

Living in the Past and Looking Toward the Future

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Michael Barton modeled land use in this area of northern Jordan, called Wadi Ziqlab. Credit: Isaac Ullah, Arizona State University

Making sense of the shards, scraps and other clues left behind by past societies compels archaeologists to study far-ranging topics, from agriculture to art and chemistry to linguistics. Until recently, however, it has not often been an experimental science.

Advanced computer models are changing the field by projecting the interactions between people and the landscape. They track agricultural activity, [soil erosion](#), game [animal populations](#), and more. Models enable archaeologists to explore life in past societies, helping them connect [field observations](#) to a sequence of events that explains them. The results may even help predict the future.

Traditional archaeology limits the types of data that can be collected, said Michael Barton, a geoarchaeologist at Arizona State University in Tempe. "At best we get snapshots, usually with very tiny windows on what's going on in the past."

Barton said that, conventionally, archaeologists compile these snapshots, which represent different times and locations, into narratives in an attempt to explain the large-scale changes within groups of people and the landscapes they inhabit.

"[Modeling] is a new way to try to take the ideas archaeologists have had about how people interact with each other and the people around them and actually turn those into a kind of a measurable reality, kind of a laboratory," he said.

"We historical scientists always have the problem that we have some kind of pattern and don't understand the processes that created it," said Timothy Kohler, an archaeologist at Washington State University in Pullman.

Science research often depends on comparing an experimental group, where one or more variables are adjusted, to a control group, with rigidly-managed conditions. Archaeologists, however, do not have the option to tweak a variable and reset a long-gone settlement for a do-over. This makes it difficult to figure out cause and effect relationships.

Kohler's research focuses on parts of Colorado, where he studies settlements and agriculture in an area where population dropped in the 1200s. He noticed that, compared to older sites going back to around 600 A.D., more recent sites contained fewer butchered deer bones and more turkey bones. The observations constituted an interesting trend without, however, explaining why the change occurred. Several factors could cause the outcome, Kohler mentioned, such as an evolving taste

preference, a desire for feathers for ceremonies or a change in the relative difficulty of obtaining meat from deer and turkeys.

About 15 years ago Kohler began using models to improve his understanding of the area. After comparing hundreds of modeled scenarios with the archaeological record, he concluded that an increase in human population led to overhunting of deer and a reduced supply. People then likely turned to raising domesticated turkeys to generate a consistent meat source. "Modeling helps you generate a causal story to connect the sort of bare facts that you get from the archaeological record," he said.

Archaeologists working without models have been able to learn a tremendous amount about past societies, but the extra punch modeling offers can help in many situations. Understanding how and why past farmers depleted or preserved their soils over long periods of time can improve researchers' ability to make recommendations to improve the sustainability of contemporary farming.

"We're interested in knowing what happens a hundred years from now when you do certain kinds of land use practices," said Barton.

A model can look far into the future, but must be verified by some sort of testing. Projecting the impact of a strategy on a particular area from today forward would offer some idea of what would happen, but it could take decades to be able to fine tune the model to mimic the real outcomes.

[Archaeologists](#) can treat the past as a proving ground for calibrating their models. This allows them to refine a model and improve its accuracy before it is applied to contemporary situations by soil and agricultural scientists. "If we can predict the past really well, then that gives us a good chance of predicting the future," said Barton.

This is similar to the way climate modelers calibrate their models with ancient climate data gathered from sources like tree rings, pollen and ice cores. Reenacting the past and comparing the outcome to what actually happened is one effective way to test a model. Large differences between what the model says and what past evidence says can expose weaknesses in the model.

A major part of Barton's research concerns settlements in the Mediterranean and deciphering why some areas have been successfully farmed for the past 8,000 years, while others were abandoned long ago. His model is built by piecing together the effects of topography, water, soils, vegetation cover, and the way land is used for farming and grazing.

When applied to an area in Jordan, the model showed that certain grazing practices could increase the amount of soil erosion, which many farmers strive to avoid. A particular strategy of animal grazing and shifting cultivation (rotating the fields that are used to grow crops) increased erosion, but for settlements of a certain size (tiny hamlets with populations of about 20 people) this actually increased the available amount of productive farmland. As populations rose, however, the same strategy proved counterproductive, resulting in soil loss, even for slightly larger settlements in the range of 80 to 100 people.

"Somewhere in that range they passed a threshold or an inflection point in which their activities went from benefitting farming to hurting farming," said Barton. "The fact that you can pass a threshold at a very small scale was pretty surprising."

In other situations with different topographies and weather conditions the outcomes would be different, but this particular model mimics the local archaeological record. As settlements grew, strategies changed, with evidence of intensifying farming and irrigation strategies, choosing herding over farming, or reducing the size of settlements to return to the

small hamlet size.

Barton plans to improve his model by increasing the accuracy of the variables it considers down to details like the calories people can obtain from wheat and barley and the amount of calories burnt by various tasks. He's also planning to look at more areas, such as Spain, which has a wetter environment than Jordan.

These efforts include using agent-based modeling, in which population groups are represented by digital agents and provided with rules to guide their decision-making. The model releases these groups within realistic virtual worlds to decide on their own what to do, like competitors in a multi-player game.

This is the type of modeling used in Kohler's recent research. Instead of programming each group to act in the same way, to seek the same amount of each type of food, the agents can be modeled to adapt -- a banner crop of produce could reduce their efforts to hunt for meat, for example.

Barton and Kohler have thus far worked in arid environments. The lessons gleaned from their models, they hope, will help them extend their work to other environments as well.

Take Iowa, for instance, and its amazingly productive farmland that has been farmed intensively for a little more than the past century.

"There's been a huge change in the landscape and vegetation and ecosystems and so on," said Jon Sandor, a soil scientist at the Iowa State University in Ames. He studies the way agriculture alters soils over long periods of time in places like New Mexico, Peru, and Mexico. In some areas farming has been productive for hundreds or thousands of years and in others the soils were depleted and have never recovered.

"The decline overall of our soils in Iowa of organic matter is really comparable to what we found in the soils in one of the New Mexico farm areas, that the organic matter has been lost by 30, 40, 50 percent over time," said Sandor. "The thing about the New Mexico example is [that the depletion has] lasted nine centuries."

If good models could be developed to apply to a wide variety of locations and environmental conditions, then they could help identify the sustainability of farming practices and suggest strategies that will help keep the land productive longer.

"Because nature is so complex, models are always some simplification of nature, but they can show us things we didn't realize or weren't even thinking about, too," said Sandor.

"I think that the models that we're doing do help us learn things that we can't learn by just looking at the archaeological record itself," said Kohler, though he stressed the importance of what he called "good, traditional archaeology."

"There's no other field that really has access to this kind of data to look at and evaluate long-term models," said Barton. "We're in a unique position, I think, to provide some information about what's the long-term impact of what we do today."

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