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Biodiversity Informatics, 15, 2020, pp. 67-68

GENERAL THEORY AND GOOD PRACTICES IN ECOLOGICAL NICHE MODELING: A BASIC GUIDE

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Abstract. Ecological niche modeling (ENM) and species distribution modeling (SDM) are sets of tools that allow the estimation of distributional areas on the basis of establishing relationships among known occurrences and environmental variables. These tools have a wide range of applications, particularly in biogeography, macroecology, and conservation biology, granting prediction of species potential distributional patterns in the present and dynamics of these areas in different periods or scenarios. Due to their relevance and practical applications, the usage of these methodologies has significantly increased throughout the years. Here, we provide a manual with the basic routines used in this field and a practical example of its implementation to promote good practices and guidance for new users.

Key words— calibration area, geographical information system, Maxent, occurrence data, species distribution modeling, variable selection.

Species distributions are understood to be determined by three limiting factors: movement capacities, abiotic conditions, and biotic interactions. The joint effects of these three factors have been summarized in the so-called BAM diagram (Soberón and Peterson 2005). The principle of ecological niche modeling (ENM) is to relate locations where a species is observed with the environmental characteristics of those locations, to estimate conditions that are favorable for the species and consequently its potential geographical range (Peterson et al. 2011).

Recent years have seen an explosion of interest in building models of environmental suitability for species based on presence, absence, and abundance data, to estimate conditions within which a species can maintain populations without immigration subsidies (i.e., the ecological niche; Peterson et al. 2011, Warren 2012). However, the employment, documentation, and understanding of the rationale for configurations used on such estimates have been poorly documented, detracting robustness from ENM studies (Cobos et al. 2019, Warren 2012).

Seeking to reduce mistakes, improve standardization, ensure consistency, and provide training on the application of these tools, we provide basic guidelines on the building of ecological niche models. This document is the second in the series of manuals in the Biodiversity Informatics Training Curriculum to provide students and researchers interested in the field with a practical guide to construct ENMs. The first manual discussed some of the steps involved in cleaning biodiversity data, and included a practical exercise (Cobos et al. 2018). Both manuals are intended to emphasize key theoretical and methodological considerations.

The present document and the associated manual are not intended as a detailed treatment of geographical information systems, Maxent functions, or to present thorough guidelines (Araújo et al. 2019, Feng et al. 2019, Merow et al. 2013, Phillips et al. 2006, Phillips and Dudík 2008, Phillips et al. 2017); in fact, multiple free resources are available, and we are including references to many of them at the end of the manual. Rather, we focus on common practices and techniques that are used when estimating the ecological niche and the potential distribution of a species. Our goal is to provide a manual for educational purposes, building capacity, and basic comprehension for the broader audience exploring the field, similar to what has been developed for other modeling approaches in the biological sciences (e.g., phylogenetics: Hall 2013, O'Halloran 2014). Here, we are providing theoretical background and a practical exercise to estimate areas of environmental suitability for our chosen model species: the poison dart frog, *Dendrobates auratus*.

The full manual and datasets used for the exercise are available at http://hdl.handle.net/1808/30276.

Acknowledgments

We thank the broader University of Kansas Ecological Niche Modeling group, which was the context within which we developed this manual. We thank A. Townsend Peterson for comments on an earlier version of the manuscript.

Competing Interests

The authors have declared that no competing interests exist.

References

Araújo, M. B., R. P. Anderson, A. M. Barbosa, C. M. Beale, C. F. Dormann, R. Early, R. A. Garcia, A. Guisan, L. Maiorano, B. Naimi, R. B. O'Hara, N. E. Zimmermann, and C. Rahbek. 2019. Standards for distribution models in biodiversity assessments. Sci. Adv. 5(1):eaat4858.

Cobos, M. E., L. Jiménez, C. Nuñez-Penichet, D. Romero-Alvarez, and M. Simões. 2018. Sample data and training modules for cleaning biodiversity information. Biodiv. Informatics 13:49–50.

Cobos, M. E., A. T. Peterson, N. Barve, and L. Osorio-Olvera. 2019. kuenm: an R package for detailed development of ecological niche models using Maxent. PeerJ 7:e6281.

Feng, X., D. S. Park, C. Walker, A. T. Peterson, C. Merow, and M. Papeş. 2019. A checklist for maximizing reproducibility of ecological niche models. Nat. Ecol. Evol. 3:1382–1395.

Hall, B. G. 2013. Building phylogenetic trees from molecular data with MEGA. Mol. Biol. Evol. 30:1229–1235.

Merow, C., M. J. Smith, and J. A. Silander. 2013. A practical guide to MaxEnt for modeling species' distributions: What it does, and why inputs and settings matter. Ecography 36:1058–1069.

O'Halloran, D. 2014. A practical guide to phylogenetics for nonexperts. JoVE 84: e50975.

Peterson, A. T., J. Soberón, R. G. Pearson, R. P. Anderson, E. Martínez-Meyer, M. Nakamura, and M. B. Araújo. 2011. Ecological niches and geographic distributions Princeton University Press, Princeton, New Jersey.

Phillips, S. J., R. P. Anderson, and R. E. Schapire. 2006. Maximum entropy modeling of species geographic distributions. Ecol. Model. 190:231–259.

Phillips, S. J., R. P. Anderson, M. Dudík, R. E. Schapire, and M. E. Blair. 2017. Opening the black box: an open-source release of Maxent. Ecography 40:887–893.

Phillips, S. J. and M. Dudík. 2008. Modeling of species distributions with Maxent: new extensions and a comprehensive evaluation. Ecography 31:161–175.

Soberon, J., and A. T. Peterson. 2005. Interpretation of models of fundamental ecological niches and species' distributional areas. Biodivers. Informatics 2:1–10.

Warren, D. L. 2012. In defense of "niche modeling." Trends Ecol. Evol. 27:497–500.