older forest stands - they prefer forests with mature sawtimber-sized trees or larger.

Forests with Ceruleans have been shown to contain trees that above-average diameter for their size class, AND trees that are relatively tall for their diameter -- in other words trees that have been released from competition and have grown taller than trees around them.

Because of the importance of these emergent canopy trees, there has been much focus on how this canopy heterogeneity is achieved through small-scale disturbance in the forest. In particular, there is still disagreement as to whether small canopy gaps, which can be created by treefalls or through active management, preferentially used by Ceruleans -- obviously this could have important ramifications for management to promote Cerulean Warbler habitat...

Heterogeneous vertical distribution of vegetation in stands may be the common thread in understanding Cerulean breeding habitat, whether due to stand structure, as illustrated in this foliage profile from study site in the Mississippi Valley (Hamel), or due to topography, or both. However, Existing methods to measure this structure are either too crude or often cannot be applied at relevant heights. Cerulean researchers are working on new methods, such as optical methods that are promising but imprecise. In the end, describing how to produce this structure through management may be easier than measuring it.

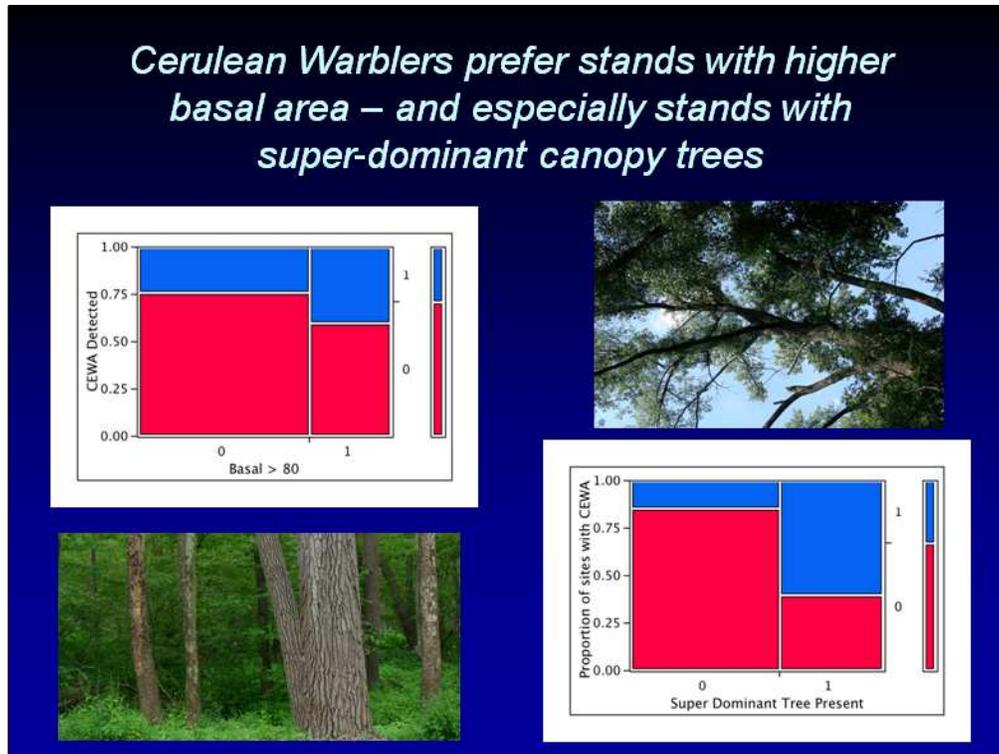


Figure 22: Stands with a total basal area of ≥ 80 were highly-significantly more likely to have a Cerulean Warbler than sites with lower basal area (Likelihood Ratio $\chi^2 = 7.35$, $df = 1$, $p < 0.0067$).

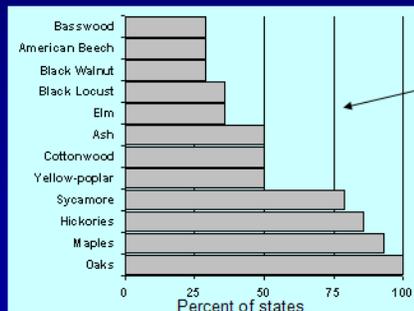
An odds ratio of 2.131 (95% CI = 1.466 – 3.099) suggests that the odds of detecting a Cerulean Warbler is effectively doubled in stands with total basal areas ≥ 80 , as compared to stands with lower total basal areas.

Figure 21: Cerulean Warblers were detected highly-significantly more often at sites that had at least one super-dominant tree ($\chi^2 = 95.330$, $df = 1$, $p < 0.0001$).

The odds-ratio of 8.84 (95% CI = 5.53– 14.13) indicates that the odds of having a territorial cerulean at a site are increased approximately eight-fold when at least one super-dominant tree is present.

Habitat Relationships: Tree species

- Preferred tree species vary by region
- Overall importance of oak-hickory
- Shade tolerant vs. intolerant species
- Nest trees vs. singing/foraging trees
 - Large, tall sawtimber trees for male song perches
 - Long-limbed midstory trees for female nest sites



Dominant tree species in overstory

In terms of tree species a large variety of trees have been identified as being used by CERW for nesting or singing. This graph from the CERW atlas project shows the dominant tree species at important sites in each state. Some trees, oaks hickories, maples and sycamore were identified at sites in a large majority of states where as other trees such as cotton wood, yellow poplar, and others were important only in parts of the species range. Throughout their distribution CERW seem to be pretty closely tied to oak hickory forests or to bottomland dominated by either sycamore, cottonwood, or red and silver maples. These tree species represent both shade tolerate and shade intolerant species which can grow to achieve the desired structure of producing a tall emergent canopy under different conditions at various sites.

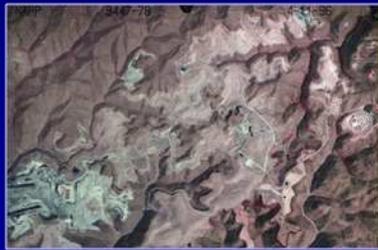
Data from the ON study sites indicate that structurally different trees may be important for different life history functions, for example males will use the tallest emergent trees as song perches whereas females may seek long limbed mid-story trees for nesting.

(In terms of tree species there is a wide range that they use again throughout their distribution. It seems as if there are no species preferences, not true, in any given area they may be very particular in the species that they are using. (Appear to be generalized in tree use, but state by state they seem to be very particular about tree use in a given location)

Graph is a summary of data from CERW atlas in which tree species were identified show percentage of states where different tree species were dominant at CERW sites. Oaks, maples and hickories were most universally identified trees whereas

Known Limiting Factors

- Loss and alteration of breeding habitat
 - Forest conversion due to development, agriculture, mining, forestry
- Loss and alteration of non-breeding habitat
 - Forest conversion due to development, agriculture (coffee)
- Reduction of habitat suitability (fragmentation, structure)
- Other factors affecting survival (towers, climate change, etc.)



Cerulean Warbler Conservation on Forest Industry Lands

“Forest managers in the Central Hardwoods are the primary stewards of Cerulean Warbler breeding habitat”

- Management to mimic natural disturbance
 - Even-aged vs. uneven-aged techniques
- Promotion of mature stand conditions
 - Competition/release to accelerate growth
- Promotion of broken, emergent canopy
 - Produce large trees with spreading crowns



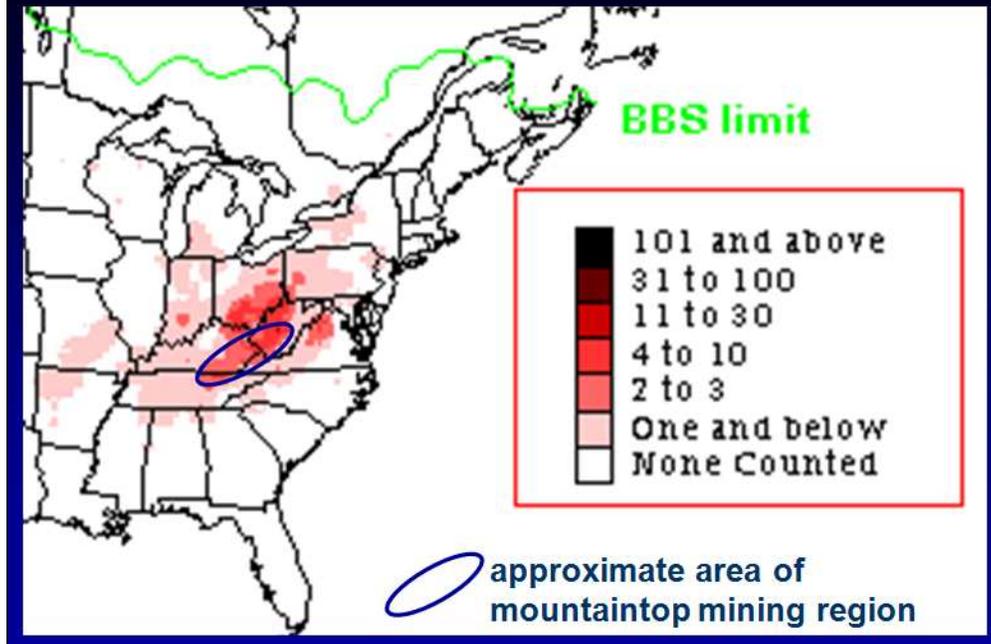
These management prescriptions are designed to mimic the types of natural disturbance regimes that promote the structural characteristics preferred by CERW, in particular the broken, emergent canopy.

Implications of Mining for Cerulean Warblers

- Topographic considerations: ridge-tops and headwater valleys = prime habitat
- Outright habitat loss from forest removal
- Fragmentation/ Edge factors
- Buehler model -- how much of the population affected?



Cerulean Warbler: Impact of mining



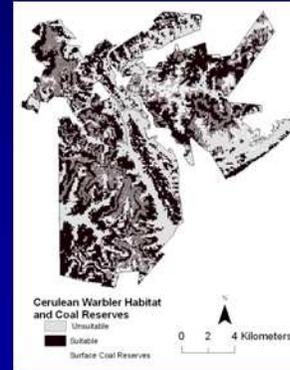
Forest spp, eg cerw, are affected both by loss of forest habitat and degradation of remaining habitat from edge effects. Also loss of ridges.

CERW esp hit hard because of limited range and declining pops. Note that mt-top mining region overlaps signif portion of most dense populations of cerw.

Modeling effects of mining on Cerulean Warbler Populations

(D. Buehler et al.)

- Cumberland Mountains
 - 39% potential Cerulean habitat
 - Population = 44,804 pairs
 - 10,000 pairs (23%) potentially displaced by mines

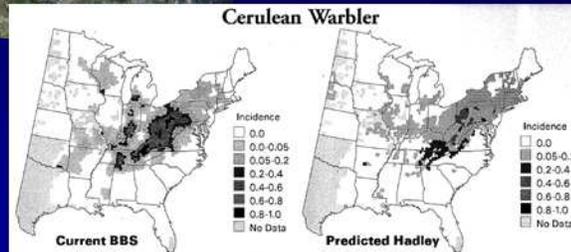


Mining Industry: what are the Opportunities?

- Identify most critical sites for Cerulean Warblers: surveys, modeling
- Focus on (change) reclamation practices
- Support for research and surveys
- How can we achieve “no net loss?”
- Focus on mitigation



Assess impacts of non-habitat threats



Outcome: increased knowledge for better conservation

Impacts of Climate Change?

Impacts of Avian Disease?

Cerulean Warbler Demography and Population Structure

Relatively few studies across range
(ON, MI, IN, TN, MAV)



Contributors

Jason Jones, Jen Barg, Amanda Rodewald et al., Paul Hamel et al.,
Kamal Islam et al., Joe Robb et al., David Buehler et al., Petra
Bohall Wood et al., Ken Rosenberg et al., Ray Adams, John
Carpenter, Raleigh Robertson et al., Randy Dettmers, Chris Rogers,
Jean Cochrane, James Giacomo and everybody else who has
struggled and contributed

Simple population model

$$\lambda = S_a + f * (S_j)$$

λ = finite population growth rate
 S_a = annual adult survival
 S_j = annual juvenile survival
 f = annual fecundity

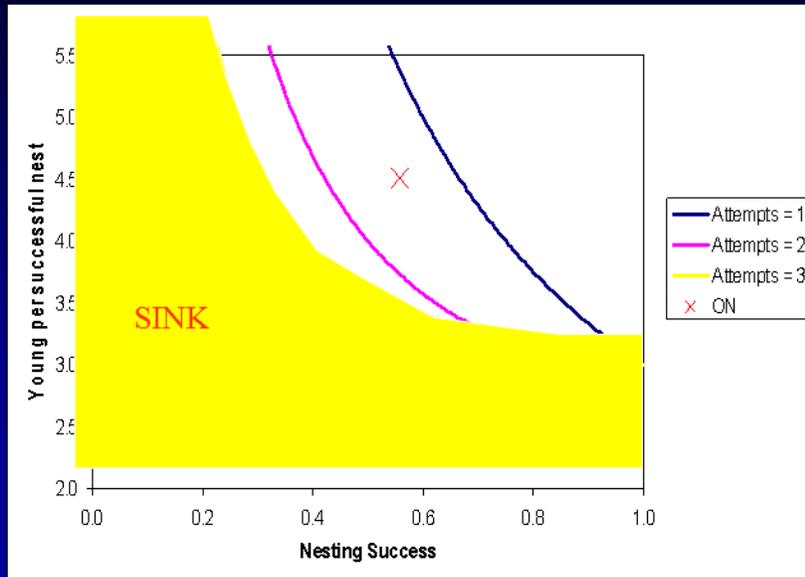
Fecundity is related to...

- number of young per successful nest
 - number of nesting attempts
 - number of broods possible in one season
 - nesting success
 - renewing rate
 - pairing rate
- $\lambda > 1$ increasing
 $\lambda = 1$ stable
 $\lambda < 1$ decreasing

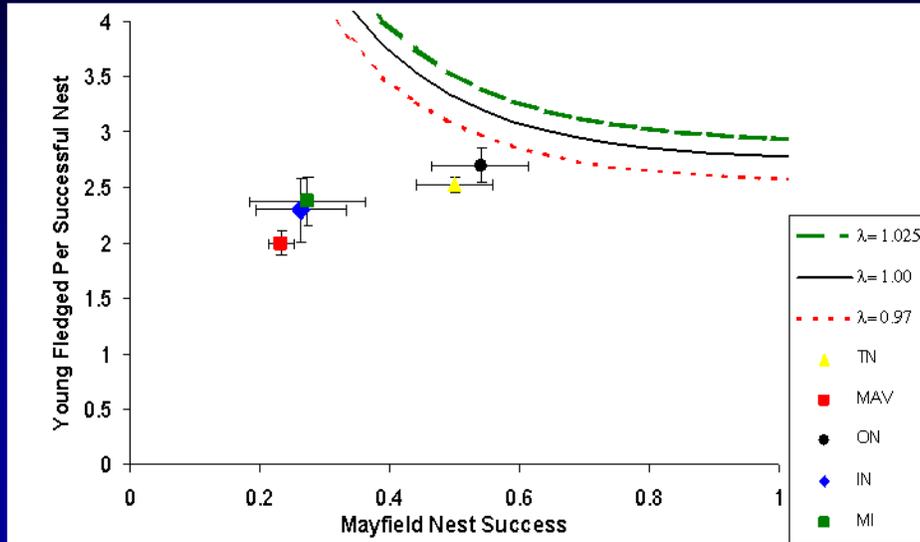
Modeling inputs/scenarios

	Low	Medium	High
Nest success	0.2	0.4	0.6
Brood size	3	3.4	3.75
Adult survival	0.54	0.59	0.64
Renest probability	0.8	0.9	1.0
Max. attempts	2	3	4
Juvenile survival ratio	0.4	0.5	0.7

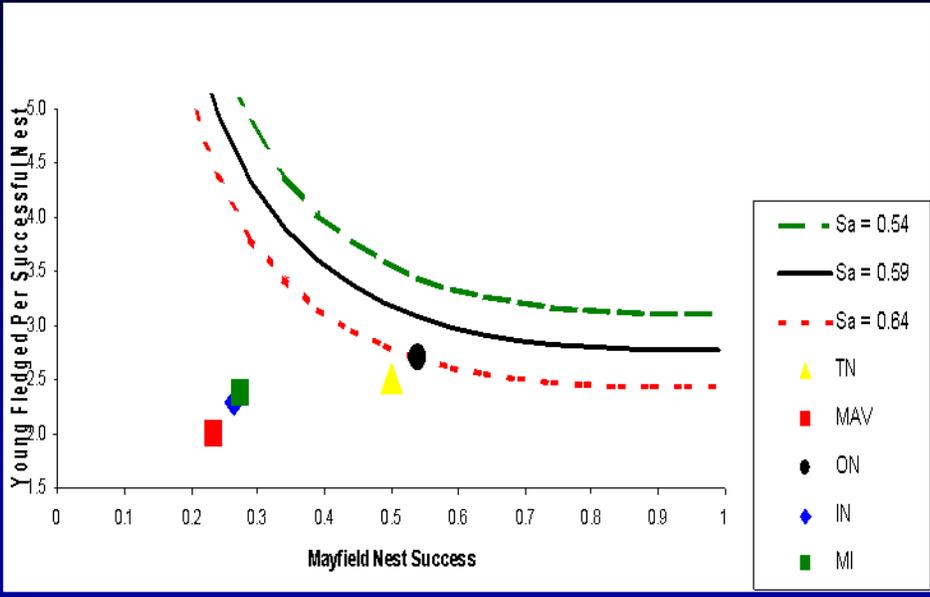
Combinations of Reproductive Parameters Result in $\lambda = 1$



Demographic analysis



Adult "survival"



Annual and monthly survival



Breeding Monthly

0.98 ± 0.01

Overall Annual

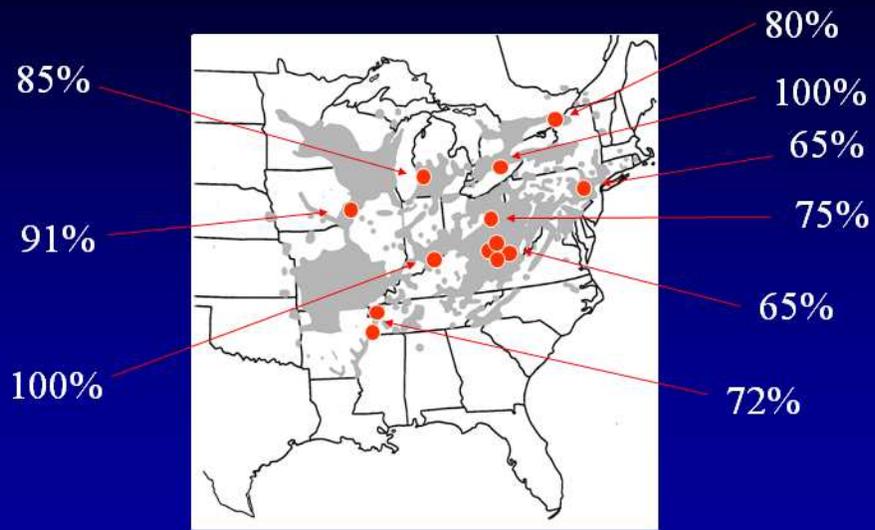
0.49 ± 0.05

Non-breeding Monthly

0.93 ± 0.01

Model elasticities imply adult mortality more important than fecundity

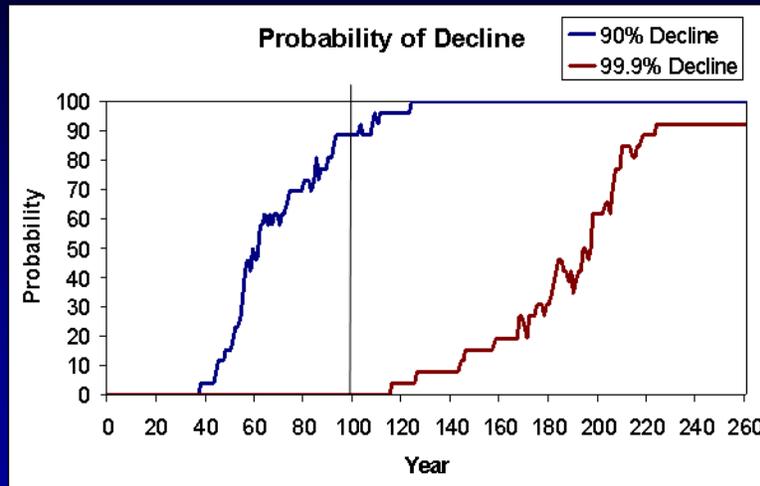
Age Ratio



Where are all the SY birds?

ASY males replacing ASY males (local or long-distance recruits)

High Probability of a 90% decline in next 100 years: $\lambda = .97$

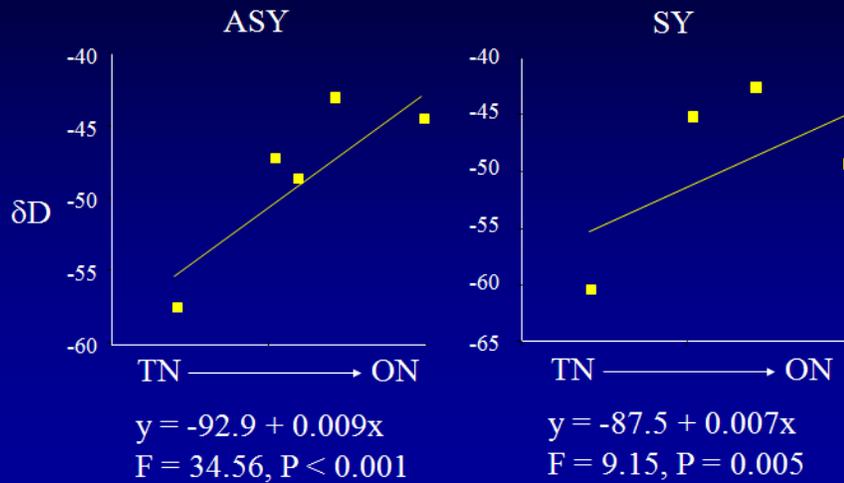


Cerulean Warbler *Demography*



- All growth rates less than 1 -- not sustainable
- Demographic rates produce probabilities of decline similar to count data (with assumptions)
- Lowest fecundity in Ag-dominated landscapes
- Higher fecundity in “core populations” not enough to offset low survival in most years
- Improving over-winter survival will have greatest effect on population growth rate!

A Hint of Connectivity



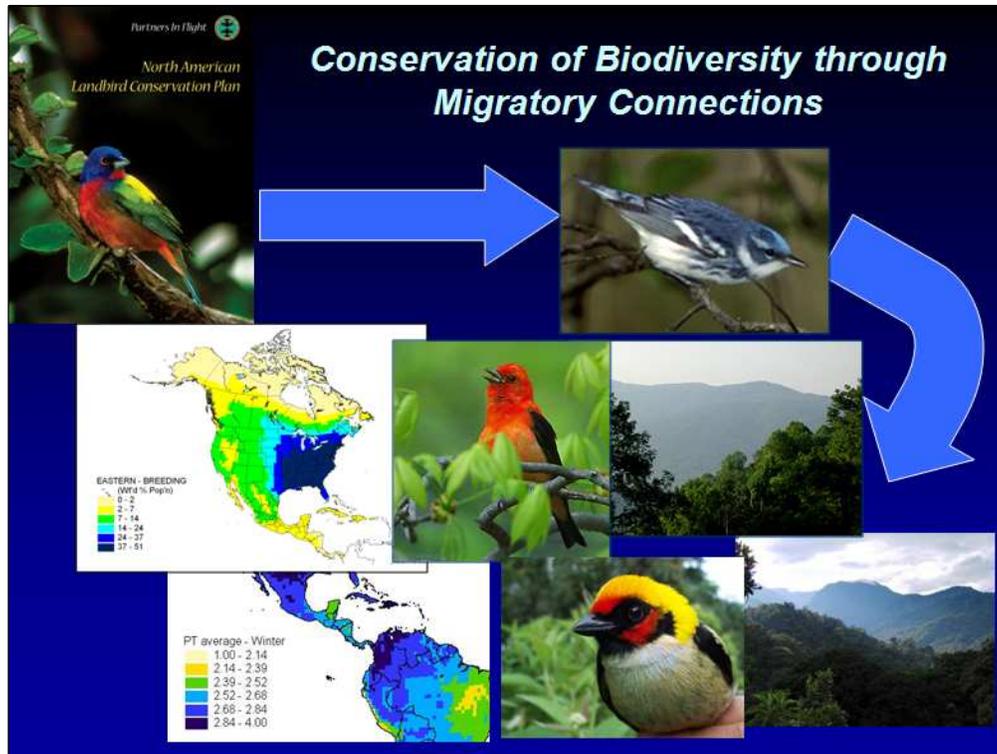
deltaD of crown feathers indicative of winter signature

high negative values indicate south winter range, low negative values indicate north winter range

Tennessee birds winter further north than Ontario birds = leapfrogging of populations

No sampling location exhibited significant differences between ASY and SY signature, implying no age-based segregation of males.

Sample size limitations with SY analysis, despite high F and low P



(in keeping with the theme of this symposium) In 2004, Partners in Flight published an assessment of the conservation risk of all 448 species of landbirds that regularly breed in the U.S. and Canada (show plan). Of course, Landbird species use essentially every vegetation type and every square meter of the North American continent during the breeding season. But it may be less well appreciated that at-risk landbird species also can be found almost anywhere. This map shows the distribution of the PIF Watch List species during the breeding season – the 100 species of landbirds of greatest conservation concern. Note the concentration of Watch List species where we are today in the Southwest. What’s more, if we look at the distribution of these species in the winter, we see that all of Mexico, the Caribbean, and Central America, and a good portion of South America include areas of interest to the conservation of these high-priority species. Because birds tend to be the best understood group of vertebrates and because avian conservation has become more organized, more strategic, and better funded in recent years, we believe that bird conservation can lead the way for biodiversity conservation in many areas. The conceptual foundation for the umbrella, flagship, or indicator role of particular avian species has been well developed. However, we have barely begun to test the relevant hypotheses generated by these constructs. Thus, it is our intent in this symposium to not only say what we know about the value of the conservation of high-priority landbirds for other components of biodiversity but to also stimulate investigations that will show us where we are on the right track and where on the wrong one.

Cerulean Warbler Conservation Initiative: "El Grupo Ceruleo"

- Winter grounds activities
 - Habitat Assessment, Surveys, Modeling & Research – *Local Conservation and Outreach*

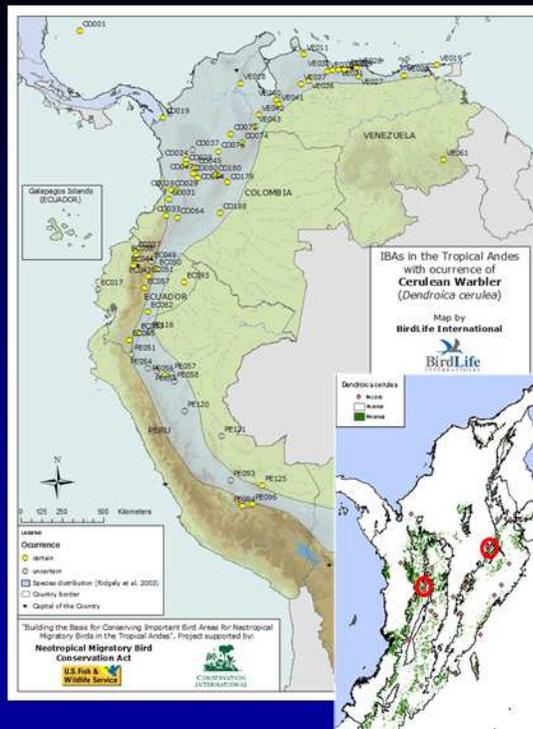


On the wintering grounds, a whole parallel effort is underway to develop and implement conservation actions, with the CWTG partnering with researchers and conservation organizations in South America – at present, our primary partner in this effort has been Funcacion Pro Aves in Colombia....

Better define current range and identify important areas for Cerulean Warblers

Partners: *El Grupo Cerúleo*, NGOs, govt, universities, & others

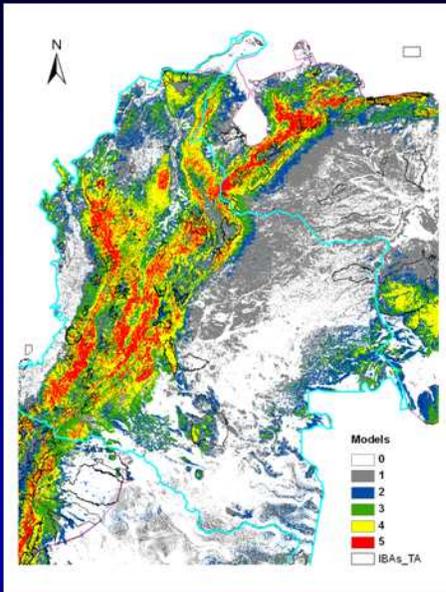
Outcome: Improved knowledge for better habitat conservation

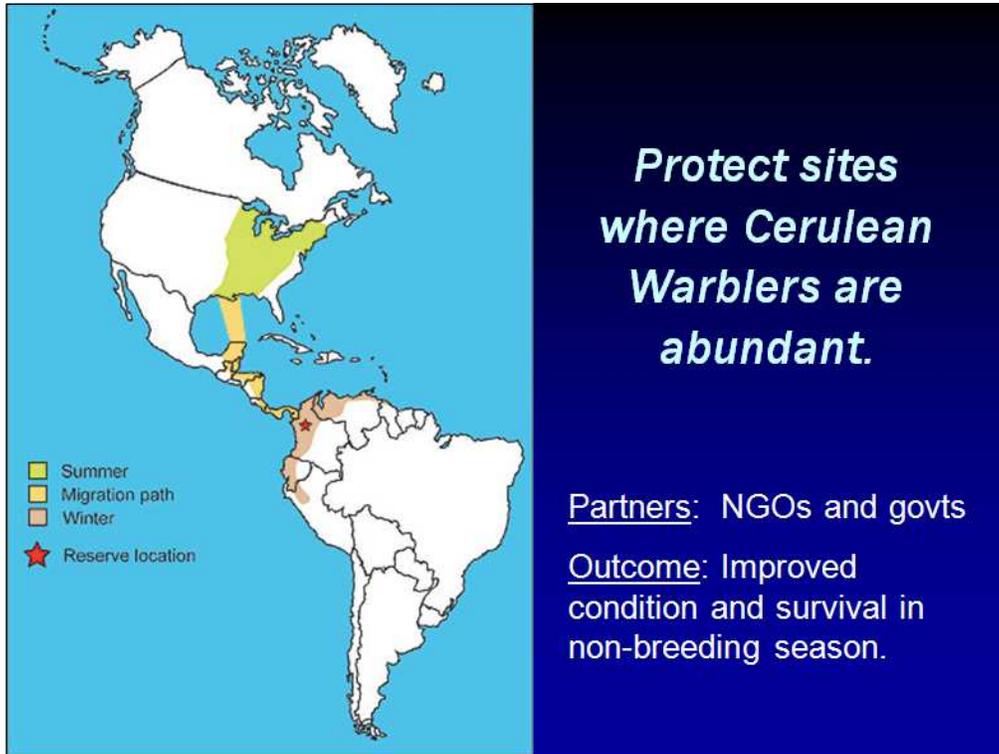


On the wintering grounds we are starting with much less information, so a primary action will be to better define the range and habitat requirements -- especially down through Peru and even Bolivia, where there are historic specimens, but very little is known about present-day distribution...

Potential distribution of Cerulean Warbler in the Northern Andes

- 800-1600 m elevation
- Subtropical humid forest
- Sheltered intermontane Andean valleys
- Range
 - Potential: 135,655 km²
 - Current: 48,799 km²
 - Habitat Loss: 64%
 - Habitat loss in reality: >90%
- Data: Grupo Cerúleo, BioMap, DATAves, ProAves





Where we do know CERW are present and abundant, we need to focus on protection, management, and restoration of remaining forested habitats in regions of high biodiversity and endemism in South America.



And, we already have an example, where ABC and ProAves purchased the first protected area in Latin America to be designated specifically for a Migrant Bird.

– includes 500 acres of natural forest as part of a rural landscape with pasture and plantations of coffee and cacao..

- The most destroyed habitats in Colombia are Dry Forest, Cloud Forest (both slope of Central Cordillera and interandean valleys of Western and Eastern Cordillera), that was cutting down to plant coffee, more critical when the shade coffee was replaced by improved Caturra coffee variety.
- Etter (1993), 80.000km² of decidue forest and only remains 1200km². And only remains 27% of the original andean forest (45.000km² of 170.km²).
- Analysis of change landcover between 1970 – 1990, shows that most transformation in Colombia occurred in Cundinamarca, Boyacá, Santander, Cauca, Nariño and south of Tolima, where was deforested 326.670 has of Andean Forest (Alarcon et. al 2002).
- Landscapes are a composed by a heterogeneous matrix of different plantations and agroecosystems where the species have to wintering.
- Cerulean Warbler Bird Reserve vicinity is an example of this heterogeneity, some plantations as Shade coffee and cacao plantations could benefit the species but are immerse in different scenarios as grasslands, unshaded coffee, banana shaded coffee and other.

Alliance for Zero Extinction

<http://www.zeroextinction.org/>




1. Beautiful Woodpecker
2. White-mantled Barbet
3. Black Inca
4. Brown-banded Antpitta
5. Chestnut-bellied Hummingbird
6. Gorgeted Wood-Quail

This site is one of many recognized in N. South America by AZE – with at least 6 very rare and critically threatened bird species known to occur on the CERW Reserve..

Cerulean Warbler can be a Flagship species for Biodiversity in the Andes



Andean Cock-of-the-Rock



White-tipped Quetzal



Turquoise Dacnis-Tanager



Yariguies brush-finch



Summer Tanager

Cerulean Warbler Conservation has Raised Awareness of Local Conservation issues in Colombia



All of this international attention and resources to develop the CERW Reserve has helped to raise awareness of local conservation issues in Colombia – they now hold a migratory bird festival in October when the Cerulean Warblers and other N. Amer. Migrants arrive in the region..

Critical to the conservation of both migrant and resident forest birds in this region, is.. Coffee



Study Cerulean Warbler ecology in South America



- Habitat use
- Foraging and Diet
- Social behavior

*How many Cerulean Warblers in Shade
Coffee Plantations vs. Intact Cloud Forest??*





Conclusions



- *Dendroica cerulea* – Neotropical migrant with small population in range-wide decline.
- Regional variation in habitat requirements.
- Still need to evaluate limiting factors and causes of population decline.
- Need to link demographic variation with landscape and habitat variation.
- Management should mimic natural disturbance and promote mature stand conditions with broken, emergent canopy.

-In conclusion, we know a lot about the status and habitat requirements of the CERW, the total pop is very small compared with other passerine migrants which mostly number in the millions and this pop is continuing to decline at a steady rate throughout the species range.

-Even though the species uses a wide range of habitat types and tree species, there is significant regional variation in habitat use and within a given area CERW are often quite specialized.

-WE still don't know very much however about why CERW are declining what are the most important limiting factors and whether they occur on the breeding grounds during migration, or in winter.

-Future research should focus on linking demographic parameters with landscape and habitat variables in order to better understand the causes of population change.

-And finally, as you will hear in the next few talks, we are in the process of learning how to manage forest habitats to enhance CERW pops, especially by mimicking natural disturbances that promote the specific structural features that CERW prefer.

Conclusions



- Flagship species for conservation in two regions of extremely high diversity and endemism
- Cerulean Warbler can help put an international spotlight on local conservation issues of global significance
- Need to understand wintering ecology and limiting factors in non-breeding season

Thank you to National Fish and Wildlife Foundation for supporting the Cerulean Warbler Conservation Initiative!

