Adapting Ecological Niche Models to Diachronic Data and Archaeological Questions

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Abstract

Models, methods, and theory developed by ecologists are increasingly adopted and adapted by archaeologists. In recent decades, archaeologists interested in understanding how aspects of the environment influence human dispersal and land use patterns have incorporated models used by ecologists understanding similar species-specific patterns. These models go by a number of names, such as species distribution models, ecological niche models, habitat suitability models, and can be implemented in a number of ways with different algorithms (Peterson et al., 2015; Sillero et al., 2021; Valavi et al., 2022). No matter the label or method used, these all fall under the overarching classification of correlative ecological niche models (Sillero, 2011; Sillero et al., 2021). Here we will refer to these sets of models collectively as ecological niche models (ENMs). There are several challenges archaeologists face in adapting ENMs and ecological niche theory (Jackson & Overpeck, 2000) to archaeological data and questions, including questions pertaining to the unit of analysis in archaeological applications, meaningful variable selection and interpretation, adequately leveraging diachronic archaeological data, and using these models to address specifically archaeological questions. Here, I will focus on the latter two, leveraging diachronic data and using ENMs to address meaningful archaeological questions. An archaeological presence point is a location in space and time. When compared to modern species data generally used by ecologists (which is often synchronic), archaeological data (and palaeoecological) data are diachronic (Svenning et al., 2011). The diachronic nature of archaeological data provides the opportunity to construct ENMs with a broader observational range of potential habitats, allowing for a better estimation of the fundamental niche space of species and human behavior using a single model. The tradeoff for this broader perspective is lower resolution predictor variables and uncertain age estimates which can obscure model estimates. By the same token, when the spatiotemporal components of archaeological data are duly incorporated into ENMs, we can build powerful models that can address a range of meaningful archaeological questions. At the basal level, these models are used to describe the spatial and temporal distributions of past people, but these are generally of limited interest. The greatest potential for these models is not in the model outputs alone but using these model outputs as a way of addressing archaeological questions through hypothesis testing. Examples include testing how estimates of occupied habitat suitability pattern with estimates of population size (Lundström et al., 2024), how population pressures can structure dispersal into habitats (Weitzel & Codding,

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2022), the impacts of climate on plant and animal distributions relative to zooarchaeological data (Carotenuto et al., 2018; Mondanaro et al., 2019; Yaworsky et al., 2023), and the impact of technological innovations on aspects of the
fundamental niche space and realized niche space.

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