

MAXIMUM ENTROPY MODELLING FOR PREDICTIVE ARCHAEOLOGY: MAPPING 8TH–11TH CENTURY SETTLEMENTS IN ILFOV COUNTY

Ioana MANEA

Bucharest Municipality Museum, Bucharest, Romania; e-mail: ioana_manea18@yahoo.com

Keywords: MaxEnt, predictive map, Ilfov County, 8th–11th century, habitation

Abstract: This study employs advanced statistical methods, specifically Maximum Entropy (MaxEnt) modelling, to predict archaeological settlement locations from the 8th to the 11th centuries in the Bucharest and Ilfov regions, focusing on the Dridu culture. Using 107 known sites, the analysis integrates environmental variables (elevation, topographic position index, slope orientation, slope steepness, and distance to water) to generate a predictive map. Data preparation involved QGIS for spatial mapping and R for statistical analysis. The model, trained on 107 presence points (one point was excluded due to NA values) and 9779 absence points, achieved an AUC of 0.821, indicating strong predictive accuracy. Distance to water (73.96% contribution) and slope (25.02%) emerged as dominant factors, with high-probability zones aligning with areas near water and on moderate slopes.

Cuvinte-cheie: MaxEnt, hartă predictivă, regiunea Ilfov, secolele VIII–XI, habitat

Rezumat: Acest studiu folosește metode statistice avansate, în special modelizarea prin entropie maximală (MaxEnt), în scopul de a prevedea amplasarea siturilor arheologice între secolele VIII și XI în regiunea București-Ilfov, punând accent pe cultura Dridu. Pornind de la 107 situri cunoscute, analiza integrează variabile de mediu – altitudine, poziția topografică, orientarea pantei, diferența de nivel și distanța față de o apă curgătoare – pentru realizarea unei hărți predictive. Pregătirea datelor a implicat folosirea QGIS pentru cartografierea spațială și R pentru analiza statistică. Modelul, făcut pe 107 puncte de prezență (un punct a fost exclus din cauza valorilor lipsă) și 9 779 puncte de absență, a atins o AUC de 0,821, indicând o precizie predictivă foarte puternică. Distanța față de o apă curgătoare (73,96%) și panta (25,02%) s-au dovedit a fi factorii dominanți, zonele cu probabilitate ridicată corespunzând regiunilor apropiate de apă și situate pe pante moderate.

INTRODUCTION

New statistical analyses have transformed the study of history, particularly in archaeology, providing efficient tools for interpreting data and reconstructing the past with striking precision. These methods, such as Bayesian analysis, spatial modelling, and maximum entropy (MaxEnt) techniques¹, allow archaeologists to extract insights from incomplete or imprecise data, test hypotheses, and make robust predictions about ancient behaviours and environments. Bayesian analysis, for example, is essential in radiocarbon dating. It integrates a priori information (such as site stratigraphy) with measured data to refine time intervals. Bronk Ramsey² demonstrates how Bayesian models reduce uncertainty in archaeological chronologies, allowing a more precise correlation of historical events. The MaxEnt techniques described by Frieden³ are used to model the distribution of species⁴ as a function of environmental variables, even with limited data. Maximum Entropy is a statistical method. It is used to determine the most likely distribution of a variable when the available information is incomplete. The idea behind this is to choose the distribution that increases uncertainty or disorder

while still respecting known limits, such as observed data or physical properties (like values that are not negative). MaxEntropy estimates are always unbiased and general⁵. In archaeology, MaxEnt helps to predict the locations of undiscovered sites⁶, optimising prospection campaigns and beyond.

Currently, in Romania, predictive maps for archaeological sites are rarely used. So far, to my knowledge, one study focused on the Buzău County area⁷, where post-Roman sites were considered. Another study focused on the Eneolithic settlements in north-eastern Romania⁸. In addition, the PROSPECT project⁹ (Non-destructive investigations in complex archaeological sites. An integrated model of applied research on immovable cultural heritage), led by the Alexandru Ioan Cuza University of Iași, has started such research for an area of 125 square kilometres in the south-western part of the Moldavian Plain. Lastly, a predictive map based on Generalised Linear Models was produced for Bucharest¹⁰, with special regard to the Chilia-Militari culture.

⁵ Jaynes 1982, p. 939–951.

⁶ Yaworsky *et alii* 2020; Rafuse 2021; Wachtel *et alii* 2018, etc.

⁷ Ștefan, Sîrbu 2010.

⁸ Nicu *et alii* 2019.

⁹ <http://arheoinvest.uaic.ro/research/prospect/>, accessed 05.03.2026, http://arheoinvest.uaic.ro/research/prospect/downloads/PROSPECT_RS-2015_RO.pdf, accessed 05.03.2026.

¹⁰ Manea 2022.

¹ Harte, Newman 2014.

² Ramsey 2009.

³ Frieden 1972.

⁴ Phillips, Dudik 2008.