Planning for Climate Change in South Florida: Climate Envelope Modeling for Threatened and Endangered Species

Laura A. Brandt[1], Stephanie S. Romañach[2], James I. Watling[3], Ikuko Fujisaki[3], Emily Pifer[3], Michelle J. Curtis[1], Yesenia Escribano[3], Frank J. Mazzotti[3], Don L. DeAngelis[2], Leonard G. Pearlstine[4],

[1]U.S. Fish and Wildlife Service, [2]U.S. Geological Survey, [3]University of Florida, [4]U.S. National Park Service

Climate change will affect our natural resources in direct ways (e.g., changes in temperature and precipitation) and indirect ways (e.g., changes in land use and water availability). Some species and habitats may thrive while others may shift in distribution or disappear. Maintaining landscapes suitable for sustaining fish, wildlife, and plant populations in the face of these challenges requires that we think proactively about where suitable conditions may be in the future and the sensitivity of species to not only changes in climate variables, but also changes in land use. Part of assessing responses of species to climate change is development and application of climate envelope models.

Climate envelope models describe relationships between species' occurrences and bioclimate variables to define a species' climate niche (envelope), and then map the geographic shift of that envelope under climate change scenarios (IPCC 2007b).

Our goal is to develop a flexible framework for developing and applying climate envelope models that can be used for a wide range of species and promotes comparability among approaches and across geographic areas.

Climate envelope models for 26 terrestrial threatened and endangered species within Peninsular Florida will be created using both contemporary climate data and 1-3 climate projections. Output will be raster-based grids, stored as ASCII and NetCDF files adhering to the Comprehensive Everglades Restoration Plan (CERP) NetCDF standard which ensures compatibility with ArcGIS and EverVIEW.

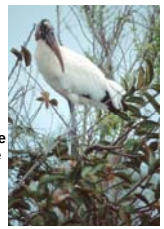
Mammals
Key Deer
Key Largo Cotton Mouse
Southeastern Beach Mouse
Anastasia Beach Mouse
Florida Salt Marsh Vole
Florida Panther
Lower Keys Marsh Rabbit
Silver Rice Rat
Key Largo Woodrat
Florida Bonneted Bat

Birds
Audubon Crested Caracara
Florida Scrub Jay
Everglades Snail Kite
Piping Plover
Cape Sable Seaside Sparrow
Florida Grasshopper Sparrow
Wood Stork
Red-cockaded Woodpecker
Roseate Tern
Whooping Crane

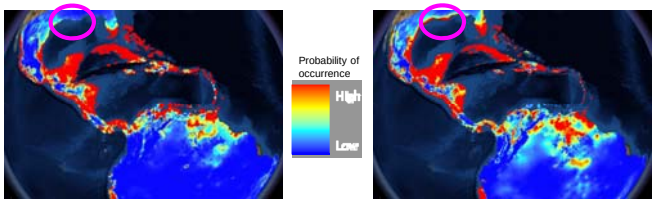
Reptiles
American Crocodile
Bluetail Mole Skink
Sand Skink
Atlantic Salt Marsh Snake
Eastern Indigo Snake

Amphibians
Flatwoods Salamander

The range of the wood stork (shaded area) overlaps several landscape conservation cooperatives. We will model the climate envelope throughout the geographic range.



We have created prototype climate envelopes for the American crocodile (*C. acutus*) using WorldClim data as the contemporary source and the WorldClim projections of the IPCC A2 (high CO_2 emissions) scenario for future climate space. Note the higher probability of occurrence in coastal Louisiana under the A2 scenario.



***C. acutus* contemporary climate envelope using WorldClim data.**

***C. acutus* climate envelope 2080 using IPCC A2 scenario**

Current occurrence data for *C. acutus*. Source: NatureServe

Climate envelope models show where the climate is suitable for the species. Habitat models show where there is habitat within the climate space. Actual occurrence of a species is an integration of climate space, habitat, and biotic interactions.

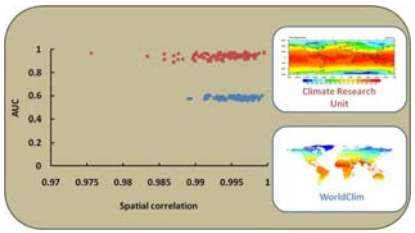
In addition to climate envelope models, we are producing a **searchable database** with species life history, habitat associations, and climate sensitivity information linked to an **EndNote library** with references. This information will inform development of the climate envelope models and provide information that can be used in vulnerability assessments, updates to recovery plans, comprehensive conservation plans, and Florida's state wildlife action plan.

A third product is a **Guidebook** for developing/using climate envelope models that discusses data needs, assumptions, and uncertainties in commonly used inputs and methods with direct reference to performance for our modeled species and application to management decisions. As the use and development of climate envelope models becomes more common, it will be important to understand the limitations and assumptions of the modeling.

Questions that will be addressed include:

- How many points are needed to define "presence and absence" for species with different characteristics?
- How does the geographic extent chosen for the modeling affect the results?
- How does the choice of contemporary climate data (i.e., WorldClim, Climate Research Unit, or PRISM) affect model performance?
- How does the modeling method used (e.g., maxent, logistic regression, regression trees and support vector machines) affect model performance?

Species such as the snail kite, with larger geographic ranges will require more occurrence points for defining climate envelopes than species that have smaller geographic ranges such as the Key Largo woodrat.



Results of bootstrap analyses exploring how data inputs affect performance of climate envelope models created for the American crocodile. All models used the same pool of species occurrences and the same number of background 'pseudo-absences' for construction.

Models built from climate input data acquired from the Climate Research Unit dataset were better able to discriminate between sites known to be occupied by *C. acutus* and sites of unknown status (lower AUC values) than models built from WorldClim input data, although the spatial consistency of predictions was similar for both datasets.

Climate envelope models, when linked with projections of changes in land use and changes in habitat, will be useful for informing decisions about:

- Land acquisition
- Suitable areas for restoration/translocation of species
- Establishment of corridors
- Development of monitoring to track effects of climate change

Acknowledgements

Funding for the first year of this project was provided by USGS Greater Everglades Priority Ecosystems Science, FWS South Florida Ecological Services Office, and NPS Critical Ecosystems Science Initiative.