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## ENM2020: A FREE ONLINE COURSE AND SET OF RESOURCES ON MODELING SPECIES NICHES AND DISTRIBUTIONS

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*Abstract.* The field of distributional ecology has seen considerable recent attention, particularly surrounding the theory, protocols, and tools for Ecological Niche Modeling (ENM) or Species Distribution Modeling (SDM). Such analyses have grown steadily over the past two decades—including a maturation of relevant theory and key concepts—but methodological consensus has yet to be reached. In response, and following an online course taught in Spanish in 2018, we designed a comprehensive English-language course covering much of the underlying theory and methods currently applied in this broad field. Here, we summarize that course, ENM2020, and provide links by which resources produced for it can be accessed into the future. ENM2020 lasted 43 weeks, with presentations from 52 instructors, who engaged with >2500 participants globally through >14,000 hours of viewing and >90,000 views of instructional video and question-and-answer sessions. Each major topic was introduced by an “Overview” talk, followed by more detailed lectures on subtopics. The hierarchical and modular format of the course permits updates, corrections, or alternative viewpoints, and generally facilitates revision and reuse, including the use of only the Overview lectures for introductory courses. All course materials are free and openly accessible (CC-BY license) to ensure these resources remain available to all interested in distributional ecology.

*Key words.* Ecological niche model, Species distribution model, Course, Open access, Methods

Distributional ecology is a branch of biogeography that focuses on the fundamental question of why species are found where they are and identifying where they could occur given changing environmental, geographic, or biotic conditions. The modern renaissance of the field began in the 1970s (MacArthur 1972, Austin 1987, Ferrier 2002), and has since led to many exciting insights (e.g., novel reflections on the frequency of ecological speciation) and useful products (e.g., detailed range maps and potential distribution maps) (Guisan and Zimmermann 2000, Araújo and Pearson 2005, Peterson and Navarro-Sigüenza 2017). Work in the field of distributional ecology includes theory, protocols, and tools drawn from many areas of inquiry, including ecology, biogeography, evolutionary biology, geographic information science, meteorology, hydrology, remote sensing, statistics, and computer science. Despite at least three book-length syntheses (Franklin 2010, Peterson et al. 2011, Guisan et al. 2017) and numerous synthetic papers on the subject (e.g., Guisan and Thuiller 2005, Elith and Leathwick 2009, Anderson 2013, Araújo et al. 2019, Feng et al. 2019, Zurell et al. 2020), the field still lacks a clearly established set of methodologies by which to guide future advances.

This novelty and speed of development of the field, combined with intense interest, have led to a series of in-person and online training programs and courses, ranging from broad surveys of all biodiversity informatics (e.g., Peterson and Ingenloff 2015) to courses specifically on ecological niche modeling (e.g., Peterson et al. 2019; note, this particular course was in Spanish). However, given the somewhat dated nature of many existing courses and the substantial fees often involved, a significant gap was noted: a free, online course in English spanning the entire suite of theory, protocols, and tools in the ecological niche modeling toolkit. A team of 52 instructors that represents a great breadth of expertise in this area worked to generate the instructional format and content of a new course. Instructors came from many countries and represented a variety of career stages.

#### THE COURSE

The course was delivered during January–November 2020. It was divided into 18 overarching themes or topics: introduction, applications, key tools, environmental data, occurrence data, visualization, distributional equilibrium, algorithms, uncertainty, evaluation, model selection, model transfers, model comparisons, reproducibility, abundances, frontiers,

practicalities, and conclusions (Table 1). Each major topic was initiated by a talk designated as an “Overview.” Persons desiring deep knowledge could view all the talks in each set following the corresponding Overview lecture, whereas individuals aiming for a general summary of the field had the option to only watch Overview talks. Completion certificates for the full course required participation in question-and-answer sessions and adequate performance on a short examination at the end of the course. The modular format of the course and its materials also facilitates later addition of updates, corrections, or alternative viewpoints, leading to a set of resources that should be adaptable and easily updated into the future.

The course followed a set weekly schedule. Lectures were pre-recorded to avoid technological and internet-related complications of live presentations, for both instructors and students. Presentations were made available on Monday morning (in the Western Hemisphere, UTC-6) in various formats: YouTube videos, .mp4 video files, .mp3 audio files, and .pdf slide decks. YouTube videos had the advantage of automatically including the option of closed-captioning, which (though not perfect) can assist both deaf and hard-of-hearing individuals and persons for whom English is not a native language. Presentations were accompanied by ancillary materials such as readings from the primary literature, example datasets, and programming code. Participants’ questions were due by Wednesday each week, and a live question-and-answer session among instructors was held each Friday, with an archived version made available online directly upon conclusion.

The course reached a large audience. In total, 2541 formal participants joined the course Facebook group<sup>1</sup>, but many more took advantage of the materials. The YouTube videos were viewed 90,938 times by participants from at least 72 countries worldwide (Figure 1), representing 14,172 hours of viewership (as of 15 November 2020). In total, 3159 questions were submitted by course participants (see Figure 2 for a word cloud summarizing the terms most frequently used in these questions; R code to produce this figure is provided via KU Scholarworks<sup>2</sup>).

Our desire in developing this course was to facilitate and motivate current and future scholars in the field worldwide to explore and innovate in distributional ecology. We also hope that the open format—made available globally via the Internet without cost—will serve to increase the diversity of partici-

<sup>1</sup> <https://www.facebook.com/groups/ENM2020/>.

<sup>2</sup> <http://hdl.handle.net/1808/32540>.



they had been presented on a single learning platform (e.g., Moodle) for more direct and easy access. Notably, ENM2020 was developed and presented with no funding other than support from the authors' institutions and a few software-development grants in the form of the salaries and facilities for each of the instructors.

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#### CONFLICTS OF INTEREST

The authors declare that no conflicts of interest exist.

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