WHAT STEWARD GOT RIGHT: TECHNOLOGY, WORK ORGANIZATION, AND CULTURAL EVOLUTION

Nathan E. Stevens

Nathan E. Stevens, Department of Anthropology, University of California, Davis, One Shields Avenue, Davis, CA 95616 (nestevens@ucdavis.edu)

Find published version of this preprint here:

Stevens, Nathan E
2015 What Steward Got Right: Technology, Work Organization, and Cultural Evolution. In *Lithic Technological Systems and Evolutionary Theory*, edited by N. Goodale and William Andrefsky Jr., pp. 253-266. Cambridge University Press, New York.

Human behavioral ecology and dual inheritance theory are related theoretical approaches with obvious applicability to the problems that occupy lithic analysts. While each has its strengths, neither satisfactorily replaces the elegant, though decidedly less formalized cultural ecology of Steward. In order to use the methodological advances of lithic analysis to understand prehistoric human behavior, a perspective incorporating technology as well as behavior, history, and process is necessary. Examples of lithic technological change from the California archaeological record are used to illustrate how current and past evolutionary theory can inform models of lithic technology.

“Tradition makes the man, by circumscribing his behaviour within certain bounds; but it is equally true that man makes the traditions (Childe 1936: 238).”

Evolutionary and optimization approaches to archaeology, and to lithic technology specifically, are a positive, if not novel, development (Beck, et al. 2002; Bettinger and Eerkens 1999; Bettinger, et al. 2006; Elston 1992; Hughes 1998; Isaac 1972; Jeske 1992; Kuhn 1994; O'Brien, et al. 2001; Pitt-Rivers 1906 [1875]; Torrence 1983, 1989; Ugan, et al. 2003; Wright 1994). The application of evolutionary concepts has varied widely in these studies, alternately including ideas traceable to Darwin, Marx, or Spencer, as well as other biological and social theorists (Bettinger 1991; Dunnell 1980). Currently, most archaeological applications of evolutionary theory align themselves with either human behavioral ecology (HBE) (Bird and O'Connell 2006; Smith and Winterhalder 1992a; Winterhalder and Smith 2000) or dual inheritance theory (DIT) (Boyd and Richerson 1985; Cavalli-Sforza and Feldman 1981; Henrich and McElreath 2008) which are rooted variously in economics, evolutionary ecology, and population genetics. Somehow, the contributions of Julian Steward (Steward 1936, 1938, 1955) to the understanding of both evolution and ecology as applied to humans have been almost forgotten in the enthusiasm for these productive approaches. I will briefly discuss why Steward’s concept of cultural ecology is still relevant and how it may be incorporated into current evolutionary approaches in anthropology.

Cultural Ecology and Current Evolutionary Approaches

Steward’s development of cultural ecology was a reaction to what he saw as competing, but equally flawed, visions of how cultures change stemming from environmental determinism and historical particularism (Steward 1955:35). Rather than attributing recurrent cultural patterns solely to environmental setting or to culture history, Steward's solution was to treat the interaction of the two as a third, uniquely creative force (Steward 1955:34). This force was mediated by what Steward called the "culture core," which continues to be one of the most appealing and confounding aspects of cultural ecology as developed by Steward. While Steward never rigorously defined the culture core, he did suggest it would consist of "…the constellation of features which are most closely related to subsistence activities and economic arrangements (Steward 1955:37)." And that, "Cultural ecology pays primary attention to those features which empirical analysis shows to be most closely involved in the utilization of environment in culturally prescribed ways (Steward 1955:37)."

In Steward's (1955) formulation, the culture core includes aspects of a culture that influence how people interact with the environment, but importantly, it is not seen as determined by the environment. Instead it is inherited historically along with many other aspects of culture that characterize a region. In this way, Steward wisely separated the vagaries of the environment from the inner workings of a culture that occupied a given environment. Viewed over the long term, this means that environment and culture are on more or less separate evolutionary tracks and that the ability of one to influence the other is dependent on how each is structured.

Two problems with cultural ecology that contributed to the development of current evolutionary approaches are 1) the ambiguous concept of the "culture core" (Harris 1968; Kelly 1995; Moran 1984), and 2) explicit or implicit appeal to adaptation and selection at the group level to explain patterns (Bettinger 1991:50; Smith 1984). Within HBE, the concept of culture core has been replaced by the belief that behaviors most affecting fitness (e.g., subsistence behavior) are of primary importance (Smith 2000), and the modeling of how individual decisions influence group-level outcomes has replaced group selection (Smith and Winterhalder 1992b)(at least of the Wynne-Edwards (1962) variety). Researchers employing DIT emphasize how cultural evolution can produce both adaptive and maladaptive behaviors but also maintain that the propensity for culture itself is the product of natural selection (Henrich and McElreath 2003). Also, DIT has found ways to model how cultural group selection could work (e.g., Soltis, et al. 1995).

Despite these changes, the materialist underpinnings and general subject matter of both HBE and DIT, especially as applied to archaeological problems, are not far off the mark from what Steward advocated. Unfortunately, while many of Steward's insights into the nature of human-environment interactions have been retained in modern evolutionary approaches, his emphasis on technology and on the social organization of work has faded. In fact, at their extremes, HBE and DIT often resemble environmental determinism and historical particularism, respectively, with HBE frequently relying on external factors such as climate change to explain cultural change, and DIT emphasizing the potential for disconnects between culture and fitness. Are we once again in need of a theoretical middle ground and are the ideas of Steward a good place to go looking for it?

Individual Behavior, Work Organization, and Technological Tradition

While it could be argued that evolutionary theory as applied to lithic technology is just another case of archaeologists discovering a fruitful research avenue late in the game, such studies hold great potential for providing the wider anthropological community with empirical data on long term culture-environment interactions. Anthropologists have long noted that certain items of material culture are highly conserved across space and time while others change frequently. Materialists among us might explain this as a function of the articulation of base and superstructure (Harris 1968), core and noncore (Steward 1955), technomic and ideo-technic (Binford 1962), or fitness-related (functional) and neutral (stylistic) traits (Dunnell 1978). In each case, the result is the same: material culture related to subsistence activities is often redundant over space and time while material culture related to other "softer" aspects of life varies more widely.

More recently, this dichotomy has been explored by anthropologists and archaeologists applying phylogenetic approaches to cultural change (see Borgerhoff Mulder 2001; Cavalli-Sforza, et al. 1992; Guglielmino, et al. 1995; Lipo, et al. 2006; Mace and Holden 2005; O'Brien, et al. 2001). Studies investigating the degree of vertical versus horizontal transmission of ethnographic traits (e.g., Jordan and Shennan 2003, 2009; Moylan, et al. 2006; Tehrani and Collard 2009) have attempted to identify "core traditions" (see Boyd, et al. 1997) made up of traits that tend to agglomerate and are less affected by outside influences (e.g., descent and marriage).

Perhaps the *core traditions* of the phylogeneticists and Steward's *culture core* bear more than superficial similarity. Rather than thinking of the culture core as static, I suggest a more appropriate definition is that the culture core, like all culture, changes, but that it changes more slowly than other, more peripheral, aspects of culture (presumably because it is tied to fitness). Lithic technology changes slowly, is closely connected with work organization, and seems to be largely (but by no means exclusively) vertically inherited. Therefore, more than other types of archaeological data, studying lithic technology, and its organization, may provide important insights into how human adaptations are structured. Among lithic technologies, those that are most closely related to subsistence practices, and that characterize large regions of otherwise culturally distinctive populations seem good candidates for core traditions that may resist rapid change due to connections with fitness and work organization.

The relationship of technology to work organization brings up a potentially important point to those of us that are interested in formal models of human behavior. Current evolutionary approaches are concerned with modeling individual decisions, but the types of tools used by a culture may affect the fit of such models because the behavioral options of individuals were likely limited to varying degrees by different types of technologies.[1] As technological traditions evolved, the tools available to an individual at any point in time would constrain his or her behavior into culturally agreed-upon task-tool combinations.

Steward asked why human adaptations looked as they did in a given environment with a given technology. More specifically, he was also concerned with how much behavioral *latitude* was possible given a particular environment and technology (Steward 1955:36). Considering these questions with some time depth, one might also ask, "In a changing environment, how much does work organization have to change to produce an archaeologically detectable change in technology?" Given the proposed relationships between technology and work organization, the answer is that it probably depends on the technology.

If potential behavioral strategies are conditioned by both the available tools and the social and environmental context of the work (see Schiffer and Skibo 1997), the behavioral repertoire of any individual should be related to: 1) the tools in the technological tradition, and 2) the culturally-learned ways to use those tools to exploit the local environment. Likewise, the tools in the technological tradition must also be influenced by the tool-use decisions of individuals over time (see Figure 1). In this way, lithic technology can be seen as reflecting the intersection between individual behavior, work organization, and cultural tradition.

The glib contention that people will make new tools if necessary or that new technologies are always available through borrowing or invention does not square with the reality that over the short term, procurement and manufacturing of tools is often embedded within, and dependent on, the coordinated activities of others (Binford 1979). Over the long term, making changes to existing technologies, and developing or adopting new technologies is as much a social problem as it is an engineering problem (Bettinger 1999; Fitzhugh 2001; Richerson and Boyd 2001; Rosenberg 1994). In Steward's language, the configuration of the culture core might prevent new technologies from being adopted or developed. In other words, interdependencies between technological tradition, work organization, and individual behavior may restrict both short-term and long-term behavioral options. Even minor changes to lithic technologies may therefore reflect important behavioral changes.

Lithic Technological Change in California

Evidence for incremental changes in lithic technology is not difficult to come by. The difficulty is in assigning causality to any particular variable related to technological change. Equally valid cases can be made for the role of increasing human population pressure, decreasing mobility, decreasing foraging efficiency, environmental change and other factors. A thorough consideration of these factors is beyond the scope of this paper, however, it is useful to point out some salient patterns and their implications for those who apply evolutionary theory to the archaeological record.

First, a general pattern of fewer multifunctional tools and more specialized tools through time is evident among flaked stone assemblages from California's central coast (Figure 2).

Evidence from use-wear analysis shows this pattern as an increasingly steep reduction in the proportion of multifunctional tools through time, in particular after ca. 3000 BP (Figure 3).

Individual artifact classes from the region also support the idea that tools became more specialized through time. For example, during the Early (ca. 5000-2500 BP) and Middle (ca. 2500-1000 BP) periods, points of the central coast stemmed series (sensu Jones 1993) are the dominant projectile point form while after 1000 BP, smaller leaf-shaped points dominate the projectile class. Morphometric comparisons as well as use-wear data suggest the earlier stemmed points were multifunctional, exhibiting projectile use in addition to use as knives, while later small leaf-shaped points exhibit only projectile use (Stevens and Codding 2009). Presumably, after the adoption of small leaf-shaped points, other tools such as bifacial knives or utilized flakes stepped in to fulfill cutting tasks for which stemmed points were formerly employed. Again, the overall pattern is one of decreasing multifunctionality and increasing numbers of specialized tools.

If the functional latitude of tools narrowed through time, we might expect design changes reflecting this. Ground stone tools illustrate this progression particularly well due to the fact that the form of ground stone tools is more plastic and much less constrained by physics when compared to flaked stone tools. Ground stone tools from the early Holocene consist of millingslabs and handstones which are thought to have been used to process a wide variety of vegetal foods including small seeds, fibrous roots, and acorns. Between about 5000 and 3000 years ago, however, the importance of the acorn as a staple foodstuff increased greatly and stone mortars and pestles first appear in the archaeological record in large numbers (Basgall 1987; Glassow 1996b). Interestingly, the older millingslab/handstone technology was not abandoned, but appears to have been retained for use with small seeds and other resources that mortars cannot process as efficiently (Figure 4).

Changes in form within each ground stone tool class also reflect this shift. Millingslabs progress from shaped and intensively-used basin forms to flat, less intensively-used forms sometime after the beginning of the Early period. Similarly, handstones from Millingstone period contexts (ca. 10,000-5000 BP) are mostly shaped and heavily-used while handstones found in later contexts are frequently unshaped and only ephemerally-used. The opposite pattern is found among mortars and pestles, with earlier mortars largely consisting of globular unshaped or minimally-shaped forms and later forms exhibiting greater degrees of shaping and thinner walls. Pestles first appear as slightly shaped squat, cylindrical forms and then later evolve into highly-shaped tapered forms (Glassow 1996b; Stevens, et al. 2004).

It is probably not coincidental that the first millingslabs and first mortars are similar to each other in form while later versions of each become increasingly differentiated, reflecting greater functional specialization (see Eerkens and Lipo 2007: 262 for discussion of artifact divergence). A similar argument has been advanced to account for changes in ground stone tools in the prehistoric Southwest (Adams 1993; Glassow 1996b; Martin and Plog 1973:216; Mauldin 1993; Plog 1974:139) although, interestingly, it is the forms of millingslabs rather than mortars that become most specialized, probably reflecting the increasing importance of maize agriculture and seed grinding, rather than balanophagy and acorn pounding (but see Adams 1999).

Discussion

Human populations along the central California coast underwent several important changes during the Late Holocene including decreases in mobility (Bamforth 1986; Lebow, et al.

2007), increasing population (Glassow 1999; Lebow, et al. 2007), and increasing diet breadth (Glassow 1996a; Jones, et al. 2008). Concurrent environmental changes include the stabilization of sea level and a cooler and more variable climate (Atwater, et al. 1977; Barron, et al. 2003; Kennett and Kennett 2000). Human behavioral ecologists might interpret the above technological patterns as related to declining foraging efficiency, perhaps brought on by environmental change and/or increased population density, spurring increased investment in more specialized tools (compare to: Broughton 1994; Broughton 1997; Glassow 1996a; Kennett 2005). A relevant model incorporating DIT might view environmental change as the catalyst for human population growth, but consider historically-inherited technology and work organization a limiting factor. Local populations undergoing social or technological intensification may subsequently alter the carrying capacity of the local environment and experience further population growth, enabling them to outcompete other groups in the area (compare to: Bettinger and Baumhoff 1982; Richerson, et al. 2001). This second model is closer to Steward's concept of cultural ecology because the technological tradition is seen as mediating the creative interplay between environmental changes on one hand, and human behavioral responses on the other. Each of these perspectives, however, contributes an important piece of our understanding of long-term cultural change. HBE explains how subsistence changes should look given changes in other variables while DIT provides a plausible evolutionary mechanism for culture change given certain rules about how cultural information is inherited. HBE highlights the economic factors conditioning technological change while DIT helps explain why technological changes might spread even if specific groups are resistant.

Whichever general explanation is used, the specifics of the observed archaeological patterns at the assemblage level can be seen as multifunctional tools being partially or completely replaced with a specialized tools, thus increasing the number of tool types while at the same time narrowing the functional latitude of each tool type. The result of this progression is that the relationship between a given tool type and its intended use becomes stronger over time. This makes sense in the context of more rigid Holocene land use systems where increasingly, people found themselves compelled to be in a particular location at a particular time where a specific activity/tool combination may have precluded other behavioral options. The effect of this may have been less room for individual learning in tool making and using decisions and overall less behavioral latitude at the level of the group. This suggests that any attempt to model individual decision making should consider the context of the task, the available technology, and work organization.

Additionally, if the fit between tool morphology and tool use is variable over time, then ideas about performance characteristics and use lives of specific artifact classes are likely not as straightforward as have been previously portrayed (Bettinger, et al. 2006; Fitzhugh 2001; O'Brien, et al. 1994; Schiffer and Skibo 1997; Shott and Sillitoe 2004; Ugan, et al. 2003). Importantly, this could also affect the archaeological visibility of large-scale behavioral changes if a given group of technologies permitted a wide latitude of behavioral change with minimal or no tool morphological change or replacement. This sort of behaviorally variable, but archaeologically subtle adaptation might help explain the apparent lack of culture change throughout the California Early (ca.11,500-7000 BP) and Middle (ca. 7000-4000 BP) Holocene, a long interval characterized by considerable climatic variability.

If the relationships between lithic technology, human behavior, environment and the "culture core" (if such an entity exists), are similar to my broad sketch, then we should not be surprised that the archaeological record is full of examples of similar environmental or climatic events resulting in dissimilar reactions by human populations. This is because the important relationship is not simply between human behavior and the environment, but how core adaptive traditions influence this relationship. This was Steward's key insight and it is one that studies of lithic technology have the potential to explore further.

Acknowledgments.

The ideas in this paper were influenced by conversations with Bruce Winterhalder, Robert Bettinger, Jelmer Eerkens, Richard McElreath, Brian Codding, and Raven Garvey. Data from Vandenberg AFB was generously provided by Douglas Harro and Chris Ryan. Jelmer Eerkens and Brian Codding read a previous version of the manuscript and greatly improved its quality.

References Cited

Adams, J. L.

1993 Technological Development of Manos and Metates on the Hopi Mesas. *Kiva* 58:331-344.

1999 Refocusing the Role of Food-grinding Tools as Correlates for Subsistence Strategies in the U. S. Southwest. *American Antiquity* 64(3):475-498.

Atwater, B., C. Hedel and E. Helley

1977 *Late Quaternary Depositional History, Holocene Sea Level Changes, and Vertical Crustal Movement, Southern San Francisco Bay, California.* US Geological Survey Professional Paper, No. 1014. US Government Printing Office, Washington, DC.

Bamforth, D. B.

1986 Technological Efficiency and Tool Curation. *American Antiquity* 51(1):38-50.

Barron, J. A., L. Heusser, T. Herbert and M. Lyle

2003 High-resolution climatic evolution of coastal northern California during the past 16,000 years. *Paleoceanography* 18(1):1-14.

Basgall, M. E.

1987 Resource Intensification Among Hunter-gatherers: Acorn Economies in Prehistoric California. *Research in Economic Anthropology* 9:21-52.

Beck, C., A. K. Taylor, G. T. Jones, C. M. Fadem, C. R. Cook and S. A. Millward

2002 Rocks are heavy: transport costs and Paleoarchaic quarry behavior in the Great Basin. *Journal of Anthropological Archaeology* 21(4):481-507.

Bettinger, R. L.

1991 *Hunter-Gatherers: Archaeological and Evolutionary Theory*. Plenum Press, New York.

1999 From Traveler to Processor: Regional Trajectories of Hunter-Gatherer Sedentism in the Inyo-Mono Region, California. In *Settlement Pattern Studies in the Americas: Fifty Years Since Viru*, edited by B. R. Billman and G. M. Feinman, pp. 39-55. Smithsonian Institution Press, Washington, D.C.

Bettinger, R. L. and M. A. Baumhoff

1982 The Numic Spread: Great Basin Cultures in Competition. *American Antiquity* 47:485-503.

Bettinger, R. L. and J. W. Eerkens

1999 Point Typologies, Cultural Transmission, and the Spread of Bow-and-Arrow Technology in the Prehistoric Great Basin. *American Antiquity* 64(2):231-242.

Bettinger, R. L., B. Winterhalder and R. McElreath
2006 A Simple Model of Technological Intensification. *Journal of Archaeological Science* 33:538-545.

Binford, L. R.
1962 Archaeology As Anthropology. *American Antiquity* 28.(2):217-225.

1979 Organization and Formation Processes: Looking at Curated Technologies. *Journal of Anthropological Research* 35(3):255-273.

Bird, D. W. and J. F. O'Connell
2006 Behavioral ecology and archaeology. *Journal of Archaeological Research* 14:143-188.

Borgerhoff Mulder, M.
2001 Using Phylogenetically Based Comparative Methods in Anthropology: More Questions than Answers. *Evolutionary Anthropology* 10:99-111.

Boyd, R., M. Borgerhoff Mulder, W. H. Durham and P. J. Richerson
1997 Are Cultural Phylogenies Possible? In *Human By Nature*, edited by P. Weingart, S. D. Mitchell, P. J. Richerson and S. Maasen, pp. 355-386. Lawrence Erlbaum Associates, Mahwah, New Jersey.

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

Broughton, J. M.
1994 Late Holocene Resource Intensification in the Sacramento Valley, California: The Vertebrate Evidence. *Journal of Archaeological Science* 21:501-514.

1997 Widening Diet Breadth, Declining Foraging Efficiency, and Prehistoric Harvest Pressure: Icthyofaunal Evidence from the Emeryville Shellmound, California. *Antiquity* 71:845-862.

Cavalli-Sforza, L. L. and M. Feldman
1981 *Cultural Transmission and Evolution*. Princeton University Press, Princeton.

Cavalli-Sforza, L. L., E. Minch and J. L. Mountain
1992 Coevolution of Genes and Languages Revisited. *Proceedings of the National Academy of Science, USA* 89:5620-5624.

Childe, V. G.
1936 *Man Makes Himself*. Watts and Company, London.

Colten, R. H., C. G. Lebow, C. Denardo, R. L. McKim, D. R. Harro, C. H. Miksicek and B. Bowser

1999 *Hunter-Gatherer Land Use in the San Antonio Creek Drainage: Archaeological Investigations at CA-SBA-2696.* California State Water Project, Coastal Branch Series, Paper No. 11. San Luis Obispo County Archaeological Society, San Luis Obispo.

Dunnell, R. C.

1978 Style and Function: A Fundamental Dichotomy. *American Antiquity* 43(2):192-202.

1980 Evolutionary Theory and Archaeology. In *Advances in Archaeological Method and Theory*, edited by M. B. Schiffer, pp. 35-99. vol. 3. Academic Press, New York.

Eerkens, J. W. and C. P. Lipo

2007 Cultural Transmission Theory and the Archaeological Record: Providing Context to Understanding Variation and Temporal Changes in Material Culture. *Journal of Archaeological Research* 15:239-274.

Elston, R. G.

1992 Economics and Strategies of Lithic Production at Tosawihi. In *Archaeological Investigations at Tosawihi, a Great Basin Quarry*, edited by R. G. Elston and C. Raven, pp. 775–801. Prepared for the Bureau of Land Management, Elko Resource Area, by Intermountain Research Reports, Silver City, NV.

Fitzhugh, B.

2001 Risk and Invention in Human Technological Evolution. *Journal of Anthropological Archaeology* 20(2):125-167.

Glassow, M. A.

1996a *Purisimeno Chumash Prehistory: Maritime Adaptations along the Southern California Coast*. Harcourt Brace College Publishers, Fort Worth.

1996b The Significance to California Prehistory of the Earliest Mortars and Pestles. *Pacific Coast Archaeological Society Quarterly* 32(4):14-26.

1999 Measurement of Population Growth and Decline During California Prehistory. *Journal of California and Great Basin Anthropology* 21(1):45-66.

Guglielmino, C. R., C. Viganotti, B. Hewlett and L. L. Cavalli-Sforza

1995 Cultural Variation in Africa: Role of Mechanisms of Transmission and Adaptation. *Proceedings of the National Academy of Science, USA* 92:7585-7589.

Harris, M.

1968 *The Rise of Anthropological Theory*. Crowell, New York.

Harro, D. R., C. G. Lebow and R. L. McKim
2001 *Archaeological Investigations at CA-SBA-1823, Vandenberg Air Force Base, Santa Barbara County, California.* Applied EarthWorks, Inc., Fresno, California, for Tetra Tech, Inc., Santa Barbara, California. Submitted to 30 CES/CEV, Vandenberg Air Force Base, California.

Harro, D. R., C. G. Lebow, R. L. McKim, C. Ryan and C. Denardo
2000 *Eligibility Testing at CA-SBA-935, -2321, and -2345 for El Nino Related Road Repairs Vandenberg Air Force Base, California*. Applied EarthWorks, Inc., Fresno, California, Submitted to 30 CES/CEV, Vandenberg Air Force Base, California.

Henrich, J. and R. McElreath
2003 The Evolution of Cultural Evolution. *Evolutionary Anthropology* 12:123-135.

2008 Dual Inheritance Theory: The Evolution of Human Cultural Capacities and Cultural Evolution. In *Oxford Handbook of Evolutionary Psychology*, edited by R. Dunbar and L. Barrett, pp. 555-570. Oxford University Press, Oxford.

Hughes, S. S.
1998 Getting to the Point: Evolutionary Change in Prehistoric Weaponry. *Journal of Archaeological Method and Theory* 5(4):345-408.

Isaac, G. L.
1972 Chronology and tempo of cultural change during the Pleistocene. *In Bishop, W. W. & Miller, J. A. Eds.Calibration of Hominoid Evolution. pp. 381-430. Edinburgh: Scottish Academic Press.*

Jeske, R. J.
1992 Energy Efficiency and Lithic Technology: An Upper Mississippian Example. *American Antiquity* 57(3):467-481.

Jones, T. L.
1993 Big Sur: A Keystone in Central California Cultural History. *Pacific Coast Archaeological Society Quarterly* 29(1):1-78.

Jones, T. L., J. F. Porcasi, J. Gaeta and B. F. Codding
2008 The Diablo Canyon Fauna: A Coarse-grained Record of Trans-Holocene Foraging from the Central California Mainland Coast. *American Antiquity* 73:289-316.

Jordan, P. and S. Shennan
2003 Cultural transmission, language, and basketry traditions amongst the California Indians. *Journal of Anthropological Archaeology* 22(1):42-74.

2009 Diversity in hunter-gatherer technological traditions: Mapping trajectories of cultural 'descent with modification' in northeast California. *Journal of Anthropological Archaeology* 28(3):342-365.

Kelly, R. L.
1995 *The Foraging Spectrum: Diversity in Hunter-Gatherer Lifeways.* Smithsonian Institution Press, Washington D.C.

Kennett, D. J.
2005 *The Island Chumash: Behavioral Ecology of a Maritime Society*. University of California Press, Berkeley.

Kennett, D. J. and J. P. Kennett
2000 Competetive and Cooperative Responses to Climatic Instability in Coastal Southern California. *American Antiquity* 65(2):379-395.

Kuhn, S. L.
1994 A Formal Approach to the Design and Assembly of Mobile Toolkits. *American Antiquity* 59(3):426-442.

Lebow, C. G., D. R. Harro, R. L. McKim and C. Denardo
2001 *Archaeological Excavations at CA SBA 246, An Early Holocene Site on Vandenberg Air Force Base, Santa Barbara County, California.* Applied EarthWorks, Inc., Fresno, California, for Tetra Tech, Inc., Santa Barbara, California. Submitted to 30 CES/CEV, Vandenberg Air Force Base, California.

Lebow, C. G., D. R. Harro, R. L. McKim, C. Denardo, J. L. Gerber and C. Ryan
1998 *Archaeological Investigations at CA SBA 671, -677, and -2961, Vandenberg Air Force Base, Santa Barbara County, California*. Applied EarthWorks, Inc., Fresno, California, for Tetra Tech, Inc., Santa Barbara, California. Submitted to 30 CES/CEVPC, Vandenberg Air Force Base, California.

Lebow, C. G., D. R. Harro, R. L. McKim, A. M. Munns, C. Denardo, J. Onken and R. Bury
2005a *The Archaeology and Rock Art of Swordfish Cave (CA-SBA-503), Vandenberg Air Force Base, Santa Barbara County, California*. Applied EarthWorks, Inc., Submitted to: 30 CES/CEVNC, Vandenberg Air Force Base.

Lebow, C. G., L. Haslouer, J. M. Fancher, N. E. Stevens and A. M. Munns
2005b *Archaeological Investigations Supporting Consultation with the State Historic Preservation Officer for the Heritage Launch Program Demolition on Vandenberg Air Force Base in Santa Barbara County, California*. Applied EarthWorks, Inc., Submitted to: 30 CES/CEVNC, Vandenberg Air Force Base.

Lebow, C. G., R. L. McKim, Douglas R. Harro, C. M. Hodges and A. M. Munns
2005c *Large Game Hunting and Other Paludal Adaptations at Barka Slough: Excavations at CA-SBA-1010, Vandenberg Air Force Base, Santa Barbara County, California*. Applied EarthWorks, Inc., Submitted to: 30 CES/CEVNC, Vandenberg Air Force Base.

Lebow, C. G., R. L. McKim, D. R. Harro and A. M. Munns
2006 *Prehistoric Land Use in the Casmalia Hills throughout the Holocene: Archaeological Investigations along Combar Road, Vandenberg Air Force Base, Santa Barbara County, California*. Applied EarthWorks, Inc., Submitted to: 30 CES/CEVNC, Vandenberg Air Force Base.

Lebow, C. G., R. L. McKim, D. R. Harro, A. M. Munns and C. Denardo
2007 *Littoral Adaptations Throughout the Holocene: Archaeological Investigations at the Honda Beach Site (CA-SBA-530), Vandenberg Air Force Base, Santa Barbara County, California.* Applied EarthWorks, Inc., Submitted to: 30 CES/CEVNC, Vandenberg Air Force Base.

Lipo, C. P., M. J. O'Brien, M. Collard and S. J. Shennan (editors)
2006 *Mapping Our Ancestors: Phylogenetic Approaches in Anthropology and Prehistory*. Aldine Transaction, New Brunswick.

Mace, R. and C. J. Holden
2005 A Phylogenetic Approach to Cultural Evolution. *Trends in Ecology and Evolution* 20(3):116-121.

Martin, P. S. and F. Plog
1973 *The Archaeology of Arizona*. Natural History Press, Garden City, NY.

Mauldin, R. P.
1993 The Relationship between Ground Stone and Agricultural Intensification in Western New Mexico. *Kiva* 58:317-330.

McKim, R. L., C. G. Lebow, D. R. Harro and A. M. Munns
2007 *CA-SBA-212: Sea Mammal Hunting and Other Late Holocene Littoral Adaptations, Vandenberg Air Force Base, Santa Barbara County, California*. Applied EarthWorks, Inc., Submitted to: 30 CES/CEVNC, Vandenberg Air Force Base.

Moran, E. F.
1984 Limitations and Advances in Ecosystems Research. In *The Ecosystem Concept in Anthropology*, edited by E. F. Moran, pp. 3-32. AAAS Selected Symposium 92. Westview Press, Boulder.

Moylan, J. W., M. Borgerhoff Mulder, C. M. Graham, C. L. Nunn and N. T. Hakansson
2006 Cultural Traits and Linguistic Trees: Phylogenetic Signal in East Africa. In *Mapping Our Ancestors: Phylogenetic Approaches in Anthropology and Prehistory*, edited by C. P. Lipo, M. J. O'Brien, M. Collard and S. J. Shennan, pp. 33-52. Aldine Transaction, New Brunswick.

O'Brien, M. J., J. Darwent and R. L. Lyman

2001 Cladistics Is Useful for Reconstructing Archaeological Phylogenies: Palaeoindian Points from the Southeastern United States. *Journal of Archaeological Science* 28:1115–1136.

O'Brien, M. J., T. D. Holland, R. J. Hoard and G. L. Fox
1994 Evolutionary Implications of Design and Performance Characteristics of Prehistoric Pottery. *Journal of Archaeological Method and Theory* 1(3):259-304.

Pitt-Rivers, A. L.
1906 *The Evolution of Culture and Other Essays*. Clarendon Press, Oxford.

Plog, F.
1974 *The Study of Prehistoric Change*. Academic Press, New York.

Richerson, P. J. and R. Boyd
2001 Institutional Evolution in the Holocene: The Rise of Complex Societies In *The Origin of Human Social Institutions*, edited by W. G. Runciman, pp. 197-204. Proceedings of the British Academy 110.

Richerson, P. J., R. Boyd and R. L. Bettinger
2001 Was Agriculture Impossible during the Pleistocene but Mandatory during the Holocene? A Climate Change Hypothesis. *American Antiquity* 66(3):387-411.

Rosenberg, M.
1994 Pattern, Process, and Hierarchy in the Evolution of Culture. *Journal of Anthropological Archaeology* 13:307-340.

Schiffer, M. B. and J. M. Skibo
1997 The Explanation of Artifact Variability. *American Antiquity* 62(1):27-50.

Shott, M. J. and P. Sillitoe
2004 Modeling Use-Life Distributions in Archaeology Using New Guinea Wola Ethnographic Data. *American Antiquity* 69(2):339-355.

Smith, E. A.
1984 Explanatory Limitations of the Ecosystem Concept. In *The Ecosystem Concept in Anthropology*, edited by E. F. Moran, pp. 51-85. AAAS Selected Symposium 92. Westview Press, Boulder.

2000 Three Styles in the Evolutionary Analysis of Human Behavior. In *Adaptation and Human Behavior: an Anthropological Perspective.*, edited by L. Cronk, N. Chagnon and W. Irons, pp. 27-46. Aldine de Gruyter, Hawthorne, NY.

Smith, E. A. and B. Winterhalder (editors)
1992a *Evolutionary Ecology and Human Behavior.* Aldine de Gruyter, New York.

1992b Natural Selection and Decision Making: Some Fundamental Principles. In *Evolutionary Ecology and Human Behavior*, edited by E. A. Smith and B. Winterhalder, pp. 25-60. Foundations of Human Behavior, S. B. Hrdy, general editor. Aldine De Gruyter, New York.

Soltis, J., R. Boyd and P. J. Richerson
1995 Can Group-Functional Behaviors Evolve by Cultural Group Selection?: An Empirical Test. *Current Anthropology* 36(3):473.

Stevens, N. E. and B. F. Codding
2009 Inferring the Function of Projectile Points from the Central Coast of Alta California. *California Archaeology* 1(1):7-28.

Stevens, N. E., R. T. Fitzgerald, N. Farrell, M. A. Giambastiani, J. M. Farquhar and D. Tinsley
2004 *Archaeological Test Excavations at Santa Ysabel Ranch, Paso Robles, San Luis Obispo County, California.* Report submitted to Weyrich Development Company, LLC. Cultural Resource Management Services, Paso Robles.

Steward, J. H.
1936 The Economic and Social Basis of Primitive Bands. In *Essays in Anthropology Presented to A. L. Kroeber*, edited by R. H. Lowie, pp. 331-350. University of California Press, Berkeley.

1938 *Basin-Plateau Aboriginal Sociopolitical Groups.* Bureau of American Ethnology Bulletin 120.

1955 *Theory of Culture Change*. University of Illinois Press, Urbana.

Tehrani, J. J. and M. Collard
2009 The Evolution of Material Culture Diversity among Iranian Tribal Populations. In *Pattern and Process in Cultural Evolution*, edited by S. Shennan, pp. 99-111. University of California Press, Berkeley.

Torrence, R.
1983 Time Budgeting and Hunter-Gatherer Technology. In *Time Budgeting and Hunter-Gatherer Economy in Prehistory: A European Perspective*, edited by G. Bailey, pp. 11-22. Cambridge University Press, New York.

1989 *Time, Energy and Stone Tools.* Cambridge University Press, New York.

Ugan, A., J. Bright and A. Rogers
2003 When is Technology Worth the Trouble? *Journal of Archaeological Science* 30(10):1315-1329.

Winterhalder, B. and E. A. Smith

2000 Analyzing Adaptive Strategies: Human Behavioral Ecology at Twenty-five. *Evolutionary Anthropology* 9:51-72.

Wright, K. I.
1994 Ground-Stone Tools and Hunter-Gatherer Subsistence in Southwest Asia: Implications for the Transition to Farming. *American Antiquity* 59(2):238-263.

Wynne-Edwards, V. C.
1962 *Animal Dispersion in Relation to Social Behavior*. Oliver & Boyd, London.

Notes

1) The words "technology" and "tools" are admittedly imprecise, but are used here in the sense that implements suitable for performing different tasks are variable in time and space as are the knowledge and materials to make them. Fitzhugh's (2001:128) definition of technology as including *material*, *practical*, *informational*, and *purposive* components is useful here.

2) Sites/components plotted in Figure 3 include: CA-SBA-212 AUs 1 and 2 (McKim, et al. 2007), SBA-246 Locus B (Lebow, et al. 2001), SBA-503 AUs 2 and 3 (Lebow, et al. 2005a), SBA-530 AUs 3, 4, and 6 (Lebow, et al. 2007), SBA-677 (Lebow, et al. 1998), SBA-755 AU5 (Lebow, et al. 2006), SBA-935 (Harro, et al. 2000), SBA-990 (Lebow, et al. 2005b), SBA-1010 AUs 1-6 (Lebow, et al. 2005c), SBA-1823 (Harro, et al. 2001), SBA-2696 AU3 (Colten, et al. 1999). "Multifunctional" tools were defined as those that showed evidence of either concurrent use for multiple actions (e.g., scraping, cutting) and/or multiple contact materials (e.g., bone, wood), or sequent use (e.g., a core recycled as a plane). Ages of all components plotted are based on associated radocarbon dates except for SBA-1823, which was plotted at 8000 BP based on Millingstone period assemblage. If this component is omitted, $r^2 = 0.57$, $p < 0.001$.

Figure Captions

Figure 1. Proposed relationships between behavior, technology, and tradition. Individual behavior is both constrained by and influenced by context, available tools, and work organization. The technological tradition results from these interactions, but also influences them.

Figure 2. Locations of California Central Coast archaeological sites with use-wear data used to create Figure 3.

Figure 3. Proportions of multifunctional tools in California Central Coast assemblages[2] plotted against calibrated years before present. Log regression $r^2 = 0.61$, $p < 0.001$.

Figure 4. Changes in California Central Coast ground stone technology throughout the Holocene.

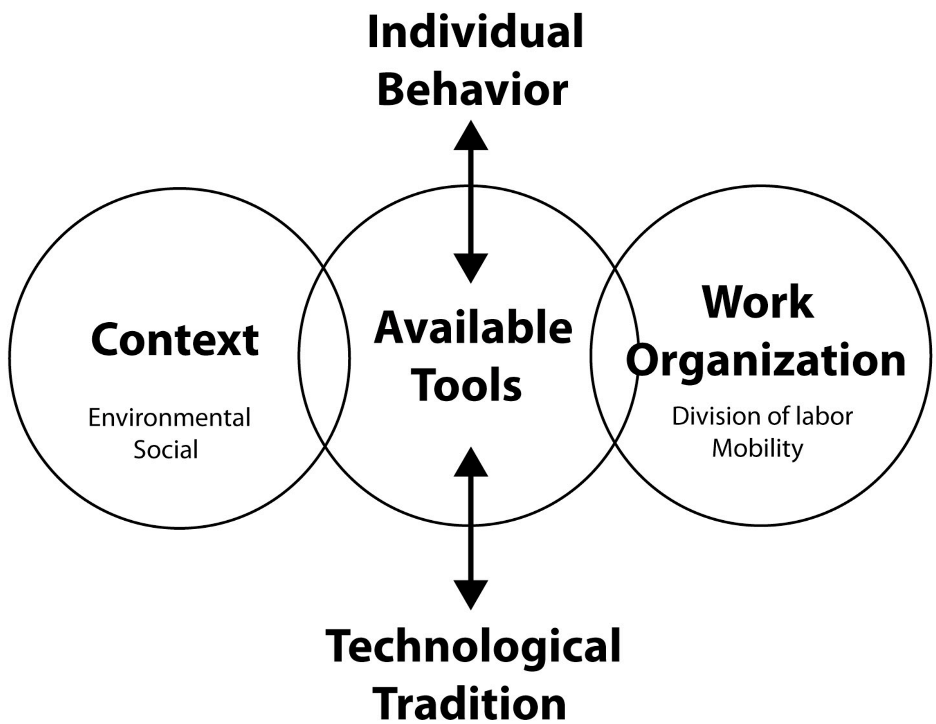
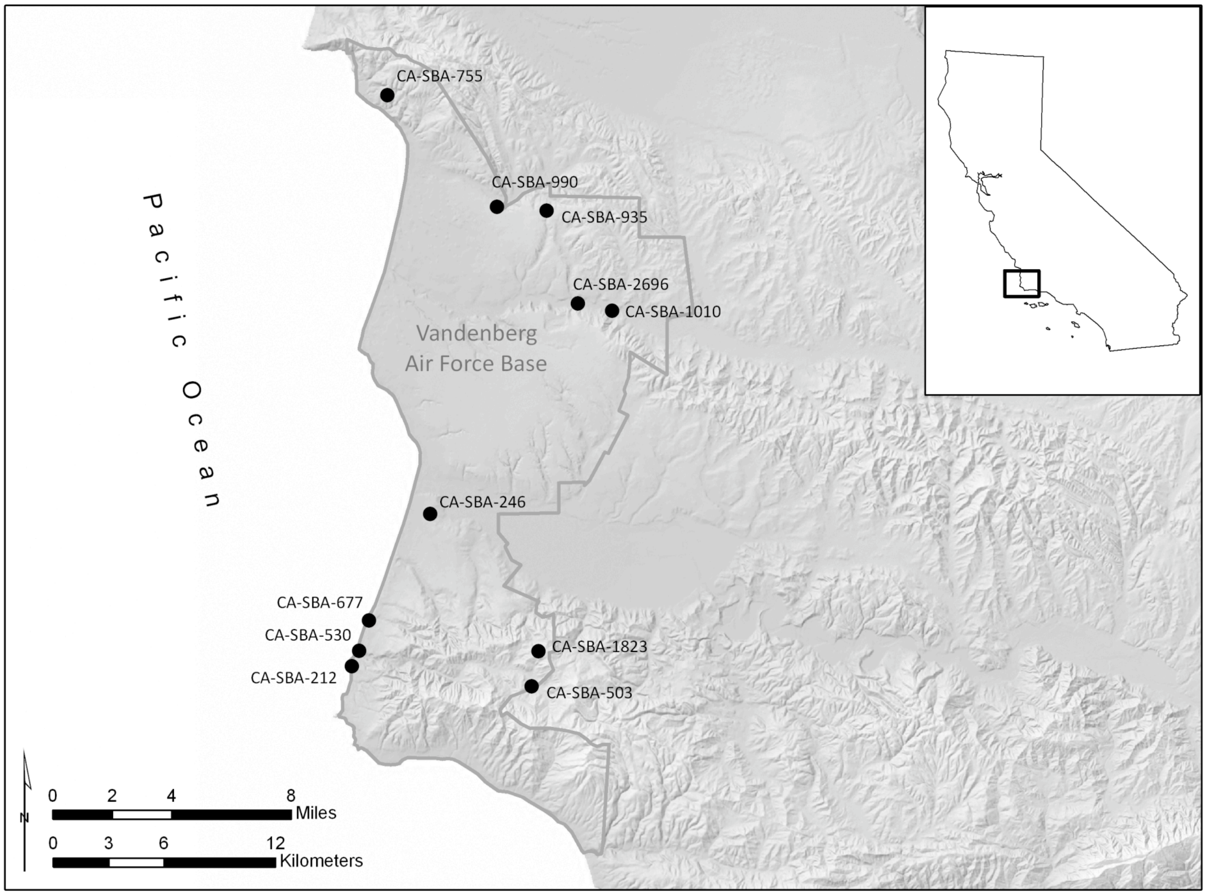
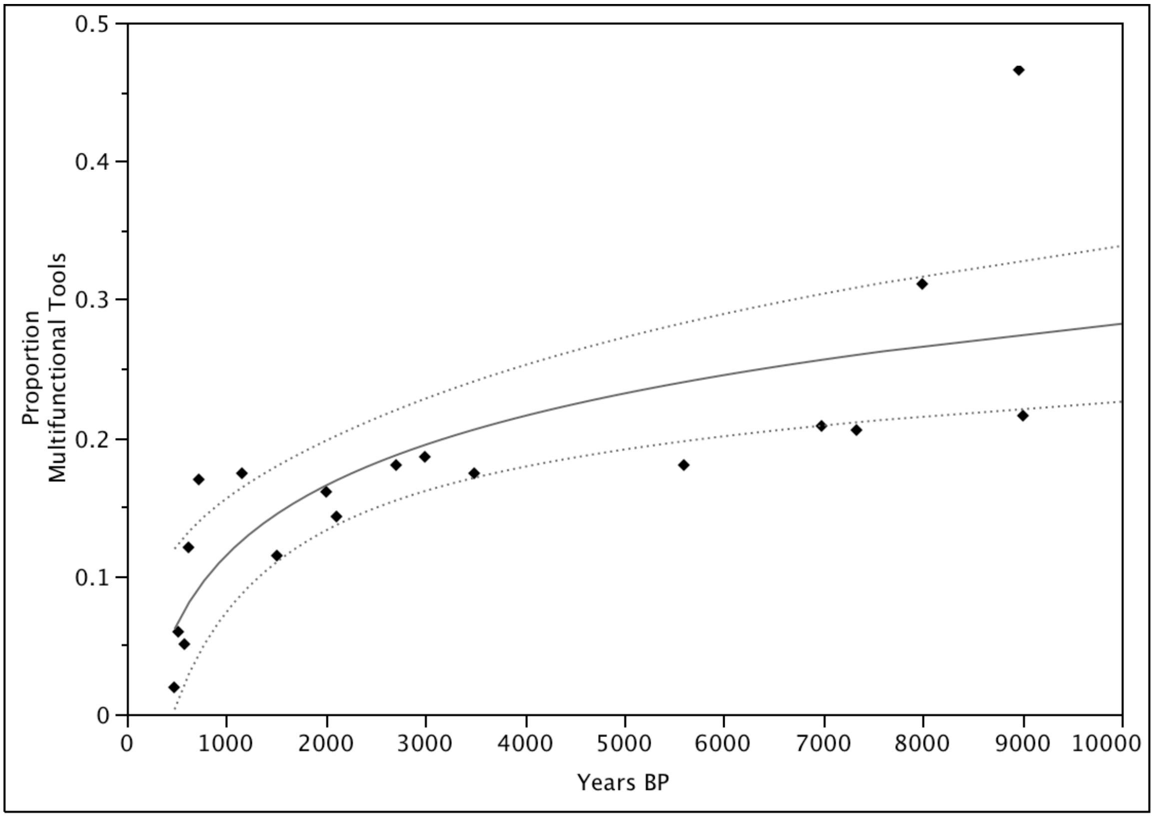

Individual
Behavior
Context
Environmental
Social
Available
Tools
Work
Organization
Division of labor
Mobility
Technological
Tradition

Figure1.



CA-SBA-755
CA-SBA-990
CA-SBA-935
CA-SBA-2696
CA-SBA-1010
Pacific Ocean
Vandenberg Air Force Base
CA-SBA-246
CA-SBA-677
CA-SBA-530
CA-SBA-212
CA-SBA-1823
CA-SBA-503
N
0 2 4 8
Miles
0 3 6 12
Kilometers

Figure2.



Proportion
Multifunctional Tools
0.5
0.4
0.3
0.2
0.1
0
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
Years BP

Figure 3.

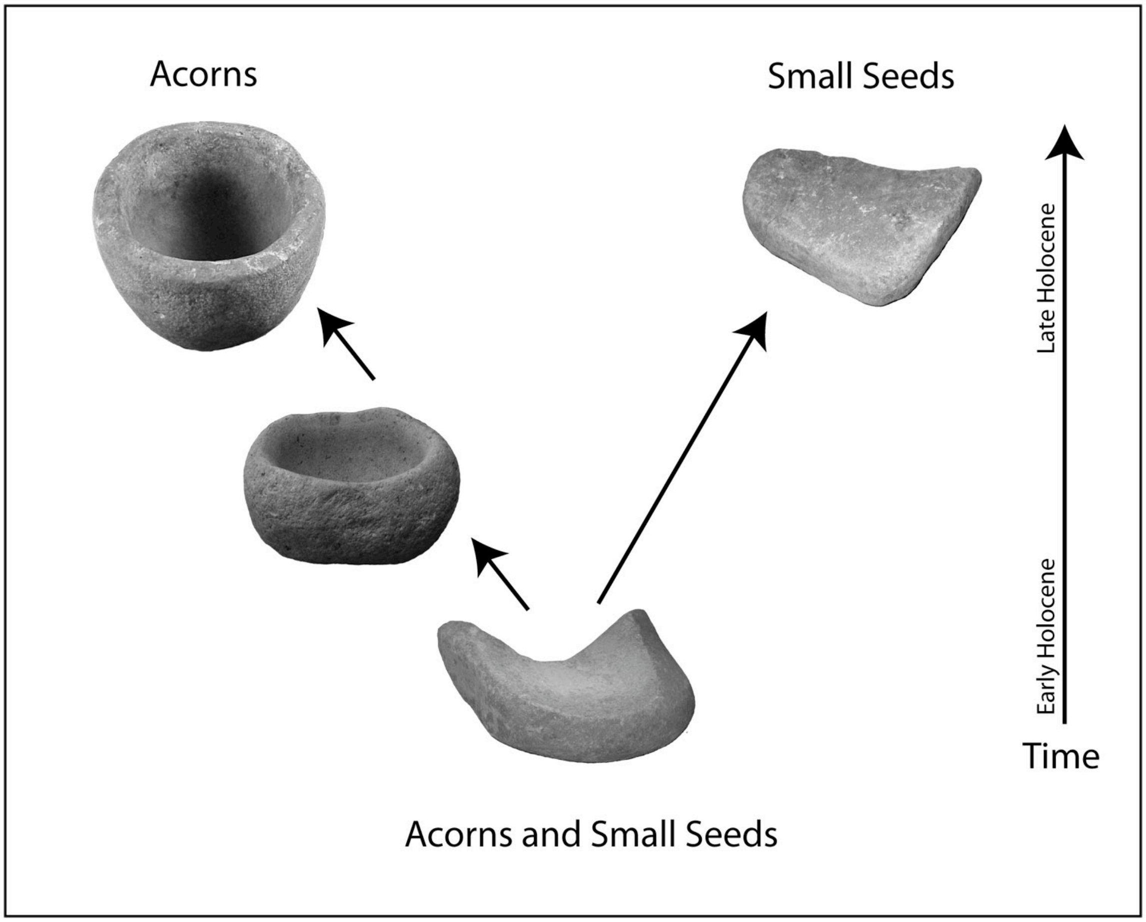

Acorns
Small Seeds
Late Holocene
Early Holocene
Time
Acorns and Small Seeds

Figure 4.