Using ecological niche modeling to predict the response of *Hydrocotyle bonariensis* to global climate change

Rachel E. Bonner, Laura K. Dease, Elizabeth A. Hughston, Justin C. Bagley

Department of Biology, Jacksonville State University, Jacksonville, AL 36265

INTRODUCTION

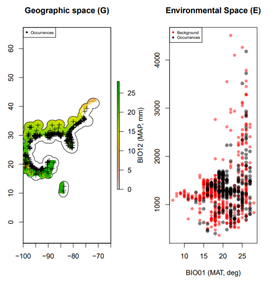
We began our research on *Hydrocotyle bonariensis*, also known as the Largeleaf pennywort. This species thrives in warm climates, with sand dunes or wet sandy soil near salt water. *Hydrocotyle bonariensis* thrives on the shoreline of the south-eastern United States where this specific climate is very prevalent. The purpose of our experiment is to gather information on *Hydrocotyle bonariensis* and utilize the 'R' coding system (Elith et al., 2009) to predict and visualize the relative occurrence of the species and the fundamental and realized niche. We also used this information to predict future models for this species habitat, taking into account climate change. Collectively, we predicted that climate change and habitat destruction will have a negative impact on our species and its occurrences in this habitat.

(Largeleaf Pennywort Photo -plantdetail.shtml)

OBJECTIVES

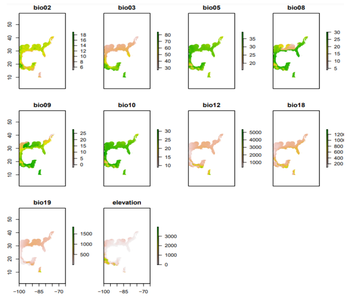
- Our objective was to gather information about the Largeleaf pennywort via Ecological Niche modeling (Peterson et al., 2011.) and look at the different occurrences and the environmental variables and put them through MaxEnt (Phillips et al., 2006, 2021.) to get the modeling.
- In more depth for the species occurrences, we looked at their presence, absence and abundance.
- For the environmental variables, we took into consideration climate, soils, elevation, vegetation, land coverage, and occurrences of other species surrounding the Largeleaf pennywort.
- We also used ODAMP protocol which stands for Overview/Conceptualization, Data, Modeling, Assessment, and Prediction.
- We also looked at bias, evaluation, and interpretation when looking at the data.

Two Panel Occurrence Plots



Our 2-panel occurrence plots that demonstrate the species' occurrences based on geographic space (left) and the species' background and occurrences based on environmental space (right). These also demonstrate bias within the data.

WorldClim Variables



Our list of WorldClim reduced variables that have affected our current and future predictions of the occurrence rates of *Hydrocotyle bonariensis*, as well as their individual influences on the occurrence rate.

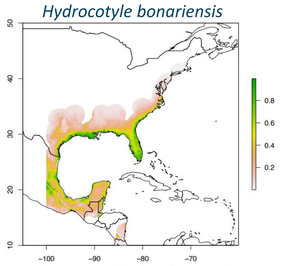
MATERIALS & METHODS

WorldClim variables: WorldClim (Hijmans et al., 2005) variables were used in our modeling to generate more biologically meaningful variables. These variables account for monthly temperature and rainfall values to more accurately consider the climate of an area. For the future environments we utilized the WorldClim cmip5 data set (https://www.worldclim.org/data/v1.4/cmip5_2.5m.html)

MaxEnt algorithm: We used the MaxEnt algorithm (maximum entropy modelling) to predict species occurrences by finding the distribution that is most spread out or closest to uniform, while still considering the environmental limits of known locations

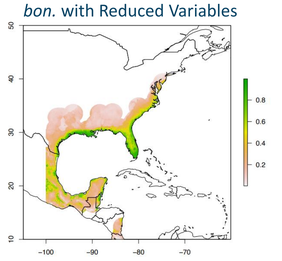
R studio: We used R-studio to keep our information organized, to be able to filter our data, and to manage our workspace. We also used it because coding saves time, and since we had so much to look at, R-studio helped keep it all in one place. We were provided a base code in "R" that we edited to meet our species' requirements and to filter out all the unnecessary information. We also used raster packs to help load and interpret our data (Hijmans et al., 2021).

Predicted Current Occurrences of *Hydrocotyle bonariensis*



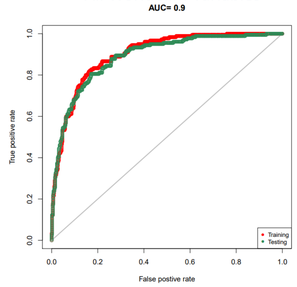
The current prediction model of *Hydrocotyle bonariensis*' occurrences with all WorldClim variables (bio01 – bio019 + elevation).

Predicted Current Occurrences of *Hyd bon.* with Reduced Variables



The current prediction model of *Hydrocotyle bonariensis*' occurrences with our reduced WorldClim variables (as seen to the left).

AUC Score for Occurrence Models with All WorldClim Variables

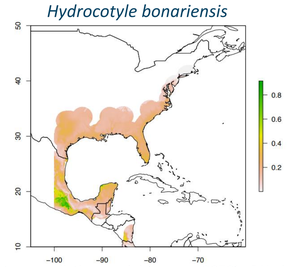


An AUC Score of 0.9 for the models with all WorldClim variables signifies a high probability that our model will be able to distinguish between True Positive and False Positive rates.

RESULTS

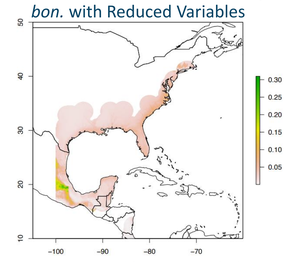
To generate our raw occurrence rates and their corresponding maps, we first obtained the species data of *Hydrocotyle bonariensis* and input it into R. With the information we obtained, we determined a set of variables most influential to the occurrence rate of our species, which included bio(02, 03, 05, 08, 09, 10, 12, 18, 19) and elevation, as seen in the bottom left figure. The *Hydrocotyle bonariensis* species data was then evaluated using the MaxEnt algorithm (Merow et al., 2013) both with and without regard to the WorldClim reduced variables, which generated the four maps below (Hijmans et al., 2020). We began with 7,053 occurrences; using coordinate cleaner, spThin, and mismatches between points and global data (Hijman et al., 2020), we ended up with 360 occurrences. From these occurrences, we were able to generate ROC plots with their corresponding AUC scores. Our AUC score for the full model was 0.9 and the AUC score for our reduced models (taking into account our reduced variables) was 0.879. The latter was obtained through correlation plots and spoke plots in order to visualize the correlation between our variables.

Predicted Future Occurrences of *Hydrocotyle bonariensis*



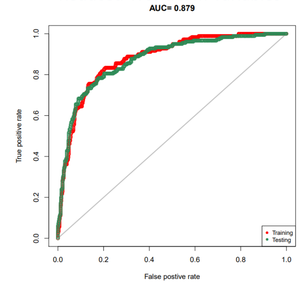
The future prediction model (approx. 2070) of *Hydrocotyle bonariensis*' occurrences with all WorldClim variables (bio01 – bio019 + elevation).

Predicted Future Occurrences of *Hyd bon.* with Reduced Variables



The future prediction model (approx. 2070) of *Hydrocotyle bonariensis*' occurrences with our reduced WorldClim variables (as seen to the left).

AUC Score for Occurrence Models with Reduced WorldClim Variables



An AUC Score of 0.879 for the models with our reduced WorldClim variables signifies a high probability that our model will be able to distinguish between True Positive and False Positive rates.

CONCLUSIONS

Since the AUC scores for both the full and reduced model equaled or were close to 0.9, we're able to infer that our model has a satisfactory performance of distinguishing between positive and negative classes. In reference to our models, we're able to visualize the current occurrence rate prediction. Both with and without our reduced variables, we see high occurrences of *Hydrocotyle bonariensis* along the shorelines of the Gulf of Mexico and the other side of Florida. When looking at the prediction of future occurrence rates with all WorldClim variables, in approximately 2070, there is a significant decline in appearances of this species. When taking into consideration the reduced variables we've chosen, there are even less occurrences of *Hydrocotyle bonariensis*. It is our suggestion that this could possibly be due to one of the following reasons: population growth and its corresponding habitat destruction, as well as climate change. In an ever-expanding world, it's inevitable that the habitat of many plant and animal species will be destroyed, whether that is to make room for housing or the continuing trend of urbanization, which is increasingly seen on the coasts due to it being a popular tourist location. Concerning climate change, as the global average temperature change continues to increase, the current habitat of *Hydrocotyle bonariensis* could become unsuitable for the species' needs.

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