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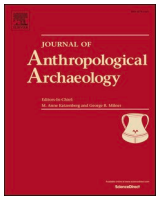

Perspective Article

The Broad-Spectrum Revolution at 50: Increasing dietary diversity reflects the heterogeneity of domesticated landscapes

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The broad-spectrum revolution (BSR) describes a pattern of resource diversification in the archeological record. It often refers to the integration of small-seeded annual plants and small-bodied animals into human diets, which preceded the transition from hunting and gathering to agriculture in many regions. These resources have been characterized within human behavioral ecology (HBE) as "low-ranked," or less efficient to obtain than other resources, especially large-bodied animals. HBE is a framework adapted from evolutionary ecology that borrows from microeconomic theory. Many practitioners of HBE create optimal foraging models, which assume that humans are rational actors who strategize to maximize energy intake, while minimizing energy expenditure. Resources are ranked based on the net energy they yield (their caloric value, minus the energy expended to find, capture, and process them). The assumption of such models is that foragers will not use lower-ranked resources until higher-ranked ones become scarce, which may occur as human population density increases or because of climate change (Kennett and Winterhalder 2006). These assumptions, coupled with the frequent occurrence of a BSR preceding the appearance of domesticated plants and animals, support the view that ancient people took up agriculture under duress, because there was no longer enough food to be got by foraging.

The assumptions of optimal foraging theories can be criticized on many levels, and Zeder's (2012), "The Broad Spectrum Revolution at 40: Resource diversity, intensification, and an alternative to optimal foraging theory," was the culmination of one such prolonged critique (Smith 2006; Smith 2011b; Zeder and Smith 2009). Here I will not consider whether humans can be relied upon to behave rationally in an economic sense, and I will ignore the issue of whether there is a universal connection between the economic efficiency of a social group and its evolutionary fitness. Even if these concessions are made, meaningful optimal foraging models still require comprehensive knowledge of the methods used to procure and process different foods, and their distribution within ecosystems and landscapes over time. When modeling the behavior of *ancient* foragers, we have to reconstruct both the ecosystem and the methods and tools applied to hunting and foraging from imperfect proxies. Ethnoarchaeology, historical ecology, and Indigenous science are providing fresh insights into the costs and benefits of various forager strategies. But even more so, they are demonstrating the importance of traditional ecological knowledge and its manifestation in domesticated landscapes in creating sustainable food systems and co-evolutionary relationships between people, plants, and animals.

1. Domesticated landscapes

In mounting their critique of HBE during the first decade of the 21st century, Zeder and Smith argued that domestication and the origins of food production should be understood in the context of ancient ecosystems (Smith 2011a; Smith 2007; Zeder 2009). They specifically called attention to human modification of ecosystems within the paradigm of niche construction theory, which can alter the distribution and overall abundance of resources. Historical ecologists had been arguing much the same thing since the mid-1990 s, but used landscapes, rather than ecosystems, as their unit of analysis (Balée 1998; Crumley 1994). The basic attributes of a domesticated landscape are 1) that is has been modified by people; 2) that these modifications have altered the structure, composition, or function of ecosystems within the landscape; and 3) that these changes result in greater productivity or predictability of important resources for people (Clement 1999).

The first decade of the 21st century also marked the beginning of a rapid increase in writing and debate about the Anthropocene, defined as the era during which human activity has had a dominant influence on Earth's climate and ecosystems. The concept that all ecosystems are, to some extent, modified by people became mainstream – at least with respect to the present day. Many scholars argued that the Anthropocene began either with the Industrial Revolution or the during the Nuclear Age, and some proposed that it began with European colonialism (Waters, et al. 2016). But Ruddiman (2003) began to mount his argument for the "early Anthropocene," which began with clearance of land for agriculture from 8 to 5,000 years ago. The fact that proposals for the origin of the Anthropocene continue to recede into the past begs the

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question: to what extent did people shape their environments before the advent of agriculture? How far back can we trace the beginnings of landscape domestication?

2. The ecology of the Broad-Spectrum Revolution

In the decade since Zeder's paper was published, the discussion of the BSR has shifted, as scholars attempt to understand what it signifies in ecological, rather than economic, terms. Janz (2016) synthesized data on proposed BSRs from around the world and argued that this pattern was caused by a global increase in the density of ecotones (boundaries between two ecosystems) at the Pleistocene/Holocene transition. As forests and marshlands began to expand into grasslands, the number of places where humans could live in close proximity to diverse prey habitats increased. Agreeing with Zeder's (2012) central argument, she concluded that BSRs are more often correlated with evidence for climate amelioration and/or increasing ecological diversity than with evidence for environmental degradation or human dietary stress. She went on to argue that BSRs result from humans foraging in increasingly heterogenous landscapes, where they had access to a variety of different resources at a relatively small spatial scale.

While patchy environments may indeed have become more common at the beginning of the Holocene (but see Fraser et al 2022 for a counter-argument), hunter-gatherers also frequently *create* ecosystem heterogeneity in their homelands. For example, Bird and colleagues (2016) synthesized their group's research with the Martu in Australia's Western Desert to show how anthropogenic burning fragments the landscape in order to increase the quality and density of habitat for important prey and decrease the travel and search time for hunters. Martu landscape domestication is focused on improving access to their most important prey, monitor lizards. The density of lizards is higher in areas managed with anthropogenic fire, *despite the fact that hunting pressure is also higher* (2016:112). This runs contrary to the assumption, implicit in many optimal foraging-based explanations for the origins of food production, that increasing hunter-gatherer population densities can only be supported by increasing diet breadth. Hunter-gatherers can also increase the carrying capacity of their homelands via niche construction, which sometimes had evolutionary consequences recognizable as domestication, sometimes not, depending on the target species and the methods employed.

Based on hundreds of hours of field work with hunters in an anthropogenic landscape, Bird and colleagues also caution would-be optimal foraging modelers: "The assumption that large bodied, slowly renewing prey are always ranked higher than smaller, more quickly renewing prey, depends on the probability that pursuits will be successful," a parameter that the Martu routinely manipulate by creating and improving habitat for their preferred small-bodied prey (2016:113). Historical and photographic records of Australian landscapes suggest that management strategies like those used by the Martu shaped landscapes across the continent before European colonization (Gammage 2013; Gammage and Pascoe 2021). Aboriginal Australians worked from ecological "templates," using fire to bring dissimilar plant communities into proximity by creating clumps of one habitat type within an expanse of another, or maintaining alternating strips of two or more ecosystems. These mosaic landscapes offered "abundance, predictability, continuity, and choice" (Gammage 2013: 211).

As in the desert, so in the rainforest – Politis' ethnoarchaeological study of the Nukak (Politis 2016) in Amazonia also provides evidence that hunter-gatherers create domesticated landscapes distinguished by their patchiness. The Nukak fall at the high end of the spectrum of hunter gatherer-residential mobility, with 70–80 moves per year, and almost never reoccupy the same camp. At each camp, they begin by cutting down all of the small trees, thus thinning the canopy of the forest in numerous small patches. Politis argues that their residential mobility itself transforms the forest into a domesticated landscape. As they deposit organic waste and the seeds of useful plants in each camp clearing, they create highly productive "wild orchards" (Politis 2016:281), the locations of which are just as predictable as any garden. Just as in the case of the Martu, rather than depleting populations of staple plant foods by eating them, their foraging increases the abundance and density of important foods, reducing the time and energy needed to obtain them and increasing the carrying capacity of the forest. However, the Nukak do not hunt the ostensibly highest-ranked prey animal in the forest, the tapir, for religious reasons (Politis 2016). Again similar to the Martu, the archaeological signature of these behaviors could be characterized as a BSR.

Past landscape domestication can also be read from present landscapes. In the Amazon, long-term dynamics like those documented by Politis might explain the hyper-dominance of certain useful tree species (Ter Steege, et al. 2013). In the Northwest Coast of North America, Armstrong and colleagues recently analyzed the functional trait diversity of "forest gardens," which occur around old village sites, compared to the surrounding forest. They found that forest gardens are more diverse than surrounding forests, both functionally and taxonomically, even 150 years after Indigenous people stopped managing them (Armstrong, et al. 2021). In eastern North America, paleoecological records indicate that Indigenous people began using fire to create open-canopy forests dominated by nut trees beginning at the same time that a classic BSR appears in the archaeological record (Delcourt and Delcourt 2004, Gremillion 2004). Since fire suppression began in the early 20th century, the species composition of remaining forests has shifted towards fire-intolerant species, suggesting that the diverse and food-rich native forests of this region were largely anthropogenic (Abrams and Nowacki 2008; Nowacki and Abrams 2008).

Indigenous people also used fire to maintain tallgrass prairies and to create savannas in parts of eastern North America that would otherwise have been completely forested (Morrissey 2019; Mueller et al 2020; Nanavati and Grimm 2020). These practices led to what historian Robert Morrissey has described as "the ecotone way of life" in 17th century Illinois (2019:46). One French observer noted alternating strips of forest and prairie of uniform length and width, in a description that is eerily similar to the "templates" of Australia, described and painted by many early European settlers (Gammage 2013). Millennia earlier in Illinois, the same ecotone way of life is reflected in the archaeological record of the communities who first domesticated annual plants in the context of a BSR, as they continued to hunt, fish, and forage in mosaic landscapes (Smith, 2011a,b).

3. The Broad-Spectrum Revolution at 50: Signature of anthropogenic biodiversity

What if BSRs are the archaeological signature of patchy domesticated landscapes? In the simplest terms, without the baggage of HBE rankings, the BSR is *an increase in the diversity of foods found at a given archaeological site*. One explanation for this pattern is that the increasing diversity of plants and animals found at a site is a rough reflection of the increasing ecological heterogeneity of the surrounding landscape. In many proposed BSRs, though, the added resources are of a specific kind: namely, small mammals (Munro 2004) or small-seeded annual plants (Gremillion 2004), many of which are disturbance-adapted species. These patterns call to mind the burning of the Martu, which creates habitat for small animals and annual plants, and the creation of residential clearings and dispersal of seeds by the Nukak and the Indigenous peoples of North America, which makes space for early successional plants and their animal predators within the forest.

It is no coincidence that all of the examples reviewed here come from Indigenous societies: such skilled dwelling relies on generations of accumulated ecological knowledge, as well as, arguably, cultural ethics of interconnectedness and reciprocity between humans, other creatures, and places. The processes of landscape domestication described above have been characterized within Western science as a kind of natural resources management or "caring for country" (Suchet-Pearson et al.,

2013). Indigenous people have pushed back against these characterizations as inappropriately centering human action and self-interest, while objectifying places and creatures that have their own agency and intent (Cajete 2000). For example, writing in co-authorship with Bawaka Country, Suchet-Pearson and colleagues (2013) argue that as people care for country, so country cares for people, in a process of co-becoming that creates and sustains abundance.

The study of domestication and the origins of food production should be focused on understanding these complex interactions between species in the context of ecosystems, and the role of traditional ecological knowledge in creating and maintaining domesticated landscapes. Both the evolution of domesticated plants and animals and the development of food producing economies were the result of these processes. In addition to holding historical and scientific interest, the diversity and fruitfulness of domesticated landscapes in the past and present should give us hope: it is possible for humans to create and maintain both biodiversity and plentiful, healthy food systems. In California and Australia, the return of cultural fire by Indigenous communities has already had beneficial ecocultural effects, and is expanding (Marks-Block et al 2019; McKemey et al 2019). The tendency of settler-colonial societies to exploit, erase, or homogenize ecosystems in the name of food production is perhaps more of an historical aberration than the norm for humanity.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

Abrams, M.D., Nowacki, G.J., 2008. Native Americans as active and passive promoters of mast and fruit trees in the eastern USA. The Holocene 18 (7), 1123–1137.

Armstrong, Chelsey Geralda, et al., 2021. Historical Indigenous Land-Use Explains Plant Functional Trait Diversity. Ecol. Soc. 26 (2).

Balée, W., 1998. Historical Ecology: Premises and Postulates. In: Balée, W. (Ed.), Advances in Historical Ecology. Columbian University Press, New York, pp. 13–29.

Bird, D.W., Bird, R.B., Codding, B.F., 2016. Pyrodiversity and the anthropocene: The role of fire in the broad spectrum revolution. Evolutionary Anthropology: Issues, News, and Reviews 25 (3), 105–116.

Cajete, G., 2000. Native science: Natural laws of interdependence. Clear Light Publishers, Santa Fe, NM.

Clement, C.R., 1999. 1492 and the loss of amazonian crop genetic resources1492 e a Perda dos Recursos Genéticos da Amazônia. I. A Relação entre Domesticação e o Declínio das Populações Humanas. Econ Bot 53 (2), 188–202.

Crumley, C.L., 1994. Historical Ecology: A Multidimensional Ecological Orientation. In: Crumley, C.L. (Ed.), Historical Ecology: Culture, Knowledge and Changing Landscapes. School of American Research Press, Sante Fe, NM, pp. 1–16.

Delcourt, P.A., Delcourt, H.R., 2004. Prehistoric Native Americans and Ecological Change: Human Ecosystems in Eastern North America since the Pleistocene. Cambridge University Press, Cambridge.

Fraser, D., Villaseñor, A., Tóth, A.B., Balk, M.A., Eronen, J.T., Andrew Barr, W., Behrensmeyer, A.K., Davis, M., Du, A., Tyler Faith, J., Graves, G.R., Gotelli, N.J., Jukar, A.M., Looy, C.V., McGill, B.J., Miller, J.H., Pineda-Munoz, S., Potts, R., Shupinski, A.B., Soul, L.C., Kathleen Lyons, S., 2022. Late quaternary biotic homogenization of North American mammalian faunas. Nat. Commun. 13 (1).

Gammage, B., 2013. The biggest estate on Earth: How Aborigines made Australia. Allen and Unwin, Corws Nest, Australia.

Gammage, B., Pascoe, B., 2021. Country: Future Fire, Future Farming. Thames & Hudson, Sidney, Australia.

Gremillion, K.J., 2004. Seed Processing and the Origins of Food Production in Eastern North America. Am. Antiq. 69 (2), 215–233.

Janz, L., 2016. Fragmented landscapes and economies of abundance: the broad-spectrum revolution in arid East Asia. Current Anthropology 57 (5), 537–564.

Kennett, D.J., Winterhalder, B., 2006. Behavioral Ecology and the Transition to Agriculture. University of California Press, Berkeley.

Marks-Block, T., Lake, F.K., Curran, L.M., 2019. Effects of understory fire management treatments on California Hazelnut, an ecocultural resource of the Karuk and Yurok Indians in the Pacific Northwest. For. Ecol. Manage. 450, 117517.

McKemey, M.B., Patterson, M., Rangers, B., Ens, E.J., Reid, N.C.H., Hunter, J.T., Costello, O., Ridges, M., Miller, C., 2019. Cross-cultural monitoring of a cultural keystone species informs revival of indigenous burning of country in South-Eastern Australia. Human ecology 47 (6), 893–904.

Morrissey, R.M., 2019. Climate, Ecology and History in North America's Tallgrass Prairie Borderlands. Past & Present 245 (1), 39–77.

Mueller, N.G., et al., 2021. Bison, anthropogenic fire, and the origins of agriculture in eastern North America. The Anthropocene Review 8 (2), 141–158.

Munro, N.D., 2004. Zooarchaeological measures of hunting pressure and occupation intensity in the Natufian: implications for agricultural origins. Current Anthropology 45 (S4), S5–S34.

Nanavati, W., Grimm, E., 2020. Humans, Fire, and Ecology in the Southern Missouri Ozarks. The Holocene 30 (1), 125–135.

Nowacki, G.J., Abrams, M.D., 2008. The demise of fire and "mesophication" of forests in the eastern United States. Bioscience 58 (2), 123–138.

Politis, G.G., 2016. Nukak: ethnoarchaeology of an Amazonian people. Rutledge, London.

Ruddiman, W.F., 2003. The Anthropogenic Greenhouse Era Began Thousands of Years Ago. Clim. Change 61 (3), 261–293.

Smith, B.D., 2006. Human Behavioral Ecology and the Transition to Food Production. In: Kennett, D.J., Winterhalder, B. (Eds.), Behavioral Ecology and the Transition to Agriculture. University of California Press, Berkeley, pp. 289–303.

Smith, B.D., 2007. Niche construction and the behavioral context of plant and animal domestication. Evol. Anthropol. 16 (5), 188–199.

Smith, B.D., 2011a. A cultural niche construction theory of initial domestication. Biological Theory 6 (3), 260–271.

Smith, B.D., 2011b. The Cultural Context of Plant Domestication in Eastern North America. Current Anthropology 52 (S4), S471–S484.

Ter Steege, Hans, et al., 2013. Hyperdominance in the Amazonian tree flora. Science 342 (6156):1243092.

Suchet-Pearson, S., et al., 2013. Caring as Country: Towards an ontology of co-becoming in natural resource management. Asia Pacific Viewpoint 54 (2), 185–197.

Waters, C.N., Zalasiewicz, J., Summerhayes, C., Barnosky, A.D., Poirier, C., Gałuszka, A., Cearreta, A., Edgeworth, M., Ellis, E.C., Ellis, M., Jeandel, C., Leinfelder, R., McNeill, J.R., Richter, D.deB., Steffen, W., Syvitski, J., Vidas, D., Wagreich, M., Williams, M., Zhisheng, A.n., Grinevald, J., Odada, E., Oreskes, N., Wolfe, A.P., 2016. The Anthropocene is functionally and stratigraphically distinct from the Holocene. Science 351 (6269).

Zeder, M.A., 2009. Evolutionary biology and the emergence of agriculture: The value of co-opted models of evolution in the study of culture change. In: Macroevolution in Human Prehistory. Springer, pp. 157–210.

Zeder, M.A., Smith, B.D., 2009. A conversation on agricultural origins. Current Anthropology 50 (5), 681–690.

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