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Data are scarce but action is necessary: Using agent-based models for conservation

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INTRODUCTION

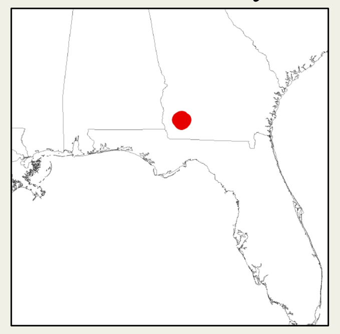
- In this poster we present preliminary results from a field study and simulation model investigating the long-term population ecology and large-scale movement patterns of the gopher tortoise (*Gopherus polyphemus*), a recent candidate for listing under the Endangered Species Act. Specifically, we are estimating survival rates, recruitment rates, dispersal rates/ distances, and landscape resistance to dispersal (i.e. functional connectivity) of gopher tortoises.
- **We are using this information to develop a spatially explicit individual-based model to explore how landscape composition and configuration (i.e. habitat fragmentation) affect tortoise population connectivity.**
- This research project is in collaboration with a larger research effort developing an adaptive landscape planning and decision framework for use by the Georgia Department of Natural Resources to make more-informed land management decisions for the statewide conservation of tortoise populations.

STUDY AREA

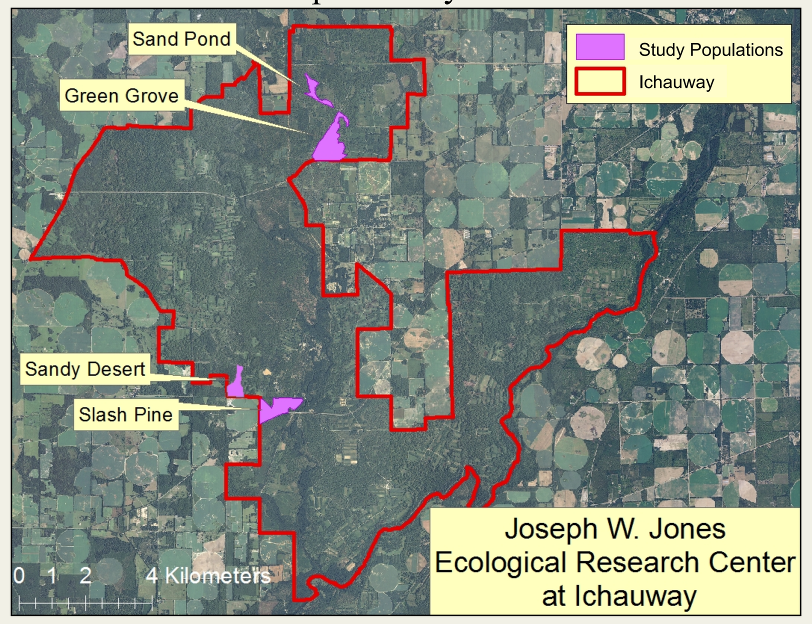
Our research is conducted at Ichauway, the ~11,200 ha private reserve of the Joseph W. Jones Ecological Research Center, located in the Coastal Plain ecosystem of the SE U.S.A.

- 4 study populations
- Original mark-recapture study: 1995-2000

Location of Study Site



Map of Study Site



ACKNOWLEDGEMENTS

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METHODS

***Core Area Tortoise Sampling* (*Long-term Population Ecology*)**

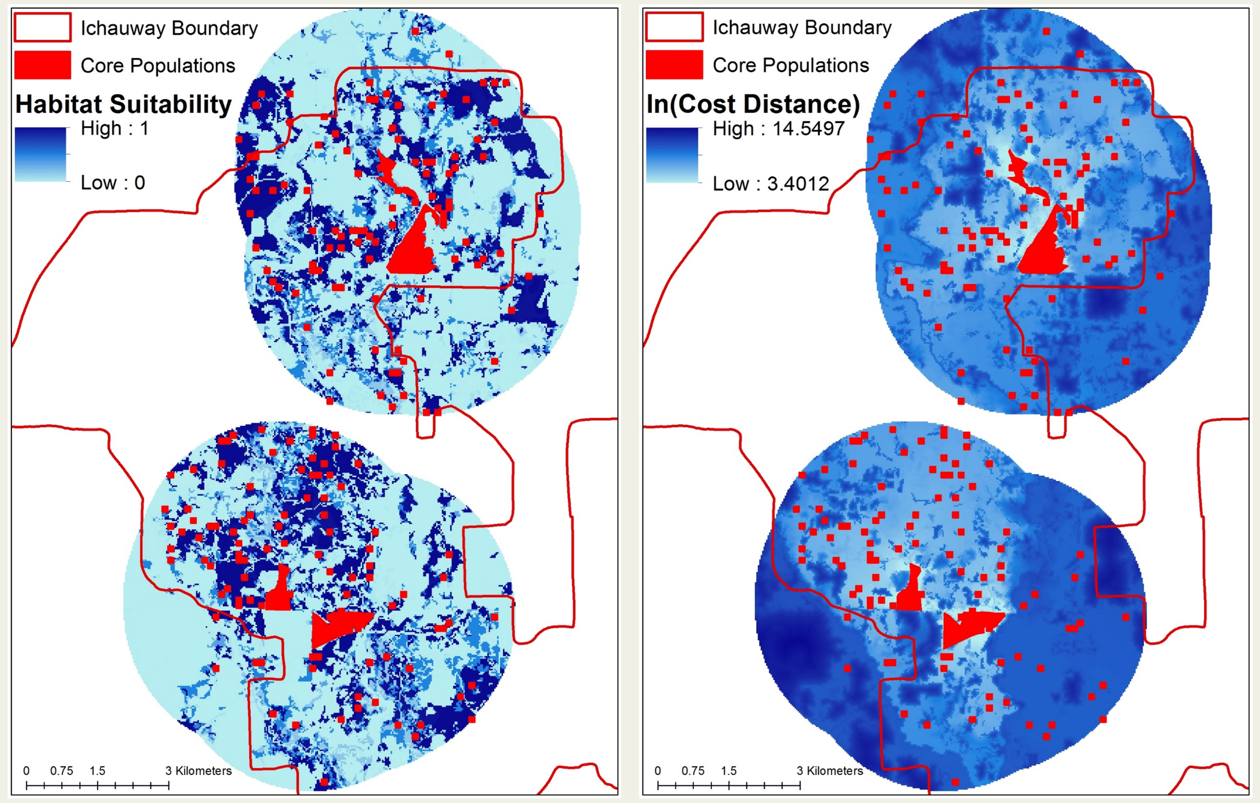
- June – August 2014 & May – June 2015 (Each of the four study populations were revisited once in this time frame)
- Study populations, all of which vary in size and suitability, were surveyed using the line transect distance sampling (LTDS) method with a dual observer (BUCKLAND et al. 2001), and all occupied gopher tortoise burrows were trapped using Havahart® live traps (Lititz, PA). Burrow occupancy was determined using a burrow camera (Environmental Management Services, Canton, GA).

***Outer Area Tortoise Sampling* (*Large-scale Movement Patterns*)**

To sample locations where the gopher tortoises trapped and marked in the early 1990's potentially dispersed to, we developed a sampling scheme that involved weighting potential dispersal locations and routes. Specifically:

- Habitat Suitability values were estimated for each pixel (30x30m) within a 3 km buffer of the study sites using burrow-presence data collected in a 2011 LTDS survey of Ichauway, land cover data, and soils types data.
- Resistance was estimated as the inverse of the habitat suitability value to calculate cost-distance, the least accumulative cost for each cell to the nearest core population over a resistance surface, in ArcGIS (ESRI, Redlands, CA).
- 2 ha sample grids were weighted by the habitat suitability value of each pixel and the cost-distance to a core area to give an unequal probability of selection.
- Approximately 200 – 2 ha grids were selected and are currently being surveyed and trapped.

FIGURE 1. Map representations of the outer area tortoise sampling grids in relation to habitat suitability and log-transformed cost-distance values.



Data Analysis

- Dispersal rates will be estimated from the long-term trapping data using Multi-state models (Two states: local vs. emigrant) in a Bayesian framework in the R-package RJAGS (2015 Plummer).
- Landscape resistance values will be estimated using the known previous and current locations of tortoises in the R-package SECR (2015 Efford).

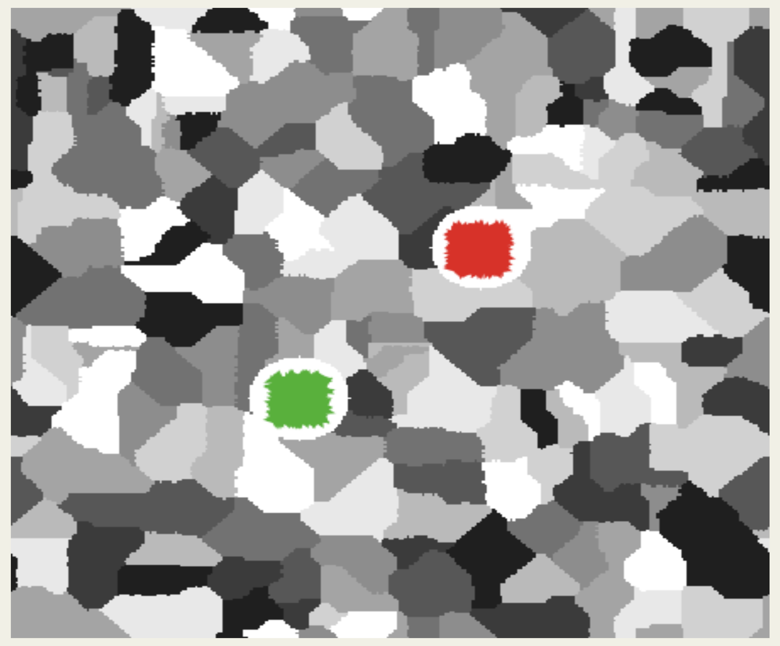
POPULATION CONNECTIVITY

Individual-Based Model (Preliminary Results)

- Based on our understanding of tortoise dispersal, reproduction, survivorship, and landscape resistance, we can ask, "**how does landscape composition and configuration** (e.g. mean patch size, cost-weighted distance, etc.) **affect population connectivity of gopher tortoise** (*Gopherus polyphemus*) **populations in a hypothetical landscape?"**
- This model simulates gopher tortoise movement and behavior for 35 years (one gopher tortoise generation). When the model is complete (see Figure 2.), the total frequency of alleles in each population is calculated and an F_{st} value (Wright's Fixation Index) is estimated to measure the genetic relatedness of the two populations.

FIGURE 2. A) Pre- and **B)** post-simulation run images from the model with a edge-to-edge distance between the two populations of 1.97 km, a mean patch size of ~ 50 hectares, and a F_{st} value of ~ 0.925. A F_{st} value of 0 represents no genetic differentiation among the two populations, a value of 1 represents no genetic mixing of the two populations. Patches range in habitat suitability from 0 (black) to 1 (white).

A)



B)

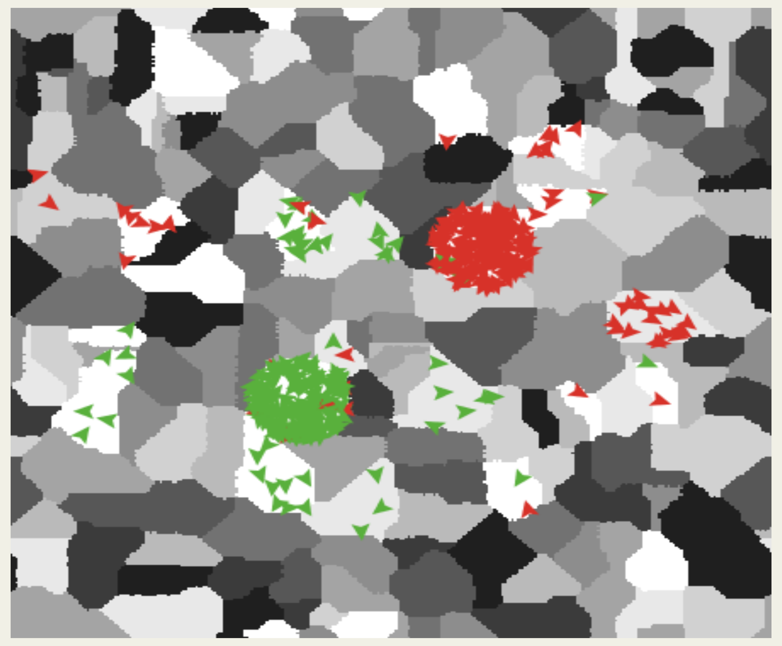
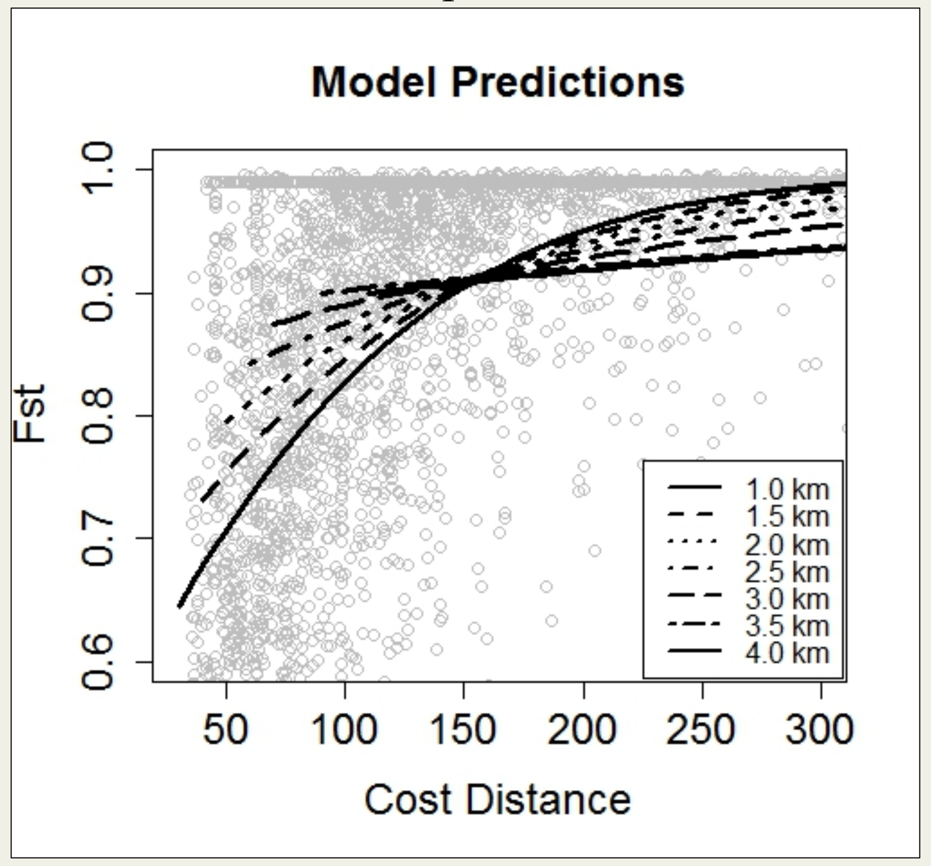


FIGURE 3. Predicted F_{st} (Wright's Fixation Index) estimates related to cost distance of the two populations at five different edge-to-edge distances with a mean patch size of 162 ha.



PRELIMINARY RESULTS

- **Our top model** incorporated cost-distance, distance, mean patch size, and their interactions (R^2=0.42). Predictions from our top model (Figure 3.) demonstrate the thresholds in which distance and cost-distance (a measure of the cumulative cost to travel across the intervening matrix) affect population connectivity.
- **By understanding** this relationship we can begin to understand and evaluate the connectivity of known populations in Georgia for the conservation of viable gopher tortoise populations across the state.