Predicting the Consequences of Global Climate Change on Aquatic Snakes in the Midwest

Ella Janson, Jess Lindberg, Joseph Milanovich
Department of Biology, Loyola University Chicago

BACKGROUND

-At least 21.1% of reptile species are threatened (Cox et al 2022).
-The rate of reptile decline is much higher in freshwater environments and tropical regions (Böhm M. et al 2013).
-As climate change is predicted to alter precipitation events, snakes without proper adaptations which would make them resilient to a drought could have negative effects on the aquatic snake population (Vogrinc et al 2018, Urban et al 2014).
-Adaptations may buffer some of the threats of climate change for reptiles and amphibians (Urban et al 2014).
- Species Distribution Models (SDMs) can predict changes in suitable habitats (Struecker 2016).
- Maxent is an ecological niche modelling program which uses occurance data to predict species distribution and was used to create the SDMs (Stuecker 2016), (Wilson et al 2011). -Maxent is able to predict the future suitable habitats by uisng predicted environmental data (Struecker 2016).

HYPOTHESIS

I predict that aquatic snake distribution will shrink and that the predicted suitable habitat will differ from the current projections. Likewise, I predict that the suitable habitat will expand northward and that this expansion will occur to a greater degree in 2070.

METHODS

-Current distribution data on aquatic snake species in the midwest was collected using the databases GBIF and USGS
-Climate data based on current conditions, predicted conditions in 2050 and predicted conditions in 2070 was collected using WorldClim
-A total of 28 maps were created using ArcGIS Pro. Two global climate models were used to create these maps: CCSM4 (Canadian model) and HadGEM2-ES (Hadley model).
-For each climate model, two representative concentration pathways (RCPs) were used to specify future conditions based on climate change mitigation efforts and carbon emissions scenarios.
-An RCP of 2.6 is the carbon emissions scenario assuming a strict climate policy while an RCP of 8.5 is the scenario assuming no climate policy.
-Maximum Entropy software (Maxent) was then ran using the distribution and climate data.
-Each year, model, and RCP was classified using three thresholds to make 36 binary maps where the data from maxent was averaged to form on value for each group.
-These thresholds defined areas of suitable habitat to demonstrate a presence (1) or absence (0) of the species in that area.
-The thresholds included a Liberal value (0.099), an Intermediate value (0.32) and a Strict value (0.26) computed from Maxent
-The projection of these maps was defined using the geographic projection WGS 1984.
-These binary maps were then clipped to the buffered range of each aquatic snake species for 2050 and 2070, which used a maximum dispersal rate of 53 m/d.

RESULTS

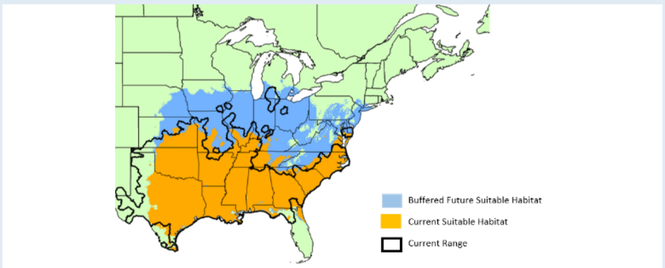

Figure 1) Worst-case scenario for 2050: Hadley model, RCP 8.5, Strict Threshold

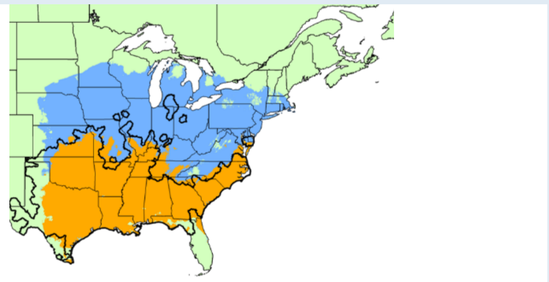

Figure 2) Worst-case scenario for 2070: Hadley model, RCP 8.5, Strict Threshold

Species	Model (Canadian or Hadley)	Year (2050 or 207	RCP (2.6 or 8	Percent Difference (%)
Nerodia erythrogaster	Canadian	2050	2.6	219
			8.5	38.9
		2070	2.6	24.4
			8.5	65.6
	Hadley	2050	2.6	40.4
			8.5	63.2
		2070	2.6	43.2
			8.5	72.6
Nerodia sipedon	Canadian	2050	2.6	7.3
			8.5	6.6
		2070	2.6	5.3
			8.5	7.6
	Hadley	2050	2.6	7.3
			8.5	34.1
		2070	2.6	15.7
			8.5	27
Nerodia fasciata	Canadian	2050	2.6	87.4
			8.5	87.2
		2070	2.6	62.8
			8.5	88.1
	Hadley	2050	2.6	79.4
			8.5	94.2
		2070	2.6	53.8
			8.5	83.8
Nerodia clarkii	Canadian	2050	2.6	65.3
			8.5	85.3
		2070	2.6	96
			8.5	99
	Hadley	2050	2.6	79.2
			8.5	207.3
		2070	2.6	83.9
			8.5	207.6
Regina grahamii	Canadian	2050	2.6	95.2
			8.5	261.2
		2070	2.6	83.3
			8.5	240.8
	Hadley	2050	2.6	207.2
			8.5	350.4
		2070	2.6	-7.9
			8.5	-29
	Canadian	2050	2.6	0
			8.5	-40.5
		2070	2.6	-36.1
			8.5	-63.2
Regina septemvittata	Hadley	2050	2.6	-27.5
			8.5	24.5

PLANS FOR THE FUTURE

-Compare the presence/absence values of the current maps to the values of all future maps
-Conduct a statistical analysis to determine percent change in the suitable habitats
-Predict species richness of aquatic snakes in the midwest by using overlaid future distribution models
-Keep these maps updated using the most recent climate models
-Potentially apply land use data to determine how much of the predicted suitable habitat for aquatic snakes is actually habitable based on current infrastructure/plans for future infrastructure

Nerodia erythrogaster neglecta - Copperbelly Water Snake

REFERENCES

-F. Aubert, R. Shrine. Thermal plasticity in young snakes: how will climate change affect the thermoregulatory tactics of ectotherms?. J Exp Biol, 15 January 2010, 213 (2): 242-248
-Urban, M.C., Richardson, J.L. and Freidenfelds, N.A. (2014), Plasticity and genetic adaptation mediate amphibian and reptile responses to climate change. Evol Appl, 7: 88-103.
-John H. Roe, Bruce A. Kingsbury, Nathan R. Herbert. Comparative water snake ecology: conservation of mobile animals that use temporally dynamic resources. Biological Conservation, vol. 118, no.1, 2004, pp. 79-89.
-Cox, N., Young, B.E., Bowles, P. et al. A global reptile assessment highlights shared conservation needs of tetrapods. Nature (2022).
-Böhm, M. et al. The status of the world's reptiles. Biol. Conserv. 157, 372–385 (2013)
-Vogrinc, Philip N.; Durso, Andrew M.; Winne, Christopher T.; and Willson, John D., "Landscape-Scale Effects of Supra-Seasonal Drought on Semi-Aquatic Snake Assemblages" (2018). Biology Faculty Publications. Paper 1584.
-Struecker, Brock, "Predicting Suitable Habitat Decline of Midwestern United States Amphibians and Quantifying the Consequence of Declines Using Pond-Breeding Salamanders" (2016). Master's Theses. 3355.
-Parella, D. (2018, March 7). Copperbelly Water Snake. Group 7. Retrieved May 5, 2022.

ACKNOWLEDGEMENTS

We would like to thank C. Cranberg and B. Struecker for their assistance and advice with GIS and modeling.