A Dialogue Between Empirical and Model-Based Agricultural Studies in Archaeology

Author(s): Andrew Gillreath-Brown and R. Kyle Bocinsky
Source: Journal of Ethnobiology, 37(2):167-171.
Published By: Society of Ethnobiology
https://doi.org/10.2993/0278-0771-37.2.167
URL: http://www.bioone.org/doi/full/10.2993/0278-0771-37.2.167

Journal of Ethnobiology 37(2): 167–171 2017

A DIALOGUE BETWEEN EMPIRICAL AND MODEL-BASED AGRICULTURAL STUDIES IN ARCHAEOLOGY

Andrew Gillreath-Brown[1*] and R. Kyle Bocinsky[2,1]

Archaeologists have been examining agricultural societies from an environmental perspective since at least the early twentieth century—study that was enhanced by the advent of new methodologies such as dendrochronology (Douglass 1929) and, more recently, by geographic information systems (Bevan and Lake 2013; Conolly and Lake 2006; Lock 2000) and computational modeling (d'Alpoim Guedes et al. 2016a; Gerbault et al. 2014). To date, many researchers, particularly computational modelers, have relied upon evolutionary approaches from human behavioral ecology (HBE) to understand agricultural systems. The optimality assumptions inherent in many HBE models are of demonstrable utility in seeking explanations for the origins of agriculture (Gremillion et al. 2014) and human behavior in agricultural systems (Bocinsky and Kohler 2016). However, some scholars have been concerned with the exclusion of human agency, thus proposing complementary approaches such as niche construction theory (Zeder 2012, 2016). They point out that human adaptations often include intentional and unintentional cultivation of food sources and maintenance of ecosystem services. We agree with other scholars that niche construction theory complements HBE models, in part, by revealing local historical trajectories (Broughton et al. 2010; O'Brien and Laland 2012). Niche construction theory is especially useful when applied in a comparative framework (Zeder 2014, 2016).

While scholars have debated on whether an ecological perspective (Rindos 1984) or a cultural view of agriculture (Flannery 1986) is more appropriate, most scholars fall somewhere in between, such as studies on Prehispanic Pueblo societies (Kohler et al. 2012; also see Turner 1993 for development in Mayan archaeology). Agricultural niche models, such as those for maize (*Zea mays)* (Bocinsky and Kohler 2014); rice (*Oryza sativa)* (d'Alpoim Guedes et al. 2015); and millet (*Setaria italica* and *Panicum miliaceum*), wheat (*Triticum aestivum*), and barley (*Hordeum vulgare*) (d'Alpoim Guedes et al. 2016b), have been used to understand social, political, and cultural change (Bocinsky et al. 2016; Boyd and Richerson 1985; Gintis et al. 2015; Renfrew and Cherry 1986). Determining how people perceived and impacted landscapes within which they lived (landscape ecology) requires reconstruction of what an environment was like at a given time. Multiple lines of evidence are needed to reconstruct and understand past environments through a variety of fields such as geoarchaeology, geomorphology, palynology, hydrology, and paleoethnobotany.

[1]Department of Anthropology, Washington State University, Pullman, WA 99164, USA
[2]Crow Canyon Archaeological Center, Cortez, CO.
[*]Corresponding author (andrew.d.brown@wsu.edu)

Landscape level methodologies can converge in the field of ethnobiology, as discussed in a previous issue by Nagaoka and Wolverton (2016). The papers in this special section highlight new methodologies and technological innovations for studying agriculture and landscapes. They also highlight the essential feedback between model-based and empirical research. Modelers require empirical data to calibrate and test their models. Empirical researchers, in turn, need models to scale geographic and temporally-local observations to reconstruct ancient agricultural systems. In this special section, the modeling studies by Hanselka and King and Bocinsky and Varien depend on empirical studies, such as Muenchrath et al., Sandor and Homburg, and Sundjordet, to be able to assess their models and better understand human behavior.

Two of the studies here focus on empirical evidence that contribute to our understanding of how the environment affects crops and how the environment-farming relationship leaves behind trace remains for archaeologists. Muenchrath and co-authors describe a gardening experiment with traditional Zuni maize varieties and two modern hybrids within a traditional dryland ecosystem, and record how water runoff enhances nutrient availability and affects the maize productivity of each variety. Sandor and Homburg review research on ancient and traditional agricultural impacts to soils in arid to semiarid environments throughout the Americas. They examine the physical and chemical properties of soils and provide examples of the Andes and the North American Southwest, where past agriculture has intentionally and unintentionally modified natural soils. These papers enhance our understanding of key human-cultivar-environment feedbacks that must be considered in any model of agriculture that hopes to achieve a modicum of realism.

The next two papers present other important considerations when studying agricultural systems: the presence of cultivars that have received relatively little attention from archaeologists and the often dramatic effect of animal pests on crops. Kinder and colleagues present evidence for the cultivation of a species of the potato family, *Solanum jamesii*, in the prehistoric southwestern United States. Their research adds to a growing list of ancient cultigens in the US Southwest (beyond the conventional "Three Sisters" of maize, beans, and squash; e.g., Adams 2014; Fritz et al. 2009; Huckell and Toll 2004) that may have provided essential nutritional benefits to ancient farmers and certainly were featured in regional cuisine. HBE models that focus on nutritional needs, such as caloric intake, must consider the availability of these now-feral crops to past farmers. Sundjordet reports on behavioral observations made during his multi-year study of Hopi farming in northern Arizona and reveals animal depredation as a primary concern among agriculturalists in the United States Southwest. Sundjordet's key observation is that animal depredation likely *increases* during periods of plant stress, such as drought, worsening their impacts. However, he reports that his informants were not easily deterred from defending their crops and documents the often extreme sacrifice of time and energy expended in their defense. Sundjordet's study reveals that Hopi cultural attitudes towards their crops lead to behaviors that likely betray conventional senses of "optimality" in HBE models.

The final two papers take a more model-based approach to understanding ancient corn farming in the southwestern US and Mexico. Hanselka and King present a landscape-based model to explore settlement and agricultural potential in the Ocampo region of southwestern Tamaulipas, Mexico. They develop a geospatial agricultural suitability model for areas near archaeological sites there, which can be used to estimate the extent of agricultural catchments around the sites. The utility of their model is enhanced by its clear presentation and applicability to other regions. Bocinsky and Varien present results from a multi-year experimental gardening collaboration with the Hopi tribe and use those data to assess the productivity of oft-referenced—but until now un-verified—reconstructions of ancient maize productivity in southwestern Colorado. Their study reveals a close correlation between model-estimated and experimental yields, enhancing confidence in the model results. Bocinsky and Varien also provide useful information about how Hopi farmers select garden locations in the Mesa Verde region, part of the ancestral Hopi homeland, and demonstrate that Hopi corn can flourish in an environment very different from that on the Hopi mesas. These studies help to bridge the gap in between the past, present, and future [agri]cultural systems (d'Alpoim Guedes et al. 2016a) by revealing how traditional ecological knowledge used by contemporary farmers is transferrable to past agricultural landscapes.

Agricultural landscape studies require not only a deep knowledge of primary cultivars, but also a broad understanding of the environmental and cultural contexts within which they operate. "Agricultural landscapes are the product of many generations of farmers applying their indigenous knowledge and technology to what are often considered marginal lands" (Erickson 2003:183). Archaeologists should be constantly asking and re-asking the question, "what are the components in the agricultural system?" Empirical and ethnographic studies document the diversity and complexity of behaviors and interactions within agricultural systems; modeling can distill those systems to their essential components and reveal feedbacks and interactions between them. The papers in this special section demonstrate the promise and necessity of both of these types of studies, and we look forward to their tighter integration in the future.

References Cited

Adams, K. R. 2014. Little Barley Grass (*Hordeum pusillum* Nutt.): A Prehispanic New World Domesticate Lost to History. In *New Lives for Ancient and Extinct Crops*, edited by P. E. Minnis, pp. 139–179. University of Arizona Press, Tucson, AZ.

Bevan, A., and M. Lake. 2013. Introduction. In *Computational Approaches to Archaeological Spaces*, edited by A. Bevan and M. Lake, pp. 17–26. Left Coast Press, Walnut Creek, CA.

Bocinsky, R. K., and T. A. Kohler. 2014. A 2,000-year Reconstruction of the Rain-fed Maize Agricultural Niche in the US Southwest. *Nature Communications* 5:1–12. DOI: 10.1038/ncomms6618.

Bocinsky, R. K., and T. A. Kohler. 2016. Complexity, Rigidity, and Resilience in the Ancient Puebloan Southwest. In *Viewing the Future in the Past: Historical Ecology Applications to Environmental Issues*, edited by H. T. Foster II, L. Paciulli, and D. Goldstein, pp. 86–105. University of South Carolina Press, Columbia, SC.

Bocinsky, R. K., J. Rush, K. W. Kintigh, and T. A. Kohler. 2016. Exploration and Exploitation in the Macrohistory of the Pre-Hispanic Pueblo Southwest. *Science Advances* 2:e1501532. DOI: 10.1126/sciadv.1501532.

Boyd, R., and P. J. Richerson. 1985. *Culture and the Evolutionary Process*. University of Chicago Press, Chicago, IL.

Broughton, J. M., M. D. Cannon, and E. J. Bartelink. 2010. Evolutionary Ecology, Resource Depression, and Niche Construction Theory: Applications to Central California Hunter-Gatherers and Mimbres-Mogollon Agriculturalists. *Journal of Archaeological Method and Theory* 17:371–421. DOI: 10.1007/s10816-010-9095-7.

Conolly, J., and M. Lake. 2006. *Geographical Information Systems in Archaeology*. Cambridge University Press, Cambridge, United Kingdom.

d'Alpoim Guedes, J., G. Jin, and R. K. Bocinsky. 2015. The Impact of Climate on the Spread of Rice to North-eastern China: A New Look at the Data from Shandong Province. *PLoS One* 10:e0130430. DOI: 10.1371/journal.pone.0130430.

d'Alpoim Guedes, J. A., S. A. Crabtree, R. K. Bocinsky, and T. A. Kohler. 2016a. Twenty-first Century Approaches to Ancient Problems: Climate and Society. *Proceedings of the National Academy of Sciences* 113:14483–14491. DOI: 10.1073/pnas.1616188113.

d'Alpoim Guedes, J., S. W. Manning, and R. K. Bocinsky. 2016b. A 5,500-year Model of Changing Crop Niches on the Tibetan Plateau. *Current Anthropology* 57:517–522. DOI: 10.1086/687255.

Douglass, A. E. 1929. The Secret of the Southwest Solved by Talkative Tree Rings. *National Geographic Magazine* 56:736–770.

Erickson, C. L. 2003. Agricultural Landscapes as World Heritage: Raised Field Agriculture in Bolivia and Peru. In *Managing Change: Sustainable Approaches to the Conservation of the Built Environment*, edited by J. M. Teutonico and F. Matero, pp. 181–204. 4th Annual US/ICOMOS International Symposium in Philadelphia, Pennsylvania, April 2001. The Getty Conservation Institute, Los Angeles, CA.

Flannery, K. 1986. Chapters 1 and 2. In *Guila Naquitz: Archaic Foraging and Early Agriculture in Oaxaca, Mexico*, edited by K. Flannery, pp. 3–28. Academic Press, Orlando, FL.

Fritz, G. J., K. R. Adams, G. E. Rice, and J. L. Czarzasty. 2009. Evidence for Domesticated Amaranth from a Sedentary Period Hohokam House Floor at Las Canopas. *Kiva* 74:393–419.

Gerbault, P., R. G. Allaby, N. Boivin, A. Rudzinski, I. M. Grimaldi, J. C. Pires, C. C. Vigueira, K. Dobney, K. J. Gremillion, L. Barton, M. Arroyo-Kalin, M. D. Purugganan, R. R. de Casas, R. Bollongino, J. Burger, D. Q. Fuller, D. G. Bradley, D. J. Balding, P. J. Richerson, M. T. P. Gilbert, G. Larson, and M. G. Thomas. 2014. Storytelling and Story Testing in Domestication. *Proceedings of the National Academy of Sciences* 111:6159–6164. DOI: 10.1073/pnas.1400425111.

Gintis, H., C. Van Schaik, and C. Boehm. 2015. *Zoon Politikon*: The Evolutionary Origins of Human Political Systems. *Current Anthropology* 56:340–341. DOI: 10.1086/681217.

Gremillion, K. J., L. Barton, and D. R. Piperno. 2014. Particularism and the Retreat from Theory in the Archaeology of Agricultural Origins. *Proceedings of the National Academy of Sciences* 111:6171–6177. DOI: 10.1073/pnas.1308938110.

Huckell, L. W., and M. S. Toll. 2004. Wild Plant Use in the North American Southwest. In *People and Plants in Ancient Western North America*, edited by P. E. Minnis, pp. 37–114. University of Arizona Press, Tucson, AZ.

Kohler, T. A., R. K. Bocinsky, D. Cockburn, S. A. Crabtree, M. D. Varien, K. E. Kolm, S. Smith, S. G. Ortman, and Z. Kobti. 2012. Modelling Prehispanic Pueblo Societies in Their Ecosystems. *Ecological Modelling* 241:30–41. DOI: 10.1016/j.ecolmodel.2012.01.002.

Lock, G., ed. 2000. *Beyond the Map: Archaeology and Spatial Technologies*. IOS Press, Amsterdam, The Netherlands.

Nagaoka, L., and S. Wolverton. 2016. Archaeology as Ethnobiology. *Journal of Ethnobiology* 36:473–475. DOI: 10.2993/0278-0771-36.3.473.

O'Brien, M. J., and K. N. Laland. 2012. Genes, Culture, and Agriculture. *Current Anthropology* 53:434–470. DOI: 10.1086/666585.

Renfrew, C., and J. F. Cherry. 1986. *Peer Polity Interaction and Socio-political Change*. Cambridge University Press, Cambridge, United Kingdom.

Rindos, D. 1984. *The Origins of Agriculture: An Evolutionary Perspective*. Academic Press, San Diego, CA.

Turner II, B. L. 1993. Rethinking the "New Orthodoxy": Interpreting Ancient Maya Agriculture and Environment. In *Culture, Form, and Place: Essays in Cultural and Historical Geography*, edited by K. Mathewson, pp. 57–88. Geoscience and Man 32. Geoscience

Publications, Department of Geography and Anthropology, Louisiana State University, Baton Rouge, LA.

Zeder, M. A. 2012. The Broad Spectrum Revolution at 40: Resource Diversity, Intensification, and an Alternative to Optimal Foraging Explanations. *Journal of Anthropological Archaeology* 31:241–264. DOI: 10.1016/j.jaa.2012.03.003.

Zeder, M. A. 2014. Alternative to Faith-based Science. *Proceedings of the National Academy of Sciences* 111:E2827–E2827. DOI: 10.1073/pnas.1408209111.

Zeder, M. A. 2016. Domestication as a Model System for Niche Construction Theory. *Evolutionary Ecology* 30:325–348. DOI: 10.1007/s10682-015-9801-8.