Using Ecological Traits to Evaluate the Vulnerability of Threatened and Endangered Species to Climate Change

Allison M. Benscoter[1], Laura A. Brandt[2], Frank J. Mazzotti[1], Stephanie S. Romañach[3], and James I. Watling[1]

[1]University of Florida, Davie, FL, USA, [2]U.S. Fish and Wildlife Service, Davie, FL, USA, [3]U.S. Geological Survey, Southeast Ecological Science Center, Davie, FL, USA

INTRODUCTION

Climate change presents unique challenges to threatened and endangered species because they are already at risk for extinction, and may have traits that make them vulnerable to environmental fluctuations. Several ecological traits have been associated with species vulnerability to environmental change and extinction, including long generation time, large body size, small geographic range size, and dispersal ability[1,2,3]. Our **objective** was to compare ecological traits between threatened and endangered subspecies and their non-endangered parent species, and use these comparisons as a tool to evaluate the vulnerability of threatened and endangered subspecies in Florida to extinction risk under climate change.

METHODS

Life history information was gathered from published literature for 14 taxon-pairs and 3 trait categories: litter/clutch size, home range size, and dispersal distance. Each taxon-pair consisted of a federally threatened or endangered subspecies located in Florida (hereafter referred to as endangered) and their non-endangered parent species.

To test for trait differences between subspecies and parent species across all taxon-pairs, data were transformed to proportions of the maximum value for each taxon-pair x trait combination, and analyzed according to a mixed model ANOVA with trait nested within taxon. Tukey's HSD contrasts were calculated to determine differences between taxon-pairs for each trait.

For taxon-pair x trait combinations with greater than 3 independent observations per taxon, we conducted Wilcoxon rank sum tests (non-transformed data) to test for trait differences in individual taxon-pairs. Observations from published literature were classified as independent if they contained data without overlapping individuals, locations, or time periods.

STUDY SPECIES

Table 1. Federally threatened and endangered subspecies used to compare life history traits between subspecies and non-listed parent species.

SUBSPECIES	FEDERAL STATUS
Mammals	
Neotoma floridana smalli	Endangered
Odocoileus virginianus clavium	Endangered
Oryzomys palustris natator	Endangered
Puma concolor coryi	Endangered
Peromyscus polionotus niveiventris	Threatened
Peromyscus polionotus phasma	Endangered
Sylvilagus palustris hefneri	Endangered
Birds	
Ammodramus maritimus mirabilis	Endangered
Ammodramus savannarum floridanus	Endangered
Polyborus plancus audubonii	Threatened
Rostrhamus sociabilis plumbeus	Endangered
Reptiles	
Drymarchon corais couperi	Threatened
Eumeces egregius lividus	Threatened
Nerodia clarkii taeniata	Threatened


Polyborus plancus audubonii


Drymarchon corais couperi


Eumeces egregius lividus


Rostrhamus sociabilis plumbeus

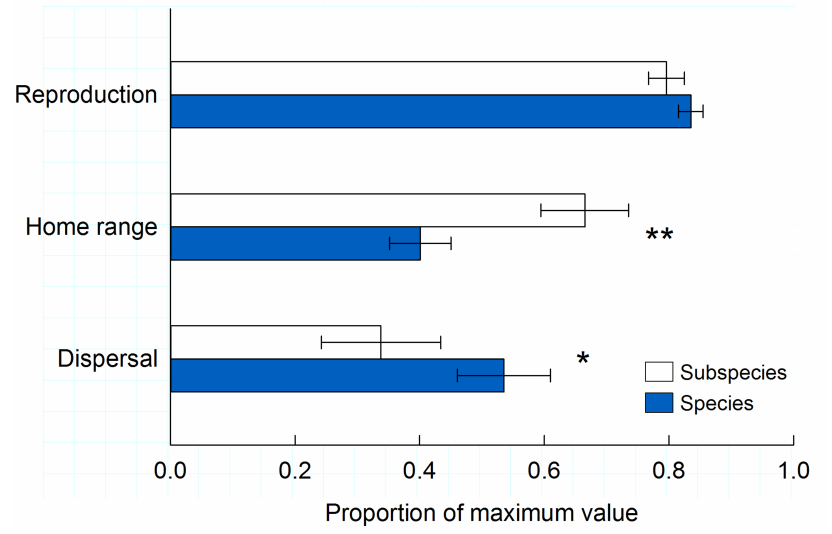

Odocoileus virginianus clavium


Ammodramus savannarum floridanus

RESULTS

COMPARISONS ACROSS TAXON-PAIRS

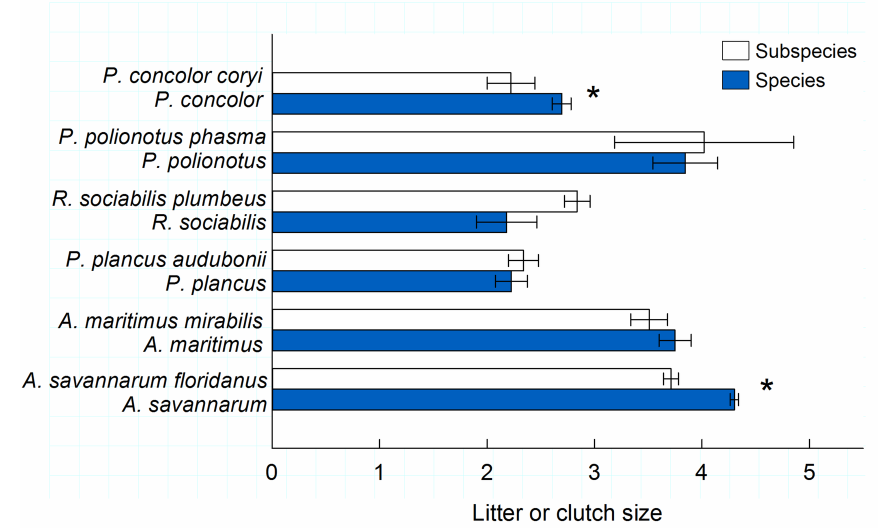
Across all taxon-pairs, there was significant variation among traits nested within taxon (p<0.001)



Across all taxon-pairs, endangered subspecies exhibited larger home range sizes (p=0.002) and shorter dispersal distances (p=0.018) than non-endangered parent species

Figure 1. Mean (± SE) transformed trait values for all endangered subspecies and non-endangered species. Data were transformed to proportions of the maximum value for each taxon-pair x trait combination. For each trait, asterisks denote significant differences between subspecies and species (**0.001 < p < 0.01; *0.01 < p < 0.05) based on Tukey's HSD.

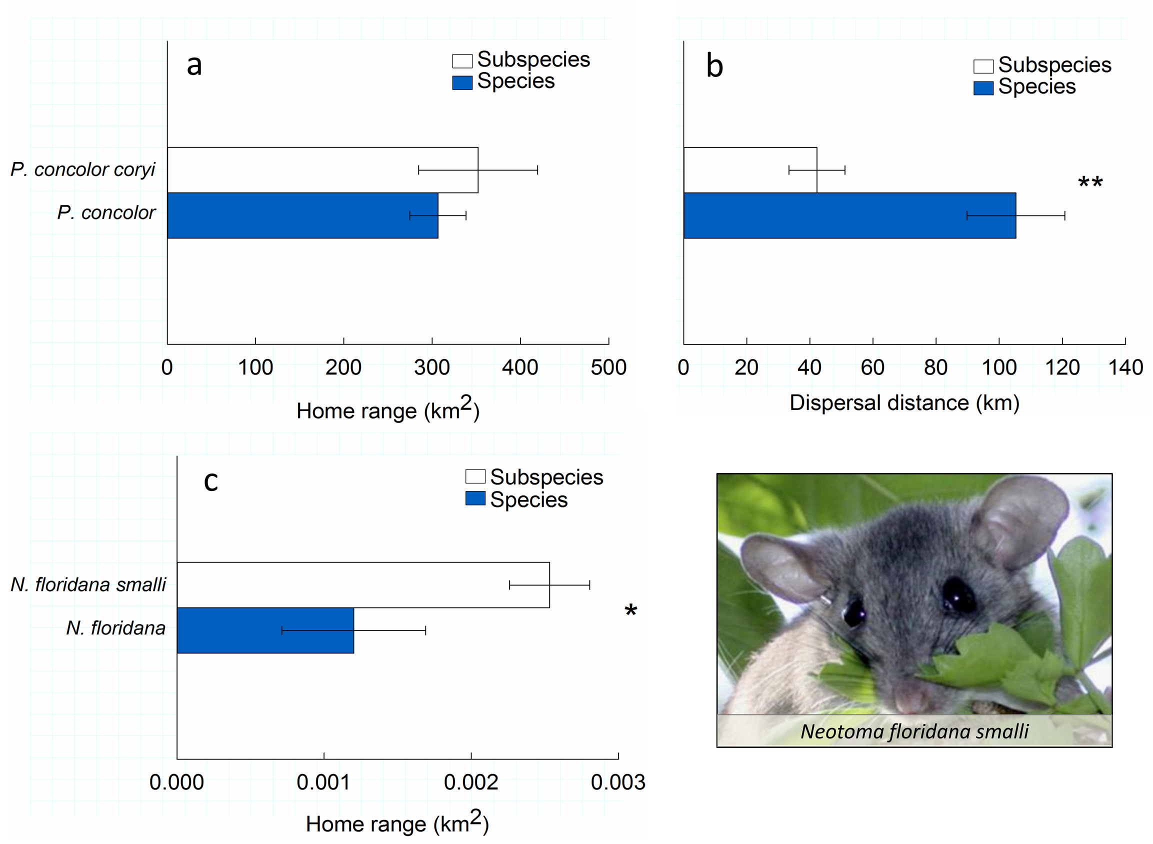
COMPARISONS WITHIN TAXON-PAIRS



P. concolor coryi (p=0.048) and *A. savannarum floridanus* (p=0.012) had lower reproductive output than their parent species.

For 4 taxon-pairs, reproductive output did not differ between endangered subspecies and parent species.

Figure 2. Mean (± SE) litter or clutch size for endangered subspecies and non-endangered species. For each taxon-pair, an asterisk denotes significant differences between subspecies and species (* p < 0.05) based on Wilcoxon rank sum tests.



Home range size of *P. concolor coryi* did not differ from *P. concolor*.

P. concolor coryi exhibited a shorter dispersal distance than *P. concolor* (p = 0.006).

N. floridana smalli showed a larger home range size than *N. floridana* (p = 0.050).

Figure 3. Mean (± SE) home range and dispersal distance for *P. concolor coryi* and *P. concolor* (a-b), and mean (± SE) home range for *N. floridana smalli* and *N. floridana* (c). For each taxon-pair, asterisks denote significant differences between subspecies and species (** 0.001 < p < 0.01; *0.01 < p < 0.05) based on Wilcoxon rank sum tests.

DATA AVAILABILITY

Data were obtained for 10 out of 14 taxon-pairs

	NUMBER OF TAXON-PAIRS WITH DATA AVAILABLE	
TRAIT	< 3 OBSERVATIONS/TAXON	≥ 3 OBSERVATIONS/TAXON
Litter/clutch size	10 out of 14	6 out of 14
Home range size	8 out of 14	2 out of 14
Dispersal distance	3 out of 14	1 out of 14
TOTAL	21 out of 42 combinations	9 out of 42 combinations

DISCUSSION

Across all taxon-pairs, endangered subspecies had larger home ranges and shorter dispersal distances than non-endangered species. Larger home range size has been associated with greater extinction risk[4], due to greater exposure to fragmentation, and may be indicative of higher resource requirements or lower habitat quality for endangered subspecies in Florida. Lower dispersal may indicate a compromised ability to colonize new areas, especially given that many endangered subspecies in Florida have already experienced environmental pressures such as habitat degradation and fragmentation. Larger home range size and shorter dispersal distance could increase climate change vulnerability in these species, and could limit their ability to track changing climate in a fragmented landscape. These traits may represent inherent characteristics of endangered subspecies in Florida, or be a consequence of the degraded landscape.

Across all taxon-pairs, there was no difference in clutch and litter size between endangered subspecies and non-endangered species, indicating that this may not be a crucial factor that will affect climate change vulnerability for most endangered subspecies in Florida. Within taxon-pairs, we observed differences in reproduction for 2 out of 6 taxon-pairs. *Puma concolor coryi* and *A. savannarum floridanus* had lower reproductive output compared to their parent species. Because slow life history is associated with increased extinction risk[5], and low reproductive output affects population growth and the ability to recover from disturbance, these subspecies may be more vulnerable to climate change.

FUTURE DIRECTIONS

- ♦ Compile data for all of the federally threatened and endangered subspecies in Florida, and their parent species
- ♦ Compile data on additional variables, including survival, maximum dispersal, and geographic range size
- ♦ Complete species vulnerability assessments for each subspecies and parent species (collaboration with Joshua Reece and Reed Noss at UCF)
- ♦ Relate indicators of extinction risk to the vulnerability assessments

LITERATURE CITED

1. Fritz, S.A., O.R.P. Bininda-Emonds, and A. Purvis. 2009. Geographical variation in predictors of mammalian extinction risk: big is bad, but only in the tropics. Ecology Letters **12**:538-549.
2. Cardillo, M. 2003. Biological determinants of extinction risk: why are smaller species less vulnerable? Animal Conservation **6**:63-69.
3. Massot, M., J. Clobert, and R. Ferriere. 2008. Climate warming, dispersal inhibition and extinction risk. Global Change Biology **14**:461-469.
4. Woodroofe, R., and J.R. Ginsberg. 1998. Edge effects and the extinction of populations inside protected areas. Science **280**:2126-2128.
5. Purvis, A., J.L. Gittleman, G. Cowlishaw, and G.M. Mace. 2000. Predicting extinction risk in declining species. Proceedings of the Royal Society of London B **267**:1947-1952.

ACKNOWLEDGMENTS

Funding and research assistance provided by the U.S. Fish and Wildlife Service, National Park Service (Everglades and Dry Tortugas National Park), through the South Florida and Caribbean Cooperative Ecosystem Studies Unit, and U.S. Geological Survey (Greater Everglades Priority Ecosystems Science).

Photo credits: *R. s. plumbeus* (D. Sanchez), *O. v. clavium* (C. Lesser and A. Drauglis), *A. s. floridanus* (C.L. Evans), *P. p. audubonii* (V. J. Franke), *D. c. couperi* (M. Rochford), *E. e. lividus* (M. Rochford), *N. f. smalli* (C. DeGayner).

Contact: A.M. Benscoter, email: abenscoter@ufl.edu

UF UNIVERSITY of FLORIDA — USGS science for a changing world — U.S. FISH & WILDLIFE SERVICE — NATIONAL PARK SERVICE