Characterization and prediction of future habitat suitability for three bird species inhabiting the Rio Grande Bosque, NM

Megan M. Friggens, Deborah M. Finch
Rocky Mountain Research Station, United States Forest Service

Background

Future expected changes in climate and human activity threaten many riparian habitats, particularly in the southwestern U.S. As part of an ongoing project to assess future climate, fire and hydrological change for riparian species along the Rio Grande, New Mexico, we report the results of an ecological niche model analysis for three bird species: Lucy's warbler (*Oreothlypis luciae*), the Southwestern willow flycatcher (*Empidonax traillii extimus*) and the Yellow-billed cuckoo (*Coccyzus americanus*). Our objective was to identify areas important for species' conservation into the future. Specifically, we ask:

1. Does the availability of suitable habitat change under future conditions?
2. What lands and areas show the most promise for providing habitat for these species in the future?

Study Site

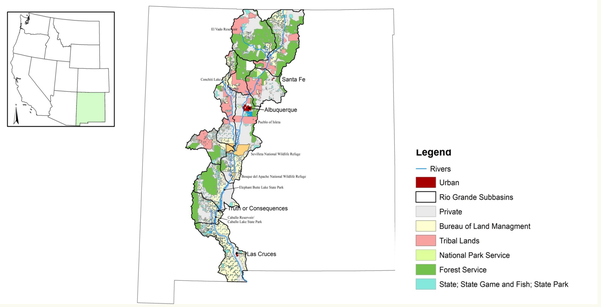

Figure 1. Study area includes watersheds adjacent to or within 20km of the Rio Grande in New Mexico.

Methods

- Collected observation data from museum collections* as well as surveys conducted by RMRS.
- Calculated current and future (2030, 2060, 2090) climate and habitat variables from available data archives (BOR 2011, Rehfeldt et al. 2006, **Fig. 2**). Climate data were compiled and averaged from downscaled CMIP3 (Gangopadhyay et al. 2011) climate and hydrological projections under three GCMs (cgcm 3.1, gfdl cm2.0, and Had cm3.1) and an A2 emission scenario (**Fig. 3**).
- Characterized habitat relationships and generated spatial predictions of habitat suitability using Maximum Entropy modeling (MaxEnt3.3.3).
- Used jackknife resampling to estimate relative importance of individual variables (**Table 1**).
- Determined probable suitability based on the equal sensitivity and specificity logistic threshold (**Fig. 4**).
- Compared distributions across BLM New Mexico Surface Ownership classes (http://rgis.unm.edu) (**Figs. 5,6**).

Results

1. Future Conditions

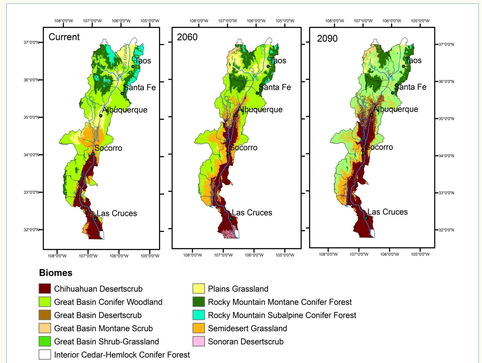

Figure 2. Changes to biomes under an A2 emission scenario. From Rehfeldt et al. 2006.

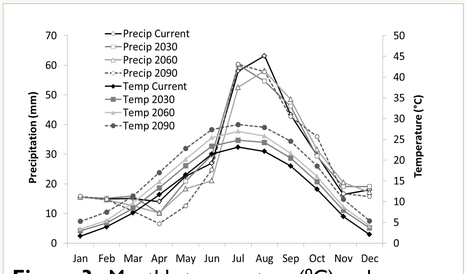

Figure 3. Monthly temperature (°C) and precipitation (mm) for three climate models (cgcm 3.1, gfdl cm2.0, and Had cm3.1) averaged over the study area for four time periods. Each time period represents a 20 year average (e.g., 2030 = mean of years 2020-2040).

2. Future Distribution

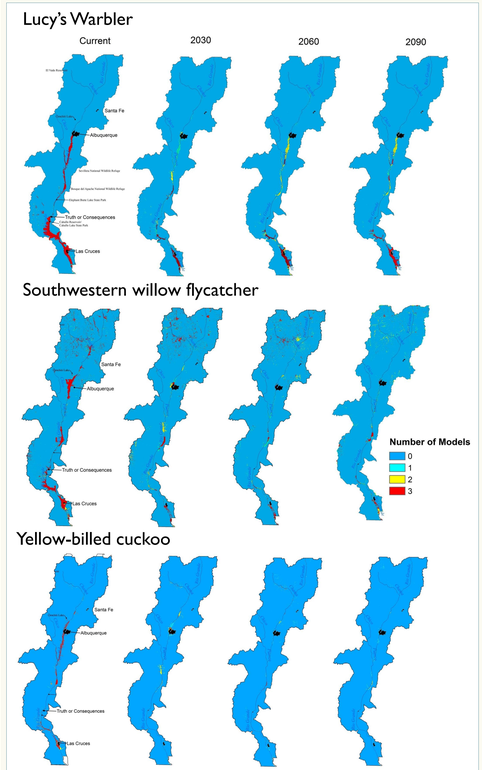

Figure 4. Consensus maps of predicted suitable habitat for four time periods.

3. Land ownership changes

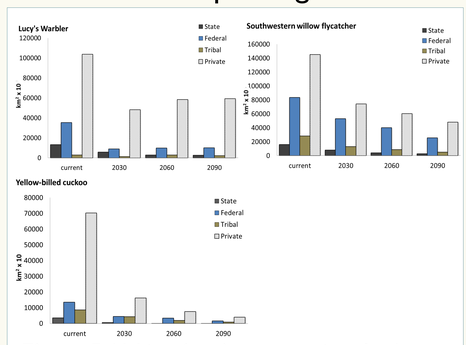

Figure 5. Habitat (area) across various land ownership classes over time.

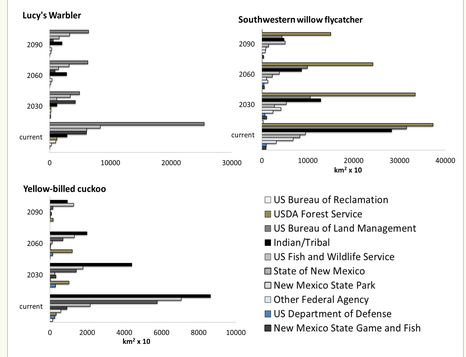

Figure 6. Habitat (area) across public and Tribal lands under changing climate conditions.

Model and Variable Performance

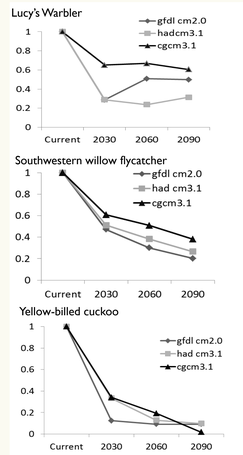

Figure 7. Percent change in area of suitable habitat under three climate scenarios.

Table 1. Model parameters and variable performance. Values represent average of output for futures based on three climate futures. Top four variables in bold.

	Lucy's Warbler	Southwestern willow flycatcher	Yellow-billed cuckoo
Training samples (10% used to test)	66	20	86
AUC	0.97	0.94	0.96
Gain	2.87	2.09	2.53
	Variable Importance (%)		
Annual Precipitation	0.1	2.62	0.39
Precipitation September (Bio13)	0.01	3.31	2.51
Precipitation JJA (Bio18)	0.10	6.02	3.98
Potential annual evapotranspiration	5.12	5.57	**5.91**
Mean Diurnal range of Temperature (Bio 2)	**11.89**	**9.66**	2.91
Isothermality (Bio3)	0.51	0	0.26
Max Temperature July (Bio5)	**8.44**	4.03	3.36
Temperature Annual Range (Bio7)	0.11	0.01	0.18
Biome	2.47	**11.04**	2.03
Distance to water	**49.39**	**38.42**	**47.99**
Elevation	**20.23**	4.52	**26.09**
Slope	1.64	**14.78**	**4.40**

Conclusion

Models performed well in predicting summer habitat and show unique habitat associations for each species (Table 1). Habitat suitability declined for all species with increasing distance from water and elevation. Habitat declines generally lead to smaller core areas of high suitability with some areas (e.g. Bosque del Apache, Fig. 1) remaining important for all three species under future conditions (Figs. 1, 4). The availability of open water adjacent to preferred nesting habitat is likely to be the most important predictor of future bird presences under warmer, dryer conditions. Future locations of suitable habitat shift across ownership boundaries though the majority remains on privately held land (Figs. 4, 5), highlighting the continued importance of collaborative land management strategies.

Acknowledgments

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*Delaware Museum of Natural History Bird Collection, University of Kansas Biodiversity Institute, Harvard University Ornithology Collection, Museum of Southwestern Biology, MVZ Bird Catalog, University of Arizona Museum of Natural, University of Colorado Museum of Natural History, University of Michigan Museum of Zoology, National Museum of Natural History, Smithsonian, Western New Mexico University.

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2. Rehfeldt, G. E., Crookston, N. L., Warwell, M.V., Evans, J. S. 2006. Empirical Analyses of Plant-Climate Relationships for the Western United States. *Int J Plant Sci* 167:1123-1150.
3. Gangopadhyay, S., Pruitt, T., Brekke, L. and Raff, D. 2011. Hydrologic projections for the western United States. *Eos, Trans American Geophys Un* 92: 0096-3941.