Predicting settlement location through cost surfaces: a case study and a proposal.

Carlo Citter°, Antonia Arnoldus-Huyzendveld*°, Chiara Maccani°

° University of Siena – MediArG - www.archeogr.unisi.it/CCGBA/laboratori/lam/
* Digiter srl - www.digiter.it/geoarcheologia/
Predictive modelling in archaeology is a long-lasting debated topic among scholars, with a consolidated set of tools. Hereafter we introduce a general procedure, which doesn't require high-level GIS skills, mathematical skills, cumulative cost surfaces to calculate least cost paths, predict settlement location, evaluate resource exploitation.

But the researcher needs to know the basics of landscape development in historical times, and the meaning of landscape features for practical purposes. In addition, one must be aware of the uncertainties created by the weighing procedures and by using proxy input data.
The first part of the procedure is deductive

1. Critical evaluation of environmental data

2. Several raster cost weighted surfaces to evaluate landscape features independently

- Attractors: act at a distance
- Detractors: act at a distance
- Facilitators: act “under our feet”
- Obstacles: act “under our feet”
3. evaluate and classify each factor for the use considered on a scale from 1 or 0 (high advantage) to 100 (no advantage, disadvantage)

4. combine all cost surfaces by weighing them against one another

5. The result is a map - or several maps - that express for each area or cell the degree of profitability for a specific category of settlement or use, for a certain period in a historical landscape with known characteristics.

The result is not a statistical evaluation, but a qualitative estimation.
The series of models in ArcGis 9.3. The procedure of raster calculator can include some or all the factors. It depends on the goal of the prediction.
Then, we turn to the archaeological features in general terms

1) how do known sites of a given category of a given period relate to the environment?

2) where could a route run in that landscape?

3) which were, and how were the natural resources of a given context exploited?

After that, the procedure becomes inductive

4) which were the central places and their territories in that period?

5) what do we know about the historical mobility- and transport network?

In this stage we upload these data to the GIS platform.
We chose this method for three reasons

1. we will never know the exact number of archaeological settlements of a given period in a territory

2. predictive models rarely evaluate the environmental sustainability for the population. In addition, we should not weigh the parameters in the same way if we wish to predict the location of a tomb, a farmstead or a shepherd's hut

3. we think quantitative approaches to predictivity do not encourage archaeologists to use them in their daily workflow
1. To work with cumulative weighted cost surfaces has a lower learning threshold, since it needs only the use of the raster calculator on a GIS platform.

2. It is a flexible tool for risk management and archaeological research. We can increase or reduce the weight of a certain parameter according to the evaluation we are running. For instance, drainage can be more relevant than slope in evaluating the cultivable land. It can be the opposite when evaluating a potential route.

3. Not even a quantitative approach avoids uncertainty, nor does the expert judgement.
1. Often, we need to use proxy input data. For instance: when we have no soil maps, we consider flatlands synonymous of highly productive soils, which is not always the case, but indeed often. This affects the uncertainty of the results.

2. Especially in coastal areas, where expansion of the shoreline occurred, we must consider the development of the landscape in historical times. The same is true for highly mobile alluvial areas, where river courses have shifted laterally in time.

3. The stream-network builder is profitable in a hilly landscape, almost useless in a flat plain.

4. Usually, one can hardly find the details of the procedure. On the contrary, it is a good practice to declare which parameters are introduced, their relative weights applied, and the overall procedure followed.
We developed and tested the procedure for predicting resource exploitation and road networks in an area along the West coast of central Italy. Next, we applied it for predicting site location in a sample area of 6.5 x 8 km in the alluvial Po plain in northern Italy (the territory of Povegiano Veronese - 8 km SE of Verona). The area is located upon the alignment between the high and low glacial Alpine outwash plains, rich in springs. (below – picture from Google Earth)
First step: the input data

- input data
  - rivers ➔ obstacles
  - springs ➔ attractors
  - lithology ➔ fine textured and humid soils ➔ facilitators
  - soils ➔ gravelly soils ➔ obstacles
  - 10 m cell size DEM ➔ 50 cm interval contour map ➔ small reliefs ➔ attractors
second step: weighing the parameters

1) weigh each parameter in relation the distance from it or to stay on it
2) turn the vector files into rasters
3) add them in the raster calculator. We fixed the final amount to 1, thus weighing each raster as a fraction

We can increase or decrease the value of each single parameter in the final cumulative cost surface, according to the type of prediction.

output

Three different combined cost surfaces to evaluate the most profitable areas for the location of rural settlements focused on crop production.

Reclassify the raster map

Class 5 = no site is likely to be found  class 1 means “it is very likely”

One of the maps matched the 65% of the known settlements within the class 1 cells. **We consider this result only an intermediate step.** Also the a-posteriori confrontation with the corine land use map gave positive results.
Finally, we did spot surveys on the most and least potential areas to get more insight in the procedure’s reliability. In particular, we chose to evaluate the 44 small ridges we derived from the DEM.
Plate 3: the ridges in relationship with the second cumulative cost surface.

Legend
- Red circles: fake ridges
- Green circles: presumed ridges
- Yellow circles: survey

Weight 2
- Class 5
- Class 4
- Class 3
- Class 2
- Class 1

Scale: 0 - 750 - 1,500 - 3,000 m
Although only standard GIS techniques are involved, we think this method deserves to be promoted in all its aspects. In particular, we stress the critical and open handling of the landscape data and of the weights applied in the cost surfaces.

In addition, we think it is crucial the accompanying field survey. We plan to develop it further, especially for practical use by the students of archaeology, through the use of open source software like QGIS.

Thus, we could overcome automatic handling of spatial data or, even worse, handling archaeological data as if they were not distributed in a real physical landscape.