HUNGARIAN ARCHAEOLOGY
E-JOURNAL • 2012 SPRING
www.hungarianarchaeology.hu

# PREDICTIVE ARCHAEOLOGICAL MODELLING AND CULTURAL HERITAGE PROTECTION IN HUNGARY

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*One of the perhaps most important tasks of archaeological heritage protection is the identification and mapping of archaeological sites. Our study proposes the introduction of predictive archaeological models in Hungary based on the currently available information contained in Hungarian site registers. These models can be used for predicting the potential presence of sites and can serve as useful tools during the initial planning phase of various development projects, ensuring the preliminary protection of Hungarian archaeological sites.*

Even though archaeological research is principally concerned with the investigation of sites, there have been few studies on to what extent Hungary's archaeological sites can be mapped and registered, i.e. to what extent we can accurately document the exact number and geographic location of the sites. This is not merely a theoretical problem[2] because the chances of protecting sites whose very existence and location remain unknown are virtually nil. The present study examines the so-called predictive archaeological models constructed for the purpose of predicting the number and location of currently unknown archaeological sites as an important means of protecting the cultural heritage.

Estimates for the number of archaeological sites range between 100,000 and 150,000,[3] of which roughly 25,000 to 30,000 are actually known, accounting for 20–30% on the national level.[4] Because only known sites can enjoy legal protection, this means that approximately 70% of Hungary's estimated archaeological sites remain unprotected.

This situation has several consequences, both academic and practical, the latter with a direct bearing on various development projects. In most cases, the existence of an archaeological site is discovered too late, which in turn lengthens construction schedules and raises the costs. One possible solution was the launching of the Hungarian Archaeological Topography (MRT) project, which set itself the goal of systematically surveying the country's entire territory and mapping the sites recorded during the field surveys. Begun in the 1960s, this ambitious project evolved into an independent academic workshop. By the late 1990s, when the project came to a virtual standstill, about 11.7% of Hungary's territory had been surveyed,[5] and it also became clear that another solution had to be found, especially in view of the quickening pace of the many new development projects across the country. Archaeological predictive models attempt to predict "the location of archaeological sites or materials in a region, based either on a sample of that region or on

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2 Act LXIV of 2010 on the Protection of the Cultural Heritage, §11 and §7 (20).

3 Katalin Wollák, "Listing – Precondition of Protection?," in *Listing Archaeological Sites, Protecting the Historical Landscape*, ed. A.C.P. Schut, 53–62. EAC Occasional paper no. 3 (Brussels: EAC, Europae Archaeologiae Consilium, 2009).

4 In 2004, the estimated figure was 10,000 to 12,000. Cp. Katalin Wollák, "The Protection of Cultural Heritage by Legislative Methods in Hungary," in *Archaeological and Cultural Heritage Preservation within the Light of New Technologies. Selected Papers from the Joint Archaeolingua – EPOCH Workshop. 27. Sept – 2. Oct 2004. Százhalombatta, Hungary*, ed. E. Jerem, Zs. Mester and R. Benczes, 76. (Budapest: Archaeolingua; 2006). However, this estimate did not include the sites identified during the systematic site surveys conducted in Transdanubia (*ibid*., 77. Fig 5).

5 Wollák, *ibid*.

fundamental notions concerning human behaviour”.[6] Most predictive models rest on two assumptions: that choices of location for human settlement were largely influenced by certain features of the one-time environment and that these environmental features can be identified to some extent on modern maps.[7] It is assumed that an area’s modern geomorphology, its soils and hydrography resemble that of the one-time environment during various archaeological periods. Given that human settlement is not random in a particular region and that the distribution of known sites can be modelled according to environmental and cultural variables, the probability of potential site locations can be determined from the available geographic information and through geostatistical analyses.

The study of environmental variables influencing settlement locations makes use of the available data that can be entered into a GIS database and presented visually. These include distance from water, an area’s inclination, surface morphology, exposure to sunlight and soil types. The *Register of the Micro-Regions of Hungary*[8] is useful for identifying the spatial boundaries and the scale of the areas to be modelled. The 230 micro-regions listed in the *Register* were distinguished on the basis of their typical ecological features; these micro-regions are usually 100−500 km$^2$ large areas, each with a more or less uniform environment.[9] Moreover, a sufficient number of archaeological sites are known from practically each area, either from earlier or more recent field surveys, enabling the construction of meaningful predictive models.

A model incorporating the known archaeological data constructed using Bayesian statistics seems to be the most versatile for predictive modelling.[10] Bayesian statistics are used in many fields, ranging from medical to geographic studies. The application of Bayes’ rule is essentially a statistical probability analysis examining a theoretical probability (in this case, the probability of archaeological sites across a particular area) and its opposite (the lack of archaeological sites). This essentially involves the weighting of the available data and the projection of the “weights” onto similar, but archaeologically uncharted areas.

The modelling appears as a raster image file in which each pixel has a fixed probability and reliability value in terms of the probability of the association of an archaeological site with a particular location, as well as the reliability of the association. These values can be categorized and presented on a colour-coded map with three to four zones, each of which indicates areas with a very low, low, medium and high archaeological significance. However, it must be borne in mind that these maps do not depict actual sites or their extent, they merely indicate the probability value of the presence of archaeological sites and phenomena. Predictive models can be used to identify areas with a high probability of archaeological sites and thus the definition of “areas with an archaeological significance” can acquire a meaningful content because it thus becomes possible to clearly determine which areas have an archaeological significance and what the criteria for identifying these areas are. According to the current legislation, areas with an archaeological significance are defined as “areas … in which the discovery of archaeological sites can be expected.”[11]

While the construction of predictive models generally follows the same procedures, two main types can be distinguished, depending on the general purpose for which it was created. The most frequently used

6 Phillip Verhagen, *Case studies in archaeological predictive modelling* (Leiden: Leiden University Press, 2007), 13.

7 R. E. Warren and D. L. Asch, “A predictive model of archaeological site location in the eastern Prairie Peninsula,” in *Practical Applications of GIS for Archaeologists: A Predictive Modelling Toolkit*, eds K. L. Wescottand and R. J. Brandon, 5–32. ((London: Taylor and Francis, 2000).

8 Sándor Marosi and Sándor Somogyi eds, *Magyarország Kistájainak Katasztere I.* (Budapest: MTA Földtudományi Kutató Intézet, 1990), 15.

9 Máté Stibrányi, “Gondolatok a régészeti topográfia lehetőségeiről” (The potentials of archaeological topography), in *Évkönyv és jelentés a Kulturális Örökségvédelmi Szakszolgálat 2008. évi feltárásairól*, ed. Judit Kvassay, 352. (Budapest: Kulturális Örökségvédelmi Szakszolgálat, 2010).

10 Arc-WofE User Guide 1998. http://www.ige.unicamp.br/wofe/documentation/wofeintr.htm

11 Act LXIV of 2010 on the Protection of the Cultural Heritage, §7 (17).

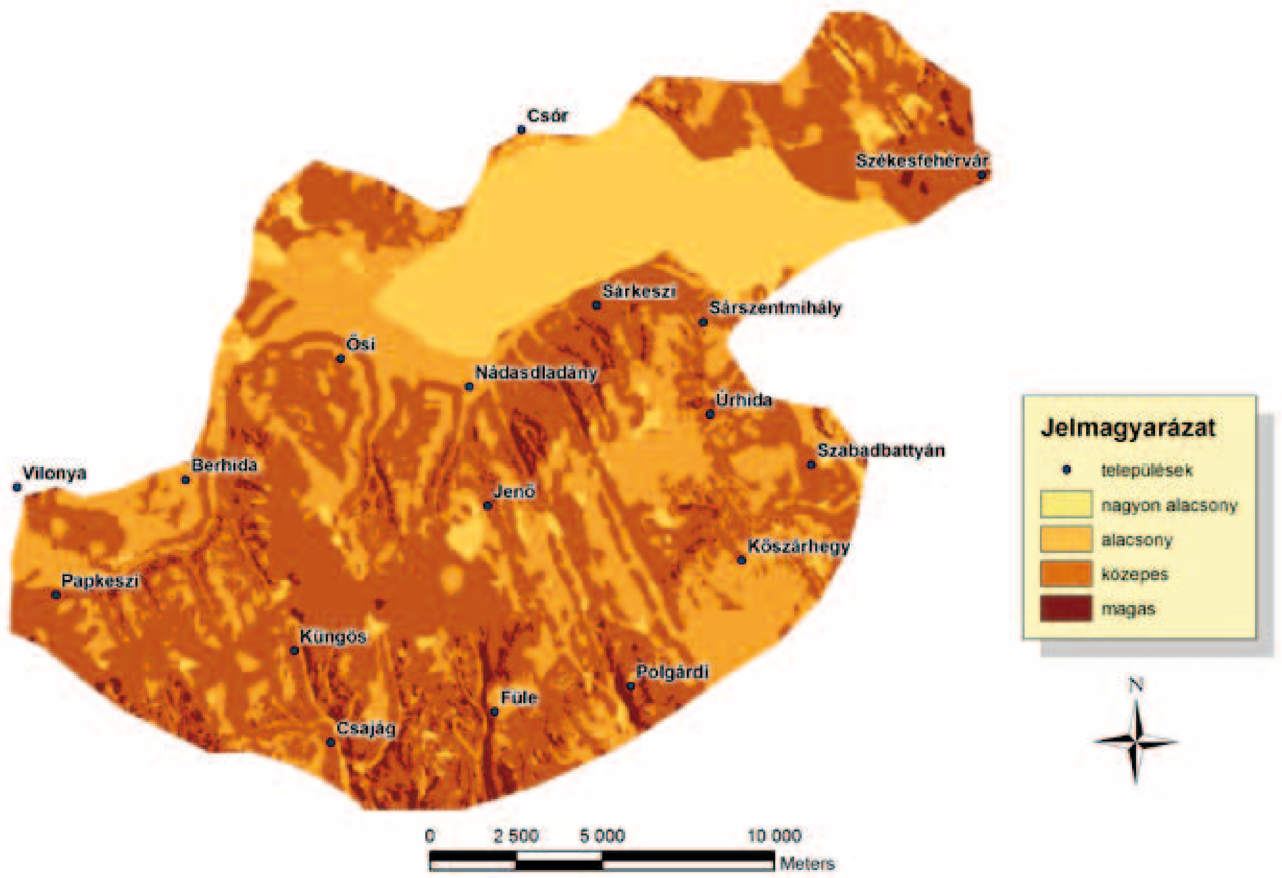


*Fig. 1. Predictive archaeological model of the Sárrét region in County Fejér (after Mesterházy 2011, 75). The colour codes represent the probability of archaeological sites. 80% of the known sites fall into the high probability category*

model is employed during the planning phase of development projects, in cases when the affected area is not particularly well known archaeologically. In this case, the model is useful for identifying areas with an archaeological significance which can be of concern for heritage protection. The other efficient use of predictive models is in research targeting the investigation of certain site types or periods.

Predictive models are also useful for predicting the possible location of "invisible" sites, one of the main concerns of cultural heritage protection. These principally affect areas with sites which cannot be identified using non-invasive techniques (e.g. in woodland areas, grass-covered areas, built-up areas, etc.) or sites which can only be investigated through excavation (e.g. burial grounds). The already available models represent the first promising steps in this area because we found that when these models were tested in the field and against the already known sites, they were found to reliably predict about 75–80% of the archaeological sites *(Fig. 1)*.[12] More precise elevation models combined with reliable and controlled data will no doubt enable the construction of even more accurate predictive models. Obviously, these models are not foolproof, but they do offer a more efficient tool in the hands of decision-makers.

Predictive archaeological modelling and the identification of sites through surveys and by other means are not two separate methods, but are interacting techniques that should be used in conjunction which each

[12] Gábor Mesterházy, *Prediktív régészeti modellek magyarországi alkalmazhatóságának lehetőségei* (Potential applications of predictive archaeological modelling in Hungary). MA thesis. NYME-GEO, 2011; Gergely Padányi-Gulyás, *Régészeti célú prediktív modellezés a Sárvíz völgyében* (Predictive archaeological modelling in the Sárvíz Valley). MA thesis. BME, 2011; Máté Stibrány, Gábor Mesterházy and Gergely Padányi-Gulyás, *Régészeti feltárás előtt – vagy helyett* (Before, or instead of, archaeological excavation). MNM-NÖK Tudományos-népszerűsítő füzetei 5 (Budapest: MNM-NÖK, 2012).

other. No matter to what extent systematic field surveys are conducted, there will always remain areas in which archaeological prospection will be virtually impossible. Given the current situation of Hungarian archaeology, predictive archaeological modelling represents an accurate and cost-effective tool for heritage protection that contributes to an efficient, continuously updated protection of archaeological sites based on geographic and statistical data.

## FURTHER READING

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