

REPLY TO ELLIS ET AL.:

Human niche construction and evolutionary theory

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We are pleased Ellis et al. (1) found value in our recent synthesis of the deep history of human impacts on global ecosystems (2) and agree that our paper should influence the current debate on if and how an Anthropocene epoch is defined. We also agree that the ecological consequences of human niche construction have profound and growing effects on the evolutionary trajectories of humans and other species living within human-altered ecosystems. Niche construction theory (NCT) provides an explicit framework for linking evolutionary and ecological processes into a coherent theory of biological evolution (3). Of special appeal to us as archaeologists is that NCT bridges biological and cultural evolution by including human culture and social learning within the mechanisms of evolutionary change, allowing scientists to address issues at the interface of human and natural systems (4). Some of us have contributed significantly to human NCT (5–8), addressing some of the very issues raised by Ellis et al. (1). Finally, we agree that human transformations of ecosystems are inherently social processes—clearly humans are intensely social organisms—and that such processes result from long-term melding of biological and cultural evolution.

As our title indicates, however, our aim was to examine the ecological consequences of human niche construction as *Homo sapiens* spread around the world (9)—not the complex evolutionary processes by which such behaviors developed. We synthesized

a global literature on the pervasive effects of ancient human niche construction with three primary goals: to (i) show that humans have significantly altered environments since the origins of our species, (ii) trace the growing scope and the scale of such activities across millennia of human cultural evolution, and (iii) use the increasingly fine-grained record of these activities afforded by new methods and data sets to demonstrate that archaeology has much to offer current ecological and policy debates about human impacts on Earth's ecosystems. In our view, such large-scale and high-resolution archaeological datasets are powerful and are ignored at our peril. They offer crucial context to controversy surrounding the role of humans in altering environments and climate today, confirming the human capacity for broad-scale ecological transformation even at past population sizes significantly lower than today.

Ultimately, our aim was to broaden recognition and understanding of new ecology-related findings in archaeology. Our hope is that this will stimulate innovative cross-disciplinary research and broader engagement with archaeological data, which, in the context of US educational funding policies, is often seen as marginal and of limited value (10). NCT is one of many approaches, theoretical and methodological, that can broaden understanding of the early roots of the Anthropocene, and the relevance of the past to the present.

1 Ellis EC, et al. (2016) Evolving the human niche. *Proc Natl Acad Sci USA*, 10.1073/pnas.1609425113.

2 Boivin NL, et al. (2016) Ecological consequences of human niche construction: Examining long-term anthropogenic shaping of global species distributions. *Proc Natl Acad Sci USA* 113(23):6388–6396.

3 Laland KN, Odling-Smee FJ, Feldman MW (1999) Evolutionary consequences of niche construction and their implications for ecology. *Proc Natl Acad Sci USA* 96(18):10242–10247.

4 Laland KN, Odling-Smee J, Feldman MW, Kendal J (2009) Conceptual barriers to progress within evolutionary biology. *Found Sci* 14(3):195–216.

5 Smith BD (2012) A cultural niche construction theory of initial domestication. *Biol Theory* 6(3):260–271.

6 Zeder MA (2012) The broad spectrum revolution at 40: Resource diversity, intensification, and an alternative to optimal foraging explanations. *J Anthropol Archaeol* 31(3):241–264.

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The authors declare no conflict of interest.

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- 7 Zeder MA (2016) Domestication as a model system for niche construction theory. *Evol Ecol* 30(2):325–348.
- 8 Boivin NL (2010) *Material Cultures, Material Minds: The Impact of Things on Human Thought, Society and Evolution* (Cambridge Univ Press, Cambridge, UK).
- 9 Erlandson JM, Braje TJ, eds (2013) When humans dominated Earth: Archeological perspectives on the Anthropocene. *Anthropocene* 4(December):1–122.
- 10 Gibbons A (2016) Ancient DNA divide. *Science* 352(6292):1384–1387.