Non-breeding habitats of Cerulean Warblers: What do we know?

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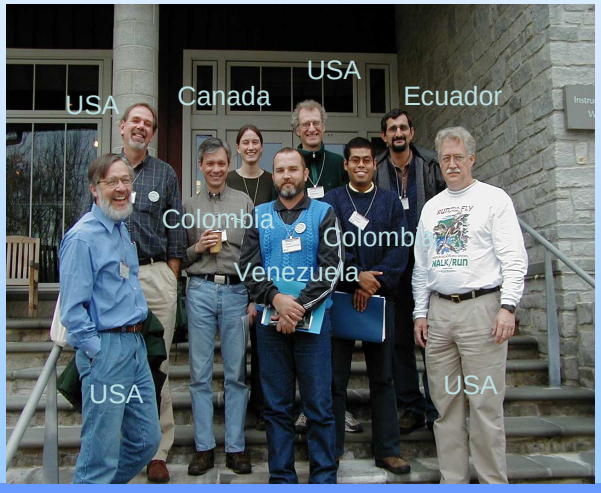
West Virginia, 2002



Some of members present at, Shepherdstown, West Virginia, USA, summit of Cerulean Warbler Technical Group

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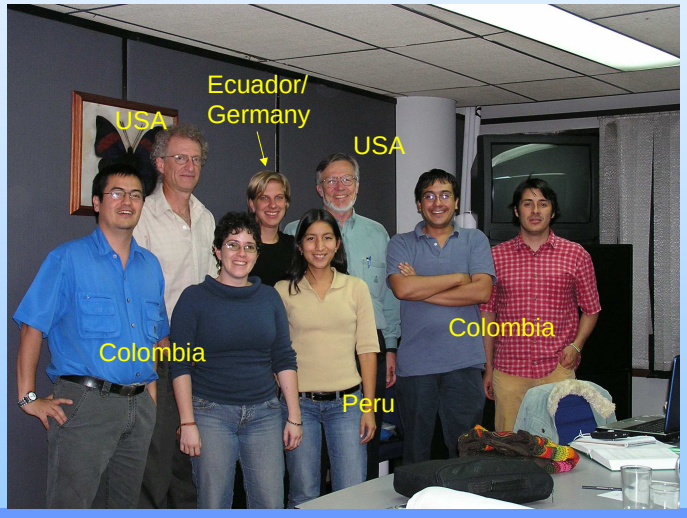
El Grupo Ceruleo began during the first Cerulean Warbler Summit in 2002. We recognized the nonbreeding grounds as a priority at that time.

It was at this meeting that the group recognized the importance not only of conducting work in the nonbreeding period in South America, but in particular the value of using the GIS technology to develop a model or set of testable models by which we could organize the work of trying to determine where the birds were in South America, and what factors were associated with that distribution, so that we could manage as many of them as we could, in the effort to conserve the species population.

This larger group developed the initial models and screened the existing data sets to assemble a modeling approach to use of the GIS to determine and investigate the nonbreeding range of the Cerulean Warbler

Bogotá, 2006



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This is the group of us who took the initial models, and refined them into the final models presented here.

Our Objectives

- Summarize existing field records with respect to existing geographic data sets
- Use respected spatial modeling algorithms to assay the range of Cerulean Warbler in South America
- Combine results of these algorithms into a stratified composite model of the range
- Use the stratified model as the basis for rigorous field investigation of the occurrence of the species

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Our objective in the presentation is to show how we did the first three of these tasks. We compiled existing records into a geographic data base. We used respected spatial modeling tools to associate these records with environmental data into models of the nonbreeding range. After presentation of the historic training data and model outputs, the newly gathered field data will be used to test the model predictions, and summarized. The fourth task is currently the next step of the project, to be carried out in Oct 2006-Mar 2007, and Oct 2007-Mar 2008

Historical Data

- Previous work hypothesized
  - primary forest
  - eastern slope of the northern Andes
  - 500-1500m
  - association with mixed-species flocks


Photo courtesy ProAves Colombia

- 186 separate localities used

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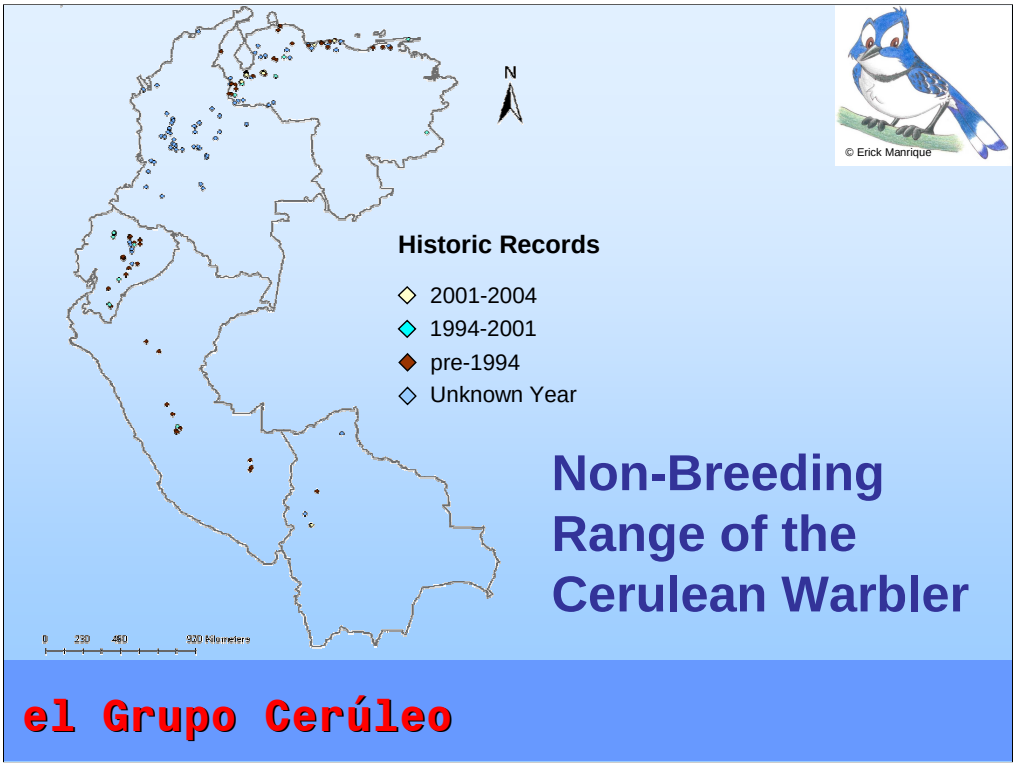
Previous work hypothesized that the non-breeding distribution of Cerulean Warbler (_Dendroica cerulea_) occurred in primary forest of the eastern slope of the northern Andes, between 500-1500m, in association with mixed-species flocks of canopy-foraging birds, especially tanagers.



We used 186 separate localities represented in these data to develop the models presented here. These records span the period from the late 19th century until the present time.

El Grupo Cerúleo Test Data

- conducted 15 studies since 2003
- in Venezuela, Colombia, Ecuador, Peru, and Bolivia
- 149 localities visited
  - 88 occurrences reported, not all in different "pixels"

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El Grupo Ceruleo, subcommittee of Cerulean Warbler Technical Group, and others conducted 15 studies since 2003 in Venezuela, Colombia, Ecuador, Peru, and Bolivia. 149 sites were visited, not all of which were more than 1km from all others. At 88 of these sites, Cerulean Warblers were located. At the remaining sites, no birds were found.

Two sample localities show primary forest in Ecuador and Shade coffee plantations in Colombia, where field teams searched for Cerulean Warblers.

Models Used and Their Algorithms

- **MAXENT** – Maximum Entropy Theory
- **GARP** – Genetic Algorithm for Rule Set Prediction
- **Domain** – Gower similarity index
- **Mahalanobis D^2** – Non-euclidean Mahalanobis distance
- **ENFA** – Ecological Niche Factor Analysis with Biomapper

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Five separate, well-respected modelling approaches were used in this work. Each was applied to five random subsets of training and test points from the historical data

Variables Subjected to Analysis

- Worldclim climatic data, 19 measures
- Elevation, Aspect, Slope from GTOPO30 DEM
- Percent tree cover from Global Land Cover Facility, MODIS
- All projected to pixel size of 1 km^2, 100 ha

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Publicly available map datasets of environmental, climatic, and vegetation data were gathered to make the models.

Worldclim climatic data, 19 measures

http://www.worldclim.org/,

Elevation, Aspect, Slope data from GTOPO30 DEM

http://edc.usgs.gov/products/elevation/gtopo30/gtopo30.html

Percent tree cover from Global land cover facility, MODIS

http://glcf.umiacs.umd.edu/data/modis/vcf/data.shtml

All projected to pixel size of 1 km^2

7 Variables Used in Models

- **Isothermality**,
  - Mean Diurnal Temperature Range as percent of Annual Range
- **Total Annual Precipitation**
- **Precipitation Seasonality**,
  - as Coefficient of Variation of mean monthly precipitation
- **Percent tree cover**
- **Elevation** from DEM (Digital Elevation Model)
- **Slope** from DEM (Digital Elevation Model)
- **Aspect** from DEM (Digital Elevation Model)

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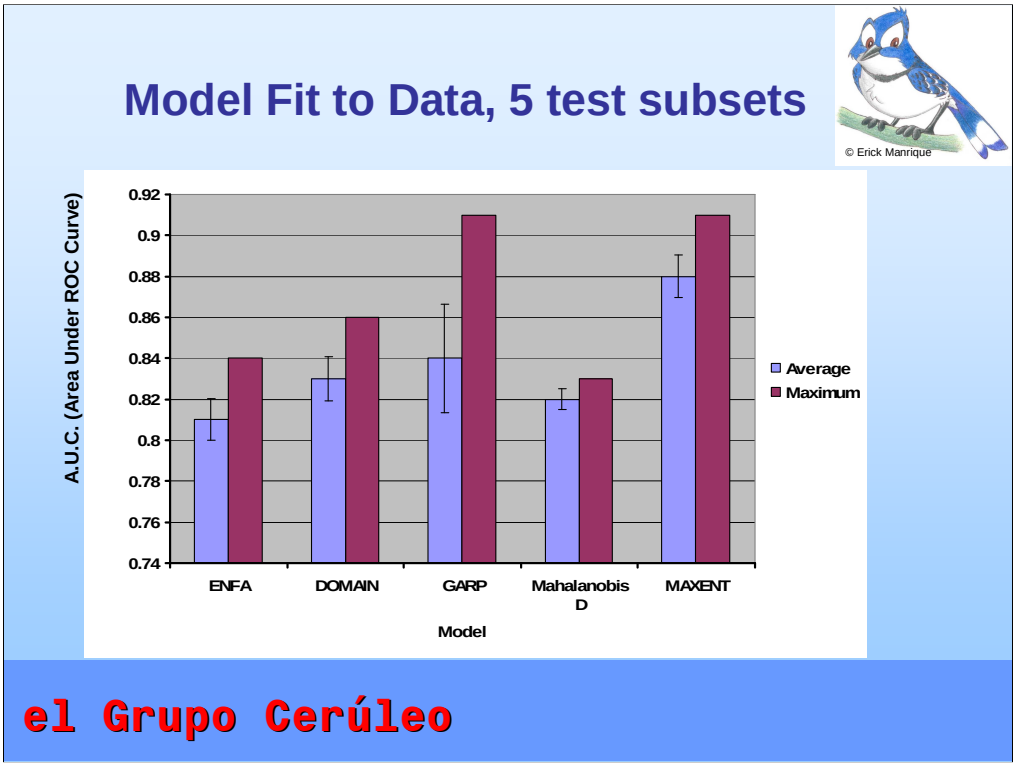
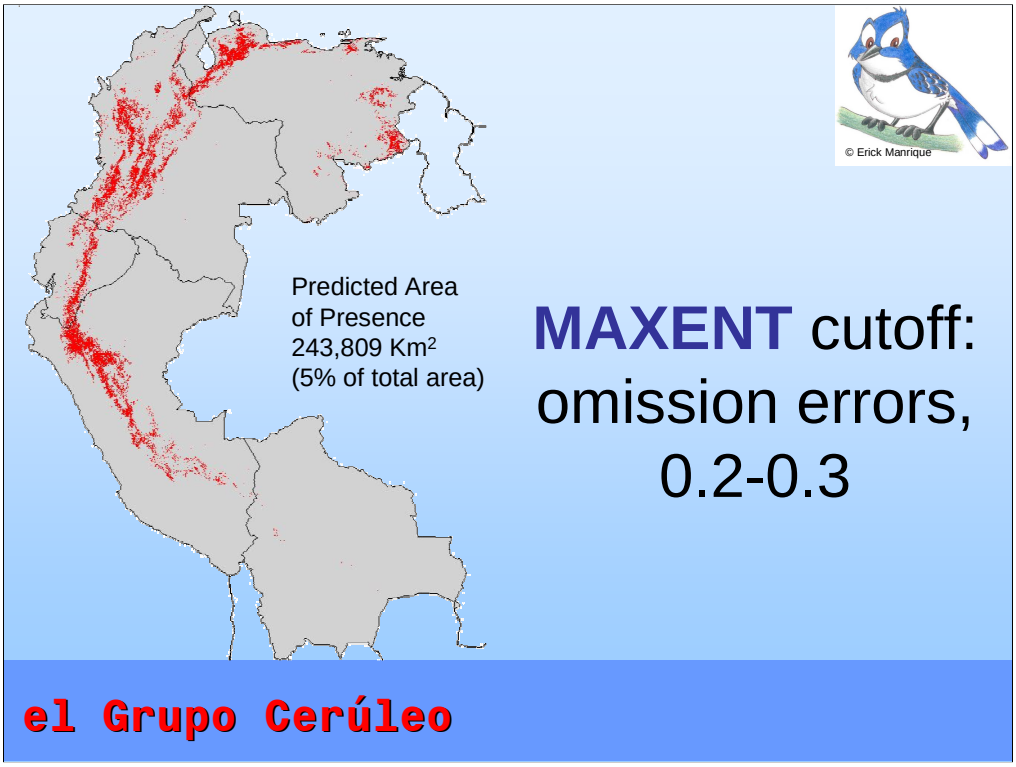
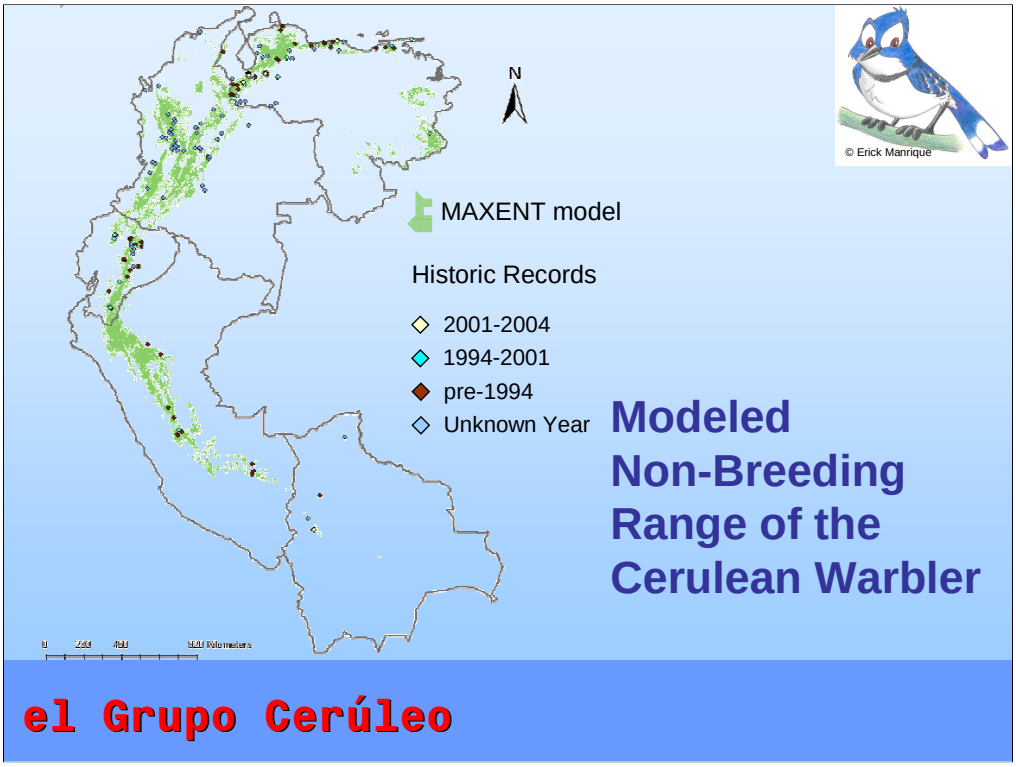
Preliminary analysis of associations among the original 23 variables identified 7 clusters of very similar patterns. One representative of each of these clusters was selected, based on our judgment of its relevance to the birds. That 3 of these variables come from the Digital Elevation Model indicates the dependence of this modeling process on that modelling process.



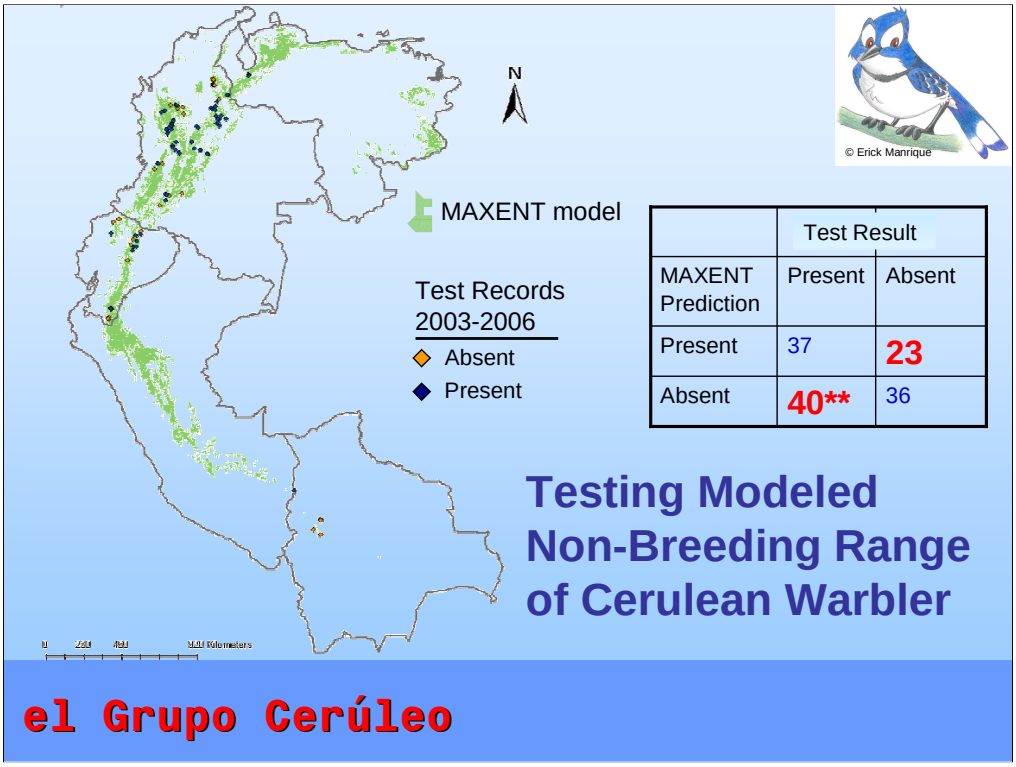
All of the models fit the original data well. Because the AUC is uniformly above 0.8, we can suggest that all the models do better than random to account for variation in the data. Because none of them are above 0.9, it seems to me reasonably clear that we have a substantial amount of noise in the original data set, noise that is going to impede the capacity of the models to actually predict the occurrence of the birds. MAXENT has a (significantly) higher AUC than the others and so is chosen for illustration of the evaluation process here. It was also the model that predicted the smallest area as potential range of the species.



MAXENT is the most specific. Nevertheless, it predicts Cerulean Warblers to occur on more than 240,000 km2 of landscape.



This model appears to fit the original data quite well.



We test the model by mapping the test records gathered 2003-2006 against predicted occurrence. The table shows a substantial number of prediction errors.

Not a very good model

	Test Result	
MAXENT Prediction	Present	Absent
Present	37	23
Absent	40**	36

> 50% of observed occurrences in locations of predicted absence

Omission Rate = 0.39
A.U.C. ~ 0.56
Not much better than random

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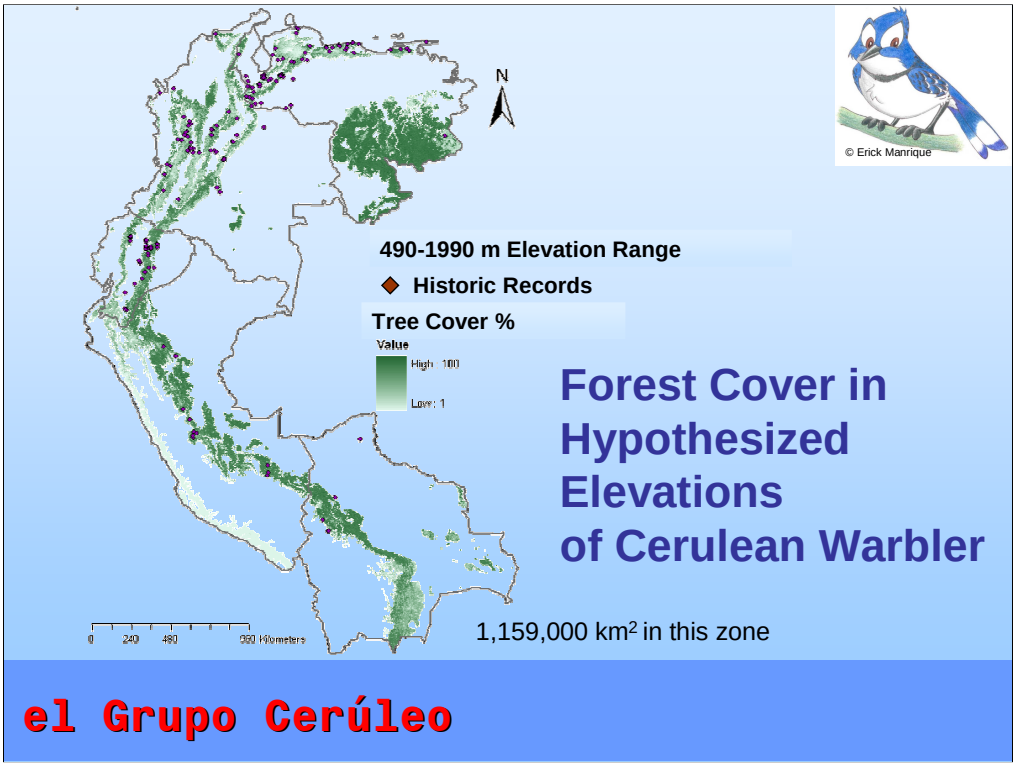
When the model whose fit to the data measured by AUC at 0.88 is tested against new data, the AUC value drops to 0.56, which is a low value. The best model we could produce from the historic records does not do a very good job at predicting a novel data set.

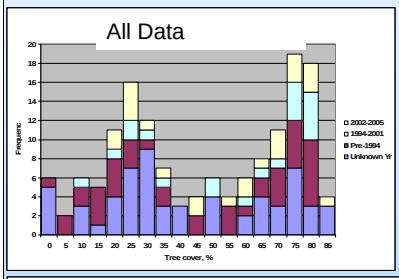
Sensitivity = probability of predicting occurrence given actual occurrence, here = 1-omission error rate = 1-40/77 = 0.48; these are what we call omission errors

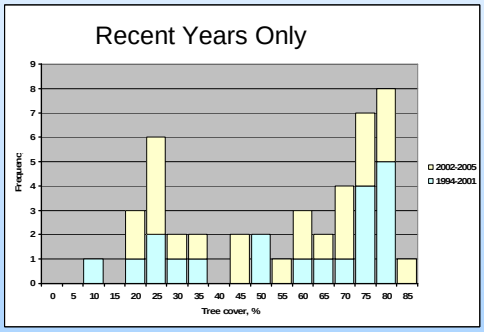
Specificity = probability of predicting absence given actual absence, here = 36/59 = 0.61; these are what we call commission errors

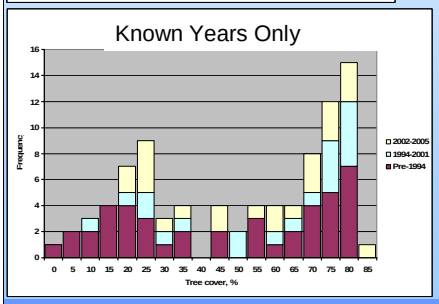


To explore why this model does not predict the recent data well, we can examine one of the variables, percent forest cover, within the hypothesized elevational range of the birds.

Cerulean Warbler and Forest Cover







Historical Records show
Same BiModal Distribution
Regardless of Time Period

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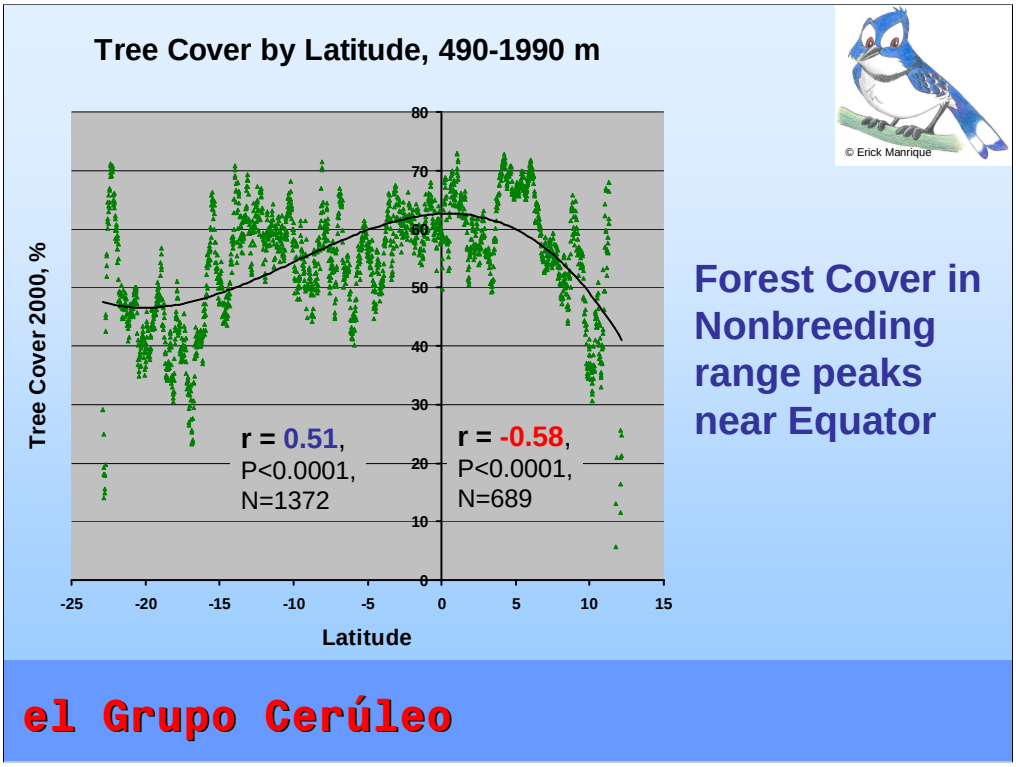
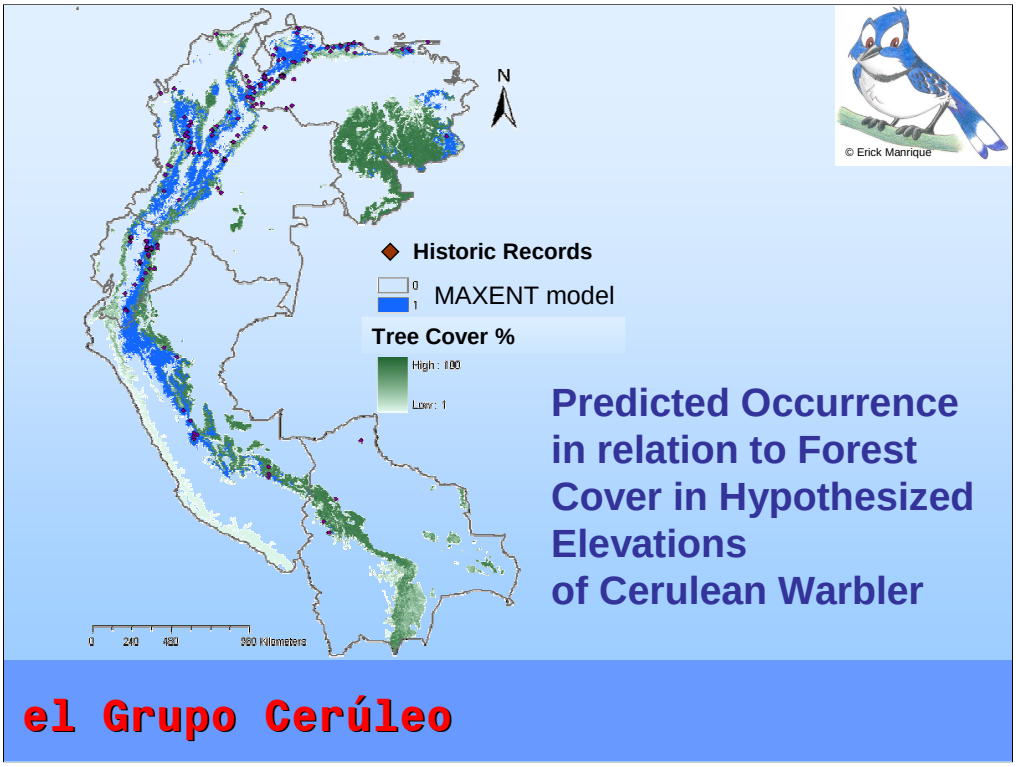
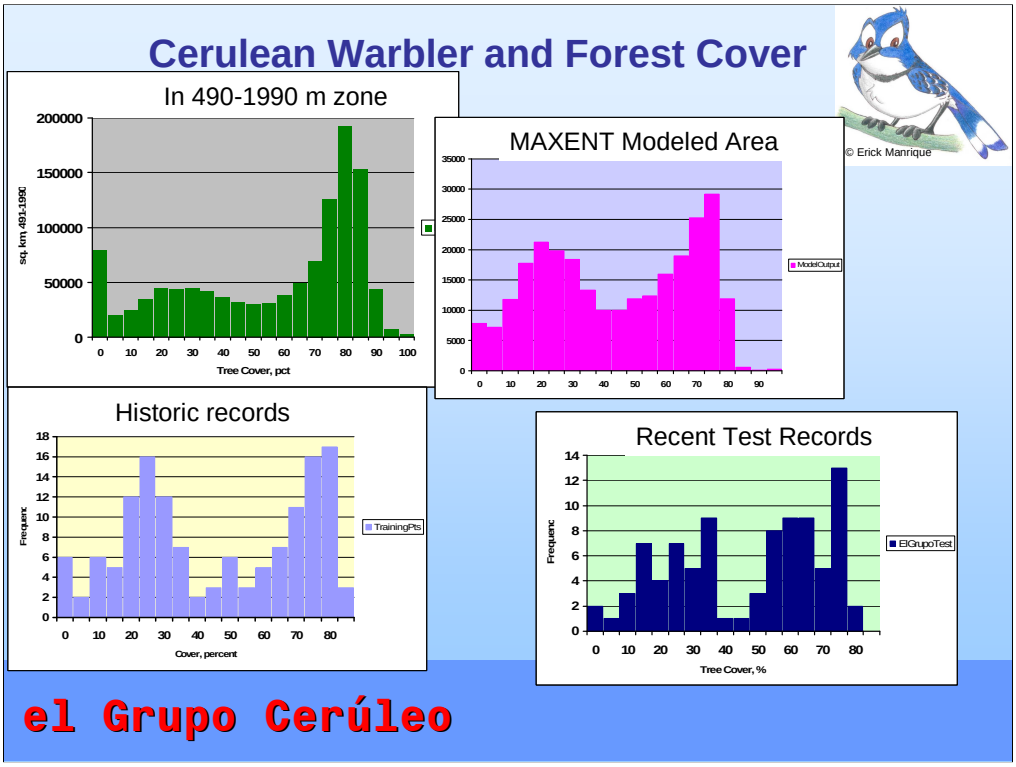
In the Historic data set, a bimodal distribution of occurrence with respect to forest cover appears to exist, with substantial occurrence in habitats with lower and with greater than 50% cover. Because this pattern appears to exist regardless of the time period involved, it cannot be related simply to habitat change between the time of observation and the evaluation of forest cover in 2000.



Forest cover within the elevational range is slightly greater on average north of the equator than south, but shows a significant decline with latitude north of the equator.



Virtually all the modeled habitat is within this elevational range, and much of it is north of the equator, as are most of the historical records.



The bimodal distribution of historical occurrence records of the birds is reflected in the model, representative of the actual distribution of forest in the Andes, and it is also repeated in the recent test records as well. This leads to questions for future research as to what is the mechanism behind it? Is this bimodal distribution due to environmental factors, to biological factors, or perhaps to limitations of the remote sensing data that were used to develop the cover data?

Limitations to this Process

- **Convenience sampling is the most serious**

- Imprecise georeferencing of test points
- Coarse pixel size of 1 km^2
- Difficulty of determining true “absence” points

- Declining population is also problematical

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Several factors inherent in the original historic data, as well as in the biology of the birds, impede the accuracy of the models and interpretation of the modeled results. Chief among them is the nature of the sampling conducted to date. Virtually all occurrence data gathered to date on this bird in South America is the result of opportunistic sampling, in which observers choose localities based upon their accessibility rather than at random based upon their location and characteristics chosen in advance.

Convenience sampling means that the test data are not well distributed to evaluate the full range

Many of the test points suffer from imprecise geographic specification

Available coverages of a variety of scales were reduced to common denominator of 1 km^2

Descriptive Results of Field Surveys

- **Distribution**
  - East slope of the Andes throughout
  - On both slopes of the Andes from Ecuador north, and in Venezuelan tepuis
  - Concentrations are in sheltered intermontane valleys
  - 500-1500 m elevation accurate south of Colombia
  - Colombian occurrence extends to 2000 m

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Nevertheless, recent surveys for the species have produced important information. Cerulean Warblers occur predominantly on the eastern slope of the northern Andes, but persistent occurrence is noted in small numbers on both slopes of the Andes from Ecuador north, and in Venezuelan tepuis. Elevational association is concentrated in upper tropical and subtropical lifezones, especially 800-1700 meters in sheltered inter-montane Andean valleys.

Descriptive Results of Field Surveys

- **Habitat**
  - Primary Forest and
  - Agroecosystems are represented
    - Shade coffee, Cardamom, Cacao
  - Association with large forest patches possible
  - Occurrence in small patches also observed

- **Detailed studies are sorely needed**

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Distributed among various habitats, they may reach highest densities in agroecosystems with mature trees, such as found in coffee, cacao, and cardamom growing under shade. Further study is required to assess association with forest patches of particular sizes, or landscapes of particular size with minimal forest cover.

Descriptive Results of Field Surveys

- **Associated Species**
  - Often with mixed species flocks
  - Not always so, in confusing pattern
- **Habitat Segregation**
  - Age and sex differences not yet understood
  - Seasonal changes in use suspected
- **Demographic Consequences**
  - Utterly unstudied

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Association with mixed species flocks is apparent in some localities, not in others. Demographic analyses are sorely needed; preliminary results indicate some interannual site fidelity and potentially high intraseasonal survivorship. Still, proportion of available landscape remaining in forest is lowest in the northern portion of this range, where birds from the expanding northern part of the breeding range reside, and higher in the south where reside birds from declining southern breeding populations.

Results Suggest

- Initial hypotheses of range basically correct
- Occurrence in SE Venezuela worth investigation
- Use of 90m DEM data will be valuable
- Exploration of Percent Forest Cover with 500m data will be useful
- Rigorously designed sampling is next step

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Our results generally confirm the understanding of the range of the species from existing literature, eg. Mid-elevations of the foothills and lower slopes of the Andes, primarily on the eastern slope of the Sierra Oriental. We may now add occurrence in sheltered valleys.

The potential occurrence in SE Venezuela is a relatively new idea, and worth investigation

The importance of more specific data to sharpen our predictions is obvious, but will depend on better georeferencing of field data in our upcoming tests.

Occurrence in tepuis of Venezuela is poorly documented, may well include portions of adjacent Brazil and Guyana

Exploration of Slope, Elevation, and Aspect with 90m DEM data will enable more precise testing and field validation

Exploration of Percent Forest Cover with 500m data will be useful

Summary

- Model results are useful, albeit poor predictors
- Population decline hinders understanding
- Unoccupied habitat may exist in the non-breeding range

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A potentially important implication of these results is that a substantial amount of unoccupied habitat may exist for the species in northern South America. A huge remaining question is why are the birds not present in it? Our field process in the upcoming years will allow us to refine these models, and to segregate the effects of low population size from the capacity to identify habitat. The best a model can ever do is identify places where the birds are likely to occur. When populations become very low, unless the habitat is shown to be a very specific, unique combination of conditions, unoccupied habitat that is perfectly suitable is going to exist. For management of future, hopefully larger, populations, knowing that decent habitat already exists and where it is, will be key to the strategy to protect the species in the future.

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- Support of **scores of bird watchers** who provided records of observations

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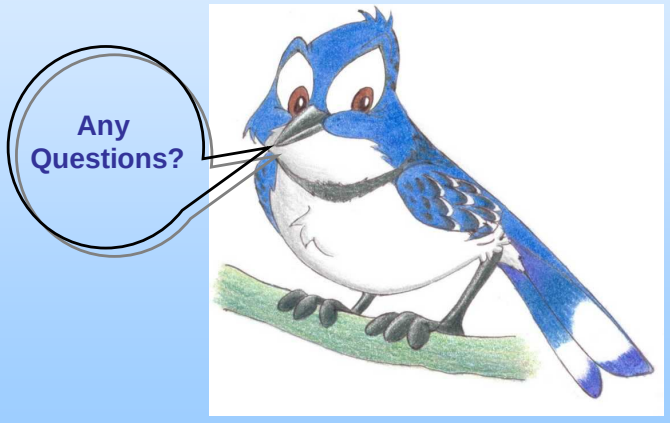
We benefit from a great deal of support and good will from many sources. Funding support has been necessary to do this work, and extensive logistical support made it successful, but without the efforts of a large number of people willing to share their observations, it would not have been possible.

Thanks also to Erick Manrique of
ProAves, Peru, for use of his drawing,
y a Enrique Acosta por su ayuda con la traduccion



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If there are any questions, I will be happy to answer them, in English.