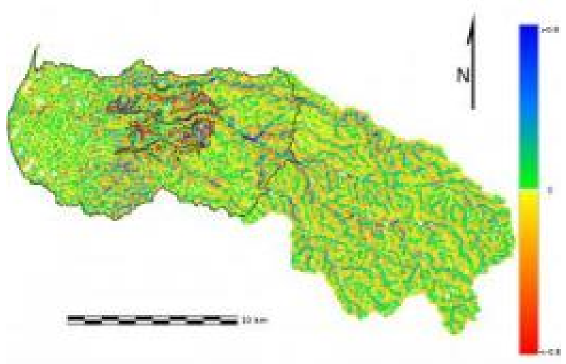
Advanced geographical models bring new perspective to study of archaeology

May 14 2010



Map of modeled cumulative hillslope erosion/deposition (HED) for the Wadi Ziqlab watershed after 200 years. The map shows HED due to human landuse, after subtracting 'natural' surface change from surface change with shifting cultivation and grazing. Credit: The Mediterranean Landscape Dynamics Project/ASU/NSF

Computational modeling techniques provide new and vast opportunities to the field of archaeology. By using these techniques, archeologists can develop alternative computerized scenarios that can be compared with traditional archaeological records, possibly enhancing previous findings of how humans and the environment interact.

An article published in the April 2010 issue of the journal *American Antiquity* by researchers at Arizona State University and North Carolina State University describes the use of computational modeling to study the long-term effects of varying land use practices by farmers and herders on landscapes. It compares the results with the Levantine Neolithic archaeological record, which preserves a record of the long-term socioecology of subsistence farming.

"Using computational modeling is a new approach in the field of archaeology. Archaeology is known for learning about the past, but these methods can help us predict the future," said Michael Barton, co-author and co-director of ASU's Center for Social Dynamics and Complexity.

"Computational Modeling and Neolithic Socioecological Dynamics: A Case Study from Southwest Asia" demonstrates how new modeling techniques are used to simulate different land use practices such as intensive farming, shifting cultivation (also called swidden or slash-and-burn) and grazing to determine long-term effects on landscapes. The research models land use in the Wadi Ziqlab drainage of northern Jordan, an area where ancient Neolithic inhabitants cultivated cereals (wheat and barley), pulses (lentils and chickpeas), herded sheep and goats and raised domestic pigs 8,000 years ago.

Intensive farming is where a plot of land is cleared of shrubs and trees and used year after year. Shifting cultivation is where new land is cleared every few years, but only farmed for a few years before it is abandoned. Abandoned, or fallowed, land regains its fertility as the natural vegetation regrows so that it can be farmed again in the future.

"One of the more interesting findings from our study was that a combination of shifting cultivation and grazing results in more erosion run off, but that run off actually makes the farmland around tiny hamlets more fertile," said Barton, who is also a professor in ASU's School of Human Evolution and Social Change in the College of Liberal Arts and Sciences. However, Barton notes that the same kinds of land use will cause increasing degradation and loss of productive farmland around larger villages.

Numerous simulation experiments were conducted to identify long-term landscape and land use dynamics. Researchers used the Geographic Resource Analysis and Support System, an open-source, general purpose geographic information system to combine detailed maps of topography, soils, vegetation and regional climate to model the consequences of different forms of land use.

Most experiments spanned land usage over a 40-year period and a few extended over a 200-year period. Experiments were also conducted where there were no inhabitants to separate landscape changes over time due to natural influences from the effects of human activities.

"We're filling in the gaps in the archaeological record," said Isaac Ullah, co-author and ASU research assistant. "We are finding ways to make archaeology applicable to what we are doing today and possibly impact future policy decisions."

Ullah added that by creating these models and combining them with archaeological data we are also learning about the origins of the vegetation typical of the Mediterranean today. This allows us to achieve a series of vegetation profiles that provide a model of long-term landscape dynamics that cannot be seen using traditional archaeological techniques.

The experiments for this study go one step further than other geographic information system modeling projects by exploring human decision-making.

Helena Mitasova, co-author and an associate professor in the Department of Marine, Earth and Atmospheric Sciences at North Carolina State University assisted with the development of the soil erosion model that was used to determine how ancient societies land use practices impacted the landscape evolution.

She said that geospatial simulations allow them to better understand the relationship between the development of prehistoric settlements and landscape evolution, especially the consequences of agricultural practices that could degrade land well beyond the settlements and have broad long-term effects on entire landscapes.

"We can explore various hypotheses on how the communities interacted with their land and how they managed it," said Mitasova. "Although soil erosion is a natural process, through the models we are able to investigate the contribution of different agricultural practices used by prehistoric societies to land degradation and how it influenced the evolution of these communities."

"The research shows the importance of threshold effects when people alter landscapes for agriculture. Land use practices that are beneficial in one context can be very harmful in a different context," said Barton.

Barton added as communities grew, they passed a threshold where farming practices that once increased yields began to cause soil loss. Faced with declining productivity, farmers were forced to make decisions, either to return to the small hamlets, choose herding over farming, or invest more labor in their fields in the form of terraces, diversion dams or new forms of cropping. All of these solutions can be found in the archaeological record of the ancient Near East.

The study was the first of several funded by the National Science Foundation's Biocomplexity in the Environment Program. Similar experiments spanning different time periods and different locations are also planned.

Provided by Arizona State University